Vietnam Food Smart Country Diagnostic

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Executive Summary

The term "food smart" refers to a food system that is efficient, meets the food needs of a country, and is environmentally sustainable. Reducing food loss and waste (FLW) is one of the critical pillars to build a smart food system. This diagnostic focuses on the FLW pillar, from farm to fork to landfill, with the objective of alerting policymakers to the role that addressing food loss and waste can play in meeting their various global and national policy commitments.

Food loss and waste is a global problem—estimates suggest that 25-30% of all food produced is never eaten, generating around 8-10% of annual global greenhouse gas emissions.* According to the United Nations, food that is lost closer to the farm, in contrast to consumer waste, equates to an annual economic loss of USD 400 billion.**

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A "FOOD SMART" VIETNAM

The food sector, for both domestic consumption and foreign export, is a key contributor to Vietnam GDP growth and is expected to remain so. Past growth came from use of more and more inputs—land, water, chemicals, and labor—now reaching their physical limits and requiring a shift to produce more from less. Compounding this challenge are two other external forces impacting the food system: urbanization and climate change. Urbanization, accompanied by a growing middle class with more varied diets, continues to strain the food supply chain, while manifestations of climate change negatively impact production and yields. Reducing food loss and waste (FLW) in Vietnam can help alleviate these stresses while advancing policy priorities: ensuring continued domestic availability of food; maintaining Vietnam's position as a global leader in agricultural exports; and reducing environmental stressors exacerbated by food production. Because of Vietnam's regional and global influence on food security, reductions in FLW can also provide a global public good by making more food available elsewhere. Currently, Vietnam loses and wastes 25% of total food production each year.

To estimate the impact of 50% reductions in FLW at various stages of the value chain on the country's policy priorities, this diagnostic focused on Vietnam rice and farmed catfish

*United Nations Intergovernmental Panel on Climate Change (2019). *Special Report on Climate Change and Land.* Chapter 5: Food Security. Accessed: October 23, 2019. URL:https://www.ipcc.ch/site/assets/uploads/2019/08/2f.-Chapter-5_FINAL.pdf

**Bloomberg (2019). *The World Loses $400 Billion of Food Before It Reaches Stores.* By Agnieszka de Sousa. Accessed: October 23, 2019. URL:https://www.bloomberg.com/news/articles/2019-10-14/the-world-loses-400-billion-of-food-before-it-reaches-stores

production. Vietnam is the world's fifth largest rice producer, and it produces 50% of the world's catfish. **The study, based on the Global Framework model, found that reducing FLW for rice and catfish would have a positive or virtually neutral effect along the entire value chain on all policy priorities of farmer welfare, food security, trade, natural resource stress, greenhouse gas emissions, and food waste.**

Within the context of these results, several tactics hold promise. They include developing insurance, financing and early warning systems for farmers to lessen the impacts of climate change; enabling access to real-time market information; establishing cooperative and wholesale trading centers to improve efficiency and food safety; implementing cooling and refrigeration throughout the value chain; establishing food safety standards and guidance, as well as disease outbreak mitigation; and improving urban food waste management.

Vietnam now needs to shift

to producing more from less; that is, producing higher value food items per unit of natural resources and labor utilized. FLW reduction can play a role in this transition, increasing the efficiency of the food system in Vietnam while providing domestic and global benefits.

Vietnam's Challenge: More from Less

Over the last 30 years, Vietnam has experienced remarkable poverty reduction and economic growth, accompanied by significant improvements in food security. The economy has transitioned from largely agrarian focused to more diversified, with greater GDP contribution coming from the services and industry sectors over the past two decades.[1] The agriculture and food sector will remain, however, a key contributor of GDP growth and employment over the next 30 years and a critical driver of food security domestically and globally. Vietnam is a top exporter of rice and seafood, and the government is strategically shifting from the production of low value, raw exports to higher value processed exports. Vietnam's burgeoning middle class in urban centers, with increased incomes and shifting diets away from staples toward proteins and perishables, as well as a booming tourism industry, is also heavily influencing the country's food demand. The share of rice in Vietnam's food calorie consumption is expected to decrease from 52% in 2009 to just over 33% by 2030, when animal products and seafood will account for 33% of caloric consumption. The evolution in urbanization and domestic consumption patterns also brings heightened concerns regarding food safety, which is also critical for the competitiveness of the agro-food system.[2]

Vietnam now needs to shift to different patterns of growth with accompanying reforms of its food system in tandem with the changes taking place in the Vietnamese economy. Past growth in food output and exports came from the use of more and more inputs—land, water, chemicals, and labor—but these are reaching their physical limits. By international standards, Vietnam is heavily land-constrained and needs to get more value from its relatively scarce resources, especially land. Agricultural growth has historically stemmed from expanded or more intensive use of land and other natural resources, and relatively heavy use of fertilizer and other agro-chemicals. This has led to a large environmental footprint from the sector, including deforestation, land degradation, excessive water use, greenhouse gas emissions, biodiversity loss, and water and air pollution.[3] Vietnam's intense natural resource exploitation compares poorly to peers, and as growth was peaking in the late 2000s, nearly 15% of gross national income was lost to natural resource depletion.[4]

In the future, further growth of food production and exports will need to be based on generating more from less; that is, producing higher value food items per unit of natural resources and labor utilized. But while the agriculture sector's performance in terms of agricultural yields, output, and exports has been impressive, Vietnam's once robust growth in total factor productivity, or its outputs compared to inputs, has weakened. In other words, Vietnam's improvements in efficiency per unit of production have slowed down, while environmental costs are increasing. Food production is now facing environmental constraints to growth, and it must pivot to increase both the efficiency and sustainability of outputs to meet its development goals. One way to move towards a more from less objective is by reducing food loss and waste (FLW) along the supply chain. This would in fact improve total factor productivity of the food system by augmenting the productivity of all resources used in the supply chain, including of natural resources such as land, water, and chemicals. More food would be produced from less. There would be more food available for domestic consumption. There would also be more food available for exports. Given Vietnam's position among the top world suppliers of some food items, the additional exports from less food loss and waste would also contribute to the lowering of the food

gap in food deficient countries. However, a "more from less" strategy in Vietnam is further complicated by two other external forces impacting the food system: urbanization and climate change.

URBANIZATION

First, Vietnam is experiencing rapid urbanization. Urban population is expected to grow from 36% today to 57% by 2050.[5] Rural population, on the other hand, is expected to decline from 62 million in 2020 to 49 million in 2050.[6] Urbanization and a larger middle class will require a larger proportion and quantity of food to be delivered to urban centers instead of being consumed locally. Concurrently, diets will become more urbanized—nutrient rich and diverse—demanding changes in the domestic food supply and a bigger role for imports of certain items such as meat. Thus, urbanization will add strains to the food supply chain. Vietnam's supply chain is known for its fragmentation and reliance on a large number of intermediaries and transactions. While this system has been able to deliver fairly nutritious diets locally, it is not up to the task of supplying ever-expanding urban centers. Food loss and waste is likely to increase along the supply chain. Urbanization is likely to lead to more food waste (see Box). Moreover, Vietnam needs to sustain its role in the global food system to help address the food challenge elsewhere where there are food gaps. With the constraints to more resource use, this can only be achieved by gains in food productivity, including by reducing food loss and waste. Added to this, a larger proportion of urban diets is likely to come from imports, demanding a more efficient trade supply chain. Lower imports from reduced food loss and waste in the trade supply chain would save food for consumption elsewhere. The evolution in urbanization and domestic consumption patterns also brings heightened concerns regarding food safety, which is critical to ensure competitiveness of the agro-food system internationally.[7]

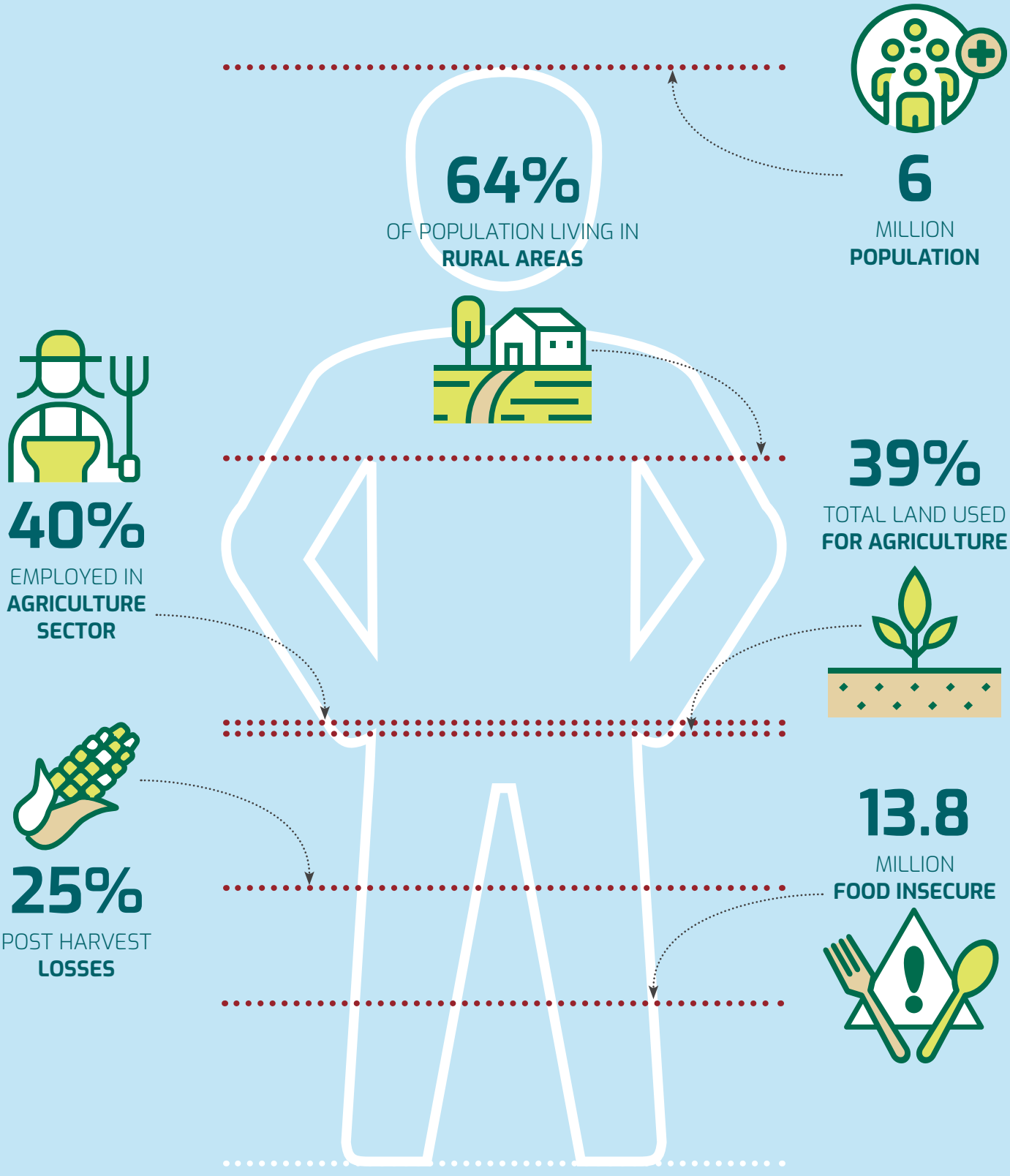
URBAN CENTERS & FOOD WASTE

Vietnam has experienced rapid urbanization over the last 30 years, with rural population migrating to cities and growing the country's middle class. The average waste generation rate per capita in Vietnam's large urban centers, where incomes are higher, is over double that of rural areas, reflected by the fact that the five biggest cities in Vietnam, with only 35% of the population, contribute 70% of the country's total waste generation. Importantly, between 60-70% of this waste is food waste, which generates potent methane emissions, compounds air pollution issues, and increases costs and land scarcity challenges for municipalities. Vietnam will see an increase in solid waste (and food waste) production over the next 30 years with urban population growing to 57% by 2050, accompanied by waste generation rates increasing by 10-15% in highly urbanized areas like Ho Chi Minh City compared to 8-10% for the rest of Vietnam.[8]

CLIMATE CHANGE

Second, as Vietnam is facing food efficiency challenges, the food production sector is also under threat from climate change impacts. While natural disasters have caused average annual economic losses of around 1-1.5% of GDP in the last two decades, economic losses from climate change impacts are expected to range as high as 3% of real GDP by 2050.[9] A variety of manifestations will impact

Vietnam Stats



Vietnam's farmers, including sea level rise, coastal erosion, changes in growing seasons, and salinity intrusion, as well as changing water resource availability arising from changes in temperature and rainfall distribution. These manifestations will negatively impact domestic food production. Rice production and yields will likely decline with warming and water availability, in addition to salinity intrusion and inundation in the deltaic regions, where much of the agriculture land lies two meters below sea level. Climate change could also lead to more food loss and waste in the food system. Facing increasing weather unpredictability, farmers will likely plant surplus crop to hedge against weather risks, while at the same time, other geographical areas will become less suitable for specific crops, leading to crop failures, pests, and diseases— all resulting in increased losses and lower food availability. These climate change impacts will further undermine Vietnam's strategy to produce more from less.

MORE FROM LESS: THE POTENTIAL OF ADDRESSING FOOD LOSS AND WASTE

As Vietnam is grappling with a natural resource scarcity challenge, urbanization, and climate change, the country could consider the role that food loss and waste reductions would play in helping meet its agro-food sector and development goals. Food loss and waste presents a promising option when considering the country's policy priorities, which are centered around three primary drivers:

1. **Domestic availability of high quality and diversified food,** including more protein and perishables, to meet shifting domestic demands as the country urbanizes and both consumption and incomes increase. Vietnam has maximized its natural resources already, while causing serious environmental degradation and pollution, and can no longer meet increased consumption requirements through additional land conversion.
2. **Global leader in agriculture exports, with a focus on high value products**. Vietnam is a top global exporter of many agricultural exports, including rice, seafood, and cassava. Sustaining Vietnam's food exports is a global good, contributing to addressing food deficits from rising population elsewhere in the world, alleviating stress on natural resources and pollution. However, the increase in production can no longer come at the expense of Vietnam's natural resources. One way in which to increase "production" is to reduce losses and waste along the value chain before commodities are exported.
3. **Environmental sustainability, through reduced stress on land and water, less contamination from waste, and lower greenhouse gas emissions**. Vietnam utilizes its natural resources more intensively than peers and natural resource depletion has weighed heavily on gross national income. Wastewater pollution from agricultural runoff and aquaculture practices pollutes the ocean as well as freshwater sources, affecting global public goods. The agriculture sector, in particular rice production, is carbon intensive, while food waste in urban areas further exacerbates emissions challenges through methane production. More food from reduced food loss and waste would not only reduce stress on domestic natural resources and pollution from domestic consumption, but also contribute to these goals elsewhere in the world through Vietnam's exports.

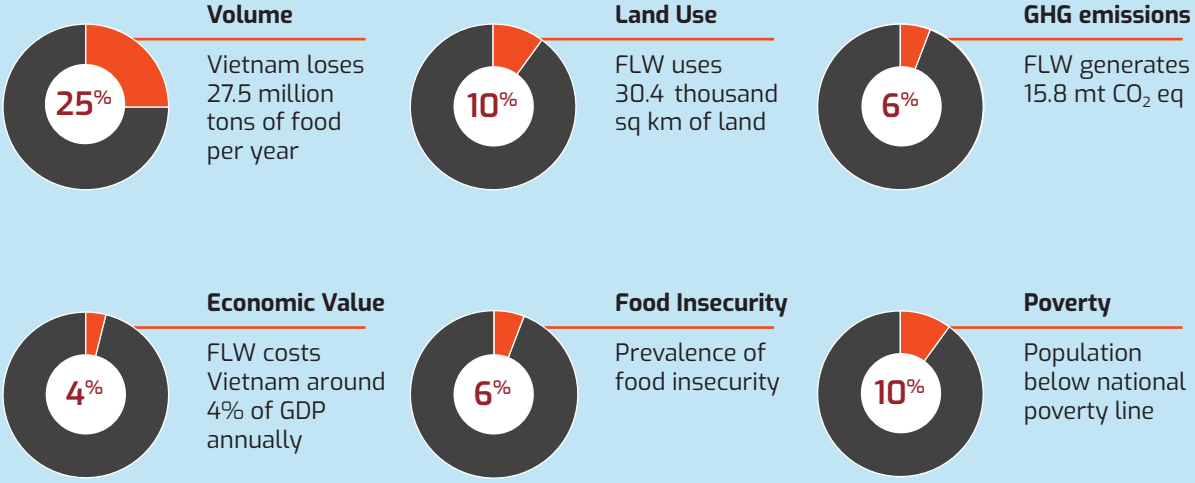
Commitment to Addressing Food Loss and Waste

Vietnam has made several commitments to reduce food loss and waste at the global, regional, and national levels. Specifically, it has committed to:

SDG 12.3	APEC Food Security Roadmap	NDC Commitment	National Commitments (2015)
By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.	By 2020, APEC economies will strive to reduce food loss and waste by 10% compared with 2011-2012 levels.	Vietnam's mitigation strategy to meet its 8% GHG reduction commitment by 2030 includes emissions reductions from both rice cultivation and solid waste landfills.	By 2020, reduce by 50% post-harvest losses of agricultural and fishery products.

INDICATORS TRIGGERING GOVERNMENT ACTION ON LOSSES AND WASTE REDUCTION[10]

Vietnam loses and wastes 25% of total food production each year, which uses 10% of total land and contributes 6% of the country's greenhouse gas emissions. These losses represent 4% of Vietnam's GDP. At the same time, 15% of Vietnamese are still food insecure and 10% of the population remains below the national poverty line.



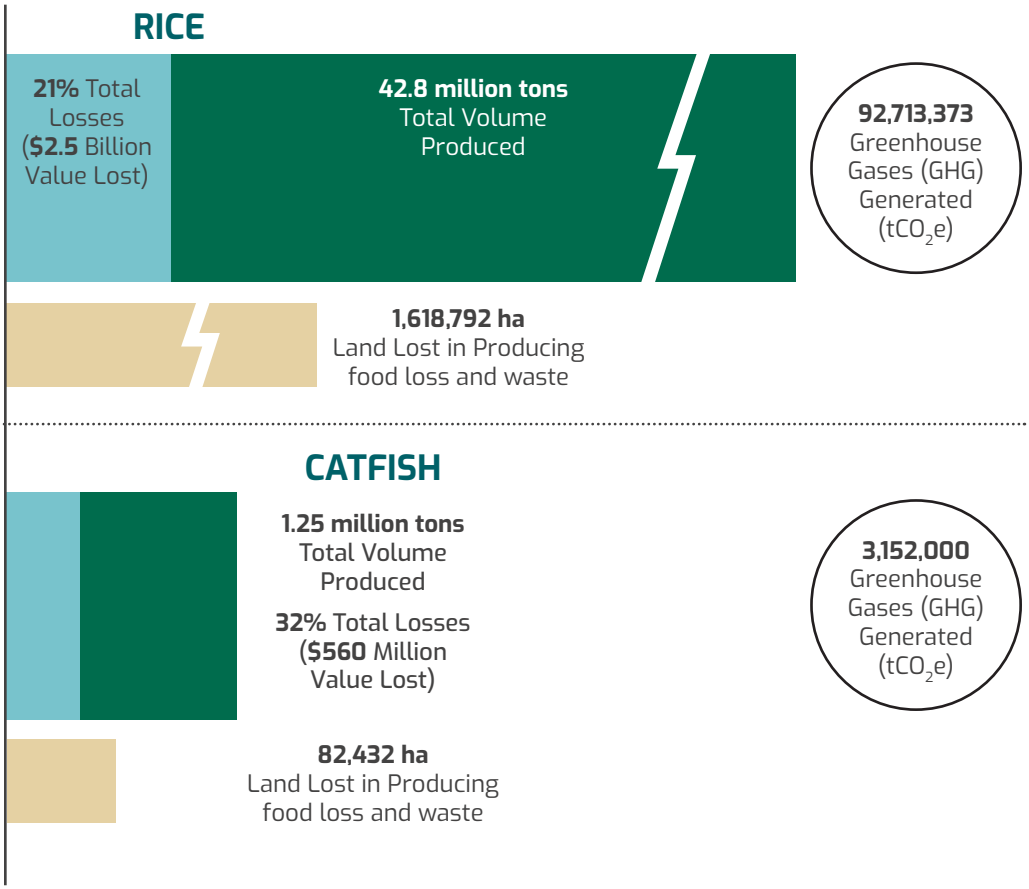
Sources: CEL Consulting (2019), World Bank Open Data; WRI CAIT Climate Data Explorer, FAO et al. (2019), WB Calculations

Key Commodities & Loss and Waste Hotspots

For Vietnam's diagnostic, rice and farmed *pangasius* (catfish) are selected to illustrate potential policy impacts when reductions of losses and waste are implemented along the value chain. While focusing on rice and catfish, the diagnostic offers insights for other food commodities. Rice is the dominant staple produced in Vietnam and remains a critical contributor to caloric sufficiency and food security in the region and globally. It is also a highly carbon intensive crop. Vietnam is the largest producer of catfish globally, and the higher margin commodity has enabled increased livelihoods for its farmers, while also providing more nutritious food for the shifting diets and growing middle class of Vietnam and broader Southeast Asia region.* Aquaculture, while not carbon intensive like rice, is highly polluting and a driver of environmental degradation in Vietnam.

KEY STATS[11]

TABLE 1. Production, losses, and associated impacts for paddy rice and catfish in 2017



Sources: FAOSTAT 2017; FAOSTAT 2011; GLOBEFISH 2018; General Statistics Office of Vietnam; WRI FLW Protocol FReSH FLW Value Calculator; Henriksson 2015; and WB calculations

*Several reports, such as FAO's SOFA 2019, stress the urgent need of data to fully understand the global magnitude of food loss and waste. However, this diagnostic and conceptual framework attempt to bridge the data gaps remaining to enable estimation of total food loss and waste at the most disaggregated levels possible.

RICE

Rice is a staple crop of Vietnam with an annual paddy production of over 42 million tons in 2017, making the country the fifth largest rice producer globally. Vietnam has strengthened its rice sector through various policies and programs, which has helped the country tackle food insecurity and emerge as a strong rice economy. Today Vietnam is one of the world's leading rice exporters and the second largest exporter in ASEAN, with an annual export of around 6 million tons.[12, 13] Rice cultivation is a major source of global GHG emissions. In 2013, emissions from agriculture in Vietnam totaled 89.4 MtCO2eq, with the largest share of around half (44.7 MtCO2eq) coming from rice cultivation. As such, reductions in agricultural emissions, and from rice especially, are a priority in Vietnam's NDC mitigation strategy.[14]

PANGASIUS (CATFISH)

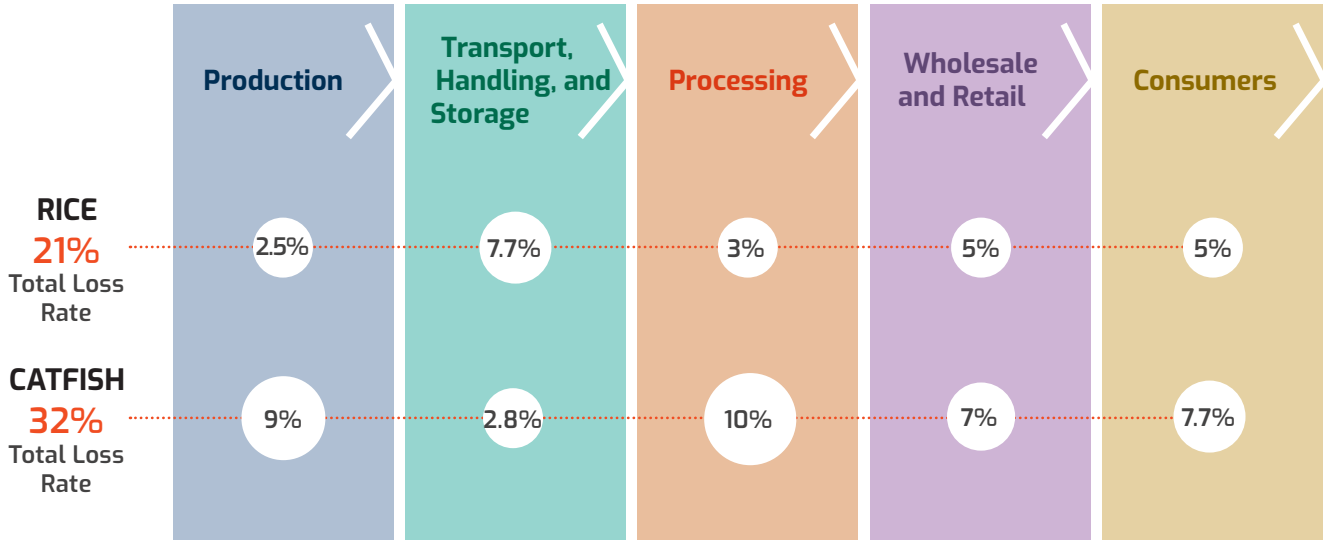
Vietnam produces 50% of the world's *pangasius*, or catfish, all of which is farmed in the Mekong Delta region. With annual production of over 1.25 million tons, Vietnam exports around 90% of its production to regional and international trade partners. The government is anticipating 2019 pangasius exports to reach USD 2.4 billion. Aquaculture production has significant implications for environmental stress, with mangrove clearance spurring erosion, and use of antibiotics and agro-chemicals polluting local water resources.

REGIONAL HIGHLIGHT: THE MEKONG RIVER DELTA

The Mekong Delta, home to 17.8 million people, 80% of which are farmers, is Vietnam's most important rice and fishing region, producing around 55% of the country's paddy rice production and 71% of fish aquaculture production.[15] In 2017, Vietnam exported 14% of its rice production, with a value of USD 2.6 billion, while fishery exports accounted for 35% of agricultural exports for a value of USD 6.1 billion.[16, 17] Vietnam is the largest global supplier of *pangasius*, or catfish, producing 1.3 million tons in 2018,[18] all farmed in the Mekong region, with associated export revenues exceeding USD 2 billion for the first time in 2018. These commodities, and therefore this region, play a critical role in Vietnam's economic growth, food security, and nutrition outcomes.

Both rice and aquaculture production in the Mekong Delta stand to be heavily impacted by climate change. According to the ND-Gain Index, Vietnam is ranked 97th globally in terms of its vulnerability versus readiness to adapt to climate change. A sea-level rise of 30 cm, which could occur as early as 2040, is projected to result in the loss of about 12% of the paddy rice cropping area of the Mekong Delta Province due to flooding and salinity intrusion. Temperature increases beyond thresholds during critical rice growth phases may further impact productivity.[19] Climate change is likely to lead to more crop failures, generating more food loss and waste. In 2016 severe droughts caused more than a billion tons of lost rice production and GDP growth in the sector fell below 2%, the lowest in 30 years.[20] While likely providing an adaptation solution and subsuming inundated rice paddy area, aquaculture is also projected to suffer increasing costs and damages associated with salinization and rising temperatures.[21] A reduction in production of rice or seafood would threaten the livelihoods and food security of smallholder farmers in Vietnam as well as lower global food security.

FIGURE 1. Food loss and waste hotspots along the value chain in Vietnam (loss percentages occur at each stage)



Sources: CEL Consulting 2018; FAOSTAT 2011; and WB calculations.

Note 1: Wholesale and retail stage percentage accounts for hotels, restaurant, and institutions (HRI) waste as well. For rice, retail and HRI waste rates are both 5%. For catfish, a weighted average was used based on volume at each stage and associated waste rates (retail stage accounts for 75% of catfish share, with 5% waste, while HRI accounts for remaining 25% share, with 15.6% waste).

Note 2: Similarly to farmed fish, around the world, an estimated 27% of landed fish (from marine catch) is lost or wasted between landing and consumption.[22]

AGRICULTURE PRODUCTION EXACERBATES CLIMATE CHANGE IMPACTS

While both rice and aquaculture production are threatened by climate change impacts, both industries are also exacerbating the problem through their highly resource- and emissions-intensive operations. Around 33% of Vietnam's greenhouse gas emissions are generated by the agriculture sector, of which 50% is generated by methane emissions from wet paddy rice production. Aquaculture is a driving cause of mangrove clearance, which releases stored carbon dioxide upon removal and exposes the coast to erosion. Additional stress on natural resources and the environment, including land subsidence and chemical pollution in wastewater, further threatens Vietnam's aquaculture production.

Losses and waste occur at different locations along the value chain between rice and catfish. Catfish have the largest total loss rate of 32%, with the greatest losses occurring at the processing and production stages. Total rice losses hover around 21%. The total loss rates are calculated by applying the respective loss rates at each stage above to the volume that makes it past the prior stage.

Global Framework Highlights Impacts of Food Loss & Waste Interventions

Policymakers for Vietnam face competing policy goals. For example, the country may be interested in:

- Reducing food loss and waste;
- Improving farm welfare;
- Meeting increasing demand for food in urban centers;
- Sustaining export growth;
- Reducing stress on natural resources and pollution through less farm production; and
- Decreasing greenhouse gas emissions.

Given Vietnam's imperative to shift its food system to produce more from less, the country's driving policy priorities will likely be reducing environmental stress while meeting increasing demand for food in urban centers as well as sustaining export growth. To guide policy development, two types of analyses are necessary. First, what the potential of reductions in FLW is to contribute to the policy goals, and second, how alternative interventions compare in terms of their effectiveness and costs and benefits.

The Global and Conceptual Framework on Food Loss and Waste focuses on the first type of analysis—how a reduction in FLW contributes to policy goals.* The Global Framework is not a projection of how the food system will evolve with demographic and income shifts over time, but rather it provides a comparison between the current state of the food system with and without food loss and waste reduction. A detailed analysis of costs, benefits and effectiveness of alternative interventions would be the next step towards a FLW strategy. The Global Framework simulates the government's commitment of reducing food loss and waste by 50%. It then looks at where the reduction should happen to support Vietnam's key priorities of increasing food availability for urban centers as well as export growth, while reducing environmental stresses. The Framework allows for the estimation of how these reductions of losses at each stage of the food supply chain affect policy goals.**

The Framework takes initial farm sales and prices observed in the market and uses data on waste rates to infer the resulting prices and quantities at each subsequent stage of the supply chain down to the consumer level. The model derives GHG emission estimates based on emissions generated during production through the value chain as well as from

THE GLOBAL FRAMEWORK

is a model that captures the interconnected nature of food waste along the food supply chain, including at the stages of the farm (F); transportation, handling, and storage (T or THS); processor (P); retailer (R); and consumer (C). It allows for exports and imports between countries and shows the relationship between reductions in loss and waste levels at various stages of the value chain and associated impacts on prices, production, consumption, and priority policy objectives.

*Global Conceptual and Economic Framework on Food Loss and Waste, developed by the World Bank and partners, is forthcoming in 2020.

**Farmer welfare is defined as farmer net profitability, while food security is defined as household food availability.

waste generated at each stage. The different waste reduction scenarios presented in the information below reflect changes based on Vietnam's target of a 50% cut in waste rates at different points of the supply chain, and shows results for a series of policy priorities of interest, including farmer welfare (as measured by net profitability), food security and availability (as measured by net consumption prices), trade (exports), natural resource stress (as measured by farm production), GHG equivalent emissions, and total food waste. By jointly considering all stages of the supply chain and assessing impacts on several policy priorities at the same time, the model is able to provide insights on the tradeoffs that result from different food waste reduction strategies.

Finally, looking at production, consumption and trade patterns, with significant exports of both commodities, influencing global prices and availability, it is clear that Vietnam should be modeled as a large open economy.

REDUCING LOSSES & WASTE OF RICE

The results highlight conflicting policy goals of reducing food loss and waste. Reducing FLW at any stage of the value chain is positive for food security, exports, and natural resources stress. Farmer welfare, on the other hand, declines with reductions of FLW at any stage. The largest improvements in consumption are achieved with cuts in waste rates at the THS, retail, and consumer levels. With reductions of losses at every stage, farm production declines marginally (at most by -0.2%), as a result of lower farm sale prices, implying reduced stress on natural resources from lowered production. In turn, farmer welfare also decreases marginally in all reduction scenarios due to lower prices associated with more food in the system. In all loss reduction scenarios, exports of rice increase, at most by 1.7% with loss reductions at the THS level. As both local production declines and exports increase in Vietnam, this results in a lower rest of world production, increased food availability globally, and therefore a decline in overall world resource stress.

TABLE 2. Impact of reducing losses and waste of rice at different points of the value chain (open economy model)

RICE–OPEN ECONOMY MODEL

LEGEND

- Positive impact < 5%
- Positive impact ≥ 5%
- Negative impact < 5%
- Negative impact ≥ 5%
- Negligible impact < 1%
- ↑↓ Direction of impact

	Farmer Welfare	Food Security	Exports	Natural Resource Stress	GHG Emissions	Total Food Waste
50% reduction at production	↓	↑	↑	↓	↑	↓
50% reduction at THS	↓	↑	↑	↓	↑	↓
50% reduction at processor	↓	↑	↑	↓	↓	↓
50% reduction at retail	↓	↑	↑	↓	↓	↓
50% reduction at consumer	↓	↑	↑	↓	↓	↓

Greenhouse gas emissions can also increase, albeit negligibly. When a 50% reduction in losses is made at the farm level, more rice flows through from the farm to the THS and processor stages, and eventually down to the consumer. Both the farm and processor stages have relatively higher GHG emission intensities compared to other stages, thereby marginally increasing the GHG emissions (0.1% increase) when a 50% loss reduction is made at the farm level. Total food waste declines significantly with reductions at any stage along the value chain, ranging from -5% to -16%. This simulation demonstrates the viability of Vietnam's *more from less* strategy through reduced FLW for rice production, increasing food availability for domestic consumption and international export while using the same or fewer natural resources.

REDUCING LOSSES & WASTE OF CATFISH

Similarly to rice, food availability improves with reductions of losses at any stage of the catfish value chain. However, the impact of farmer welfare, exports, and natural resource stress depends on the stage of the supply chain where the reduction actually takes place. Reductions of FLW at the farm, THS, retail, and consumer levels improve farmer welfare. However, a cut of FLW at the processor level reduces farmer welfare. Exports decline marginally with the reduction of losses at the retail and consumer levels because the associated increase in catfish availability increases retail sales and consumption, and causes domestic production to decline, leading to a minimal decline in exports. Net resource stress increases in all cases, except for reductions of FLW made at the processor level. All of these impacts are very small in magnitude.

Reductions in GHG emissions is explicit for catfish, with emissions declining for reductions of losses at all stages. The greatest GHG emissions reduction is -1.38% when losses are reduced at the processor stage. In reduction scenarios at every stage of the value chain, total food waste is reduced significantly, ranging from -4 to -13%. Similarly to rice, Vietnam

TABLE 3. Impact of reducing losses and waste of catfish at different points of the value chain (open economy model)

CATFISH–OPEN ECONOMY MODEL

	Farmer Welfare	Food Security	Exports	Natural Resource Stress	GHG Emissions	Total Food Waste
50% reduction at production	↑	↑	↑	↑	↓	↓
50% reduction at THS	↑	↑	↑	↑	↓	↓
50% reduction at processor	↓	↑	↑	↓	↓	↓
50% reduction at retail	↑	↑	↓	↑	↓	↓
50% reduction at consumer	↑	↑	↓	↑	↓	↓

LEGEND

- Positive impact < 5%
- Positive impact ≥ 5%
- Negative impact < 5%
- Negative impact ≥ 5%
- Negligible impact < 1%
- ↑↓ Direction of impact

can gain more food from existing natural resource use through reductions in FLW in the catfish value chain, always increasing food availability domestically and usually providing more food for exports.

Key Loss Drivers for Rice and Catfish in Vietnam

The Global Framework suggests that interventions to reduce losses at all stages of both the rice and catfish value chains could positively impact food security, exports, and greenhouse gas emissions. Where the direction of impact is negative, the magnitude is negligible. The next broad policy thrust for the food system under the *more from less* strategy will be to improve the quality and increase the quantity of food reaching urban centers and export markets to meet domestic consumption needs and high value export targets, as well as support the booming tourism industry, including the hospitality and restaurant sectors.

FOOD SAFETY CHALLENGES—INCREASING LOSSES & WASTE

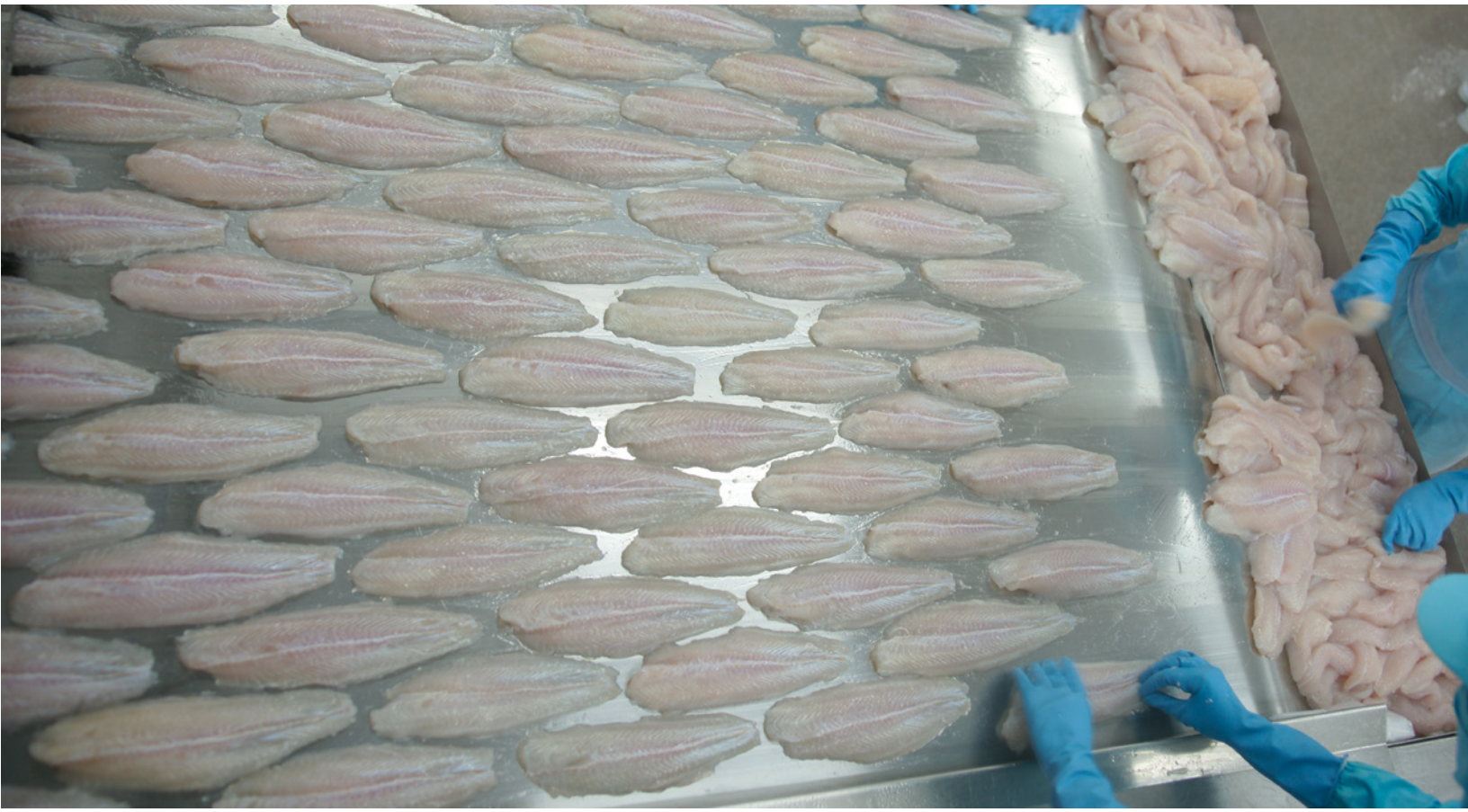
The expanding middle class in urban areas, as well as trade partners, are already demanding increased availability of higher quality food products. Vietnam is working to address its food safety challenges, which domestically impact Vietnam's major cities the most due to the diversified consumption patterns, higher incidence of out-of-home eating, higher per capita income, and the longer value chains servicing cities. Evidence of progress is limited, however, with recent studies showing that microbiological, chemical, and antibiotic contamination levels remain high in meat, vegetables, and aquaculture products.[23] Urban consumer confidence in the safety of local food is low—a 2018 survey in multiple cities found that 89% of respondents characterized local food as "unsafe".[24] Internationally, Vietnam has faced increasingly strict technical standards for its agricultural exports, with China enhancing its quality standards, while the US has continued its inspection program for catfish. Japanese and Korean markets regularly review and adjust their regulations on food safety, coupled with increased inspections, disadvantaging Vietnam's exports.[25] Both domestically and internationally, contaminated food, whether by pathogens, chemicals, or antibiotics, is leading to higher food waste levels in Vietnam—all threats to the *more from less* strategy.

Moreover, Vietnam's booming tourism industry, with over 15 million foreign visitors annually, up from only 4 million a decade ago, is further increasing the demand for high quality and safe food products, especially in urban centers. As of 2017, tourism directly accounted for 8% of GDP and was the country's single largest services export.[26] Demands from tourism, coupled with the urbanization and trade trends, signify an imperative to focus on reducing avoidable losses from quality degradation and contamination throughout the supply chain. Increasing food waste awareness for both urban dwellers, as well as the hospitality sector, is also key. This all requires certain infrastructure investments, policy changes, and capacity support for various actors along the value chain. Interventions to improve the quality of food will also have big impacts on addressing food loss and waste. For example, cooling systems, less fragmented value chains, and enforcement of food safety standards will enable Vietnam to keep a greater quantity of higher quality, safe food in the supply chain—thereby maximizing agricultural output without further compromising natural resources.

LOOKING FORWARD TO SOLUTIONS

The section below identifies some of the drivers of food loss and waste and associated policy interventions to reduce the inefficiency of Vietnam's value chain stemming from losses and waste. Early warning systems and access to real-time market information can help farmers make better planting and investment decisions, reducing risk mitigating actions that lead to overplanting and losses. Significant effort will need to focus on food safety standards, labeling, and reducing the fragmentation of the supply chain. Standards will provide information on the quality of food, increasing consumer confidence and lowering food waste from food safety concerns. Confusing or conflicting food labeling has been identified in other countries as a source of food loss and waste, and improving and regulating the food labeling process will also help consumers make better decisions around the disposal of food items.

Vietnam will also need to increase the capacity of its cold chain. The design of the cooling system needs a holistic plan, with thoughtful intervention around where investments should be made. To increase private sector participation, risk mitigation measures will need to be examined. Finally, with food waste accounting for the majority of landfill volume and releasing potent methane emissions, urban municipalities will need to invest in facilities and capacity to make more efficient use of food waste, for composting, waste-to-energy, or animal feed purposes, to meet its international and domestic greenhouse gas targets.



1. INSURANCE, FINANCING & EARLY WARNING SYSTEMS FOR FARMERS

Farmers in Vietnam, and in the Mekong Delta specifically, will face significant impacts from climate change, including salinity intrusion and droughts.[27] One of the biggest challenges for rice and aquaculture farmers is inadequate forecasting and climate data to enable better planting and investment decisions. Early warning systems can provide this critical information through digital and/or mobile phone technology, thereby enabling adaptation and reducing decision-making under uncertainty, which often leads to surplus crop and losses to hedge against unknown climate risks. Financial instruments, such as insurance, will be important to mitigate losses in farmer income due to climate impacts. As certain geographical areas become unsuitable for specific crops, farmers will need to be equipped with the capacity and financing to adapt to new climate conditions, such as planting new varieties or converting from rice production to aquaculture, which will enhance the agricultural value chain efficiency and minimize losses.

2. COOPERATIVES AND WHOLESALE TRADING CENTERS

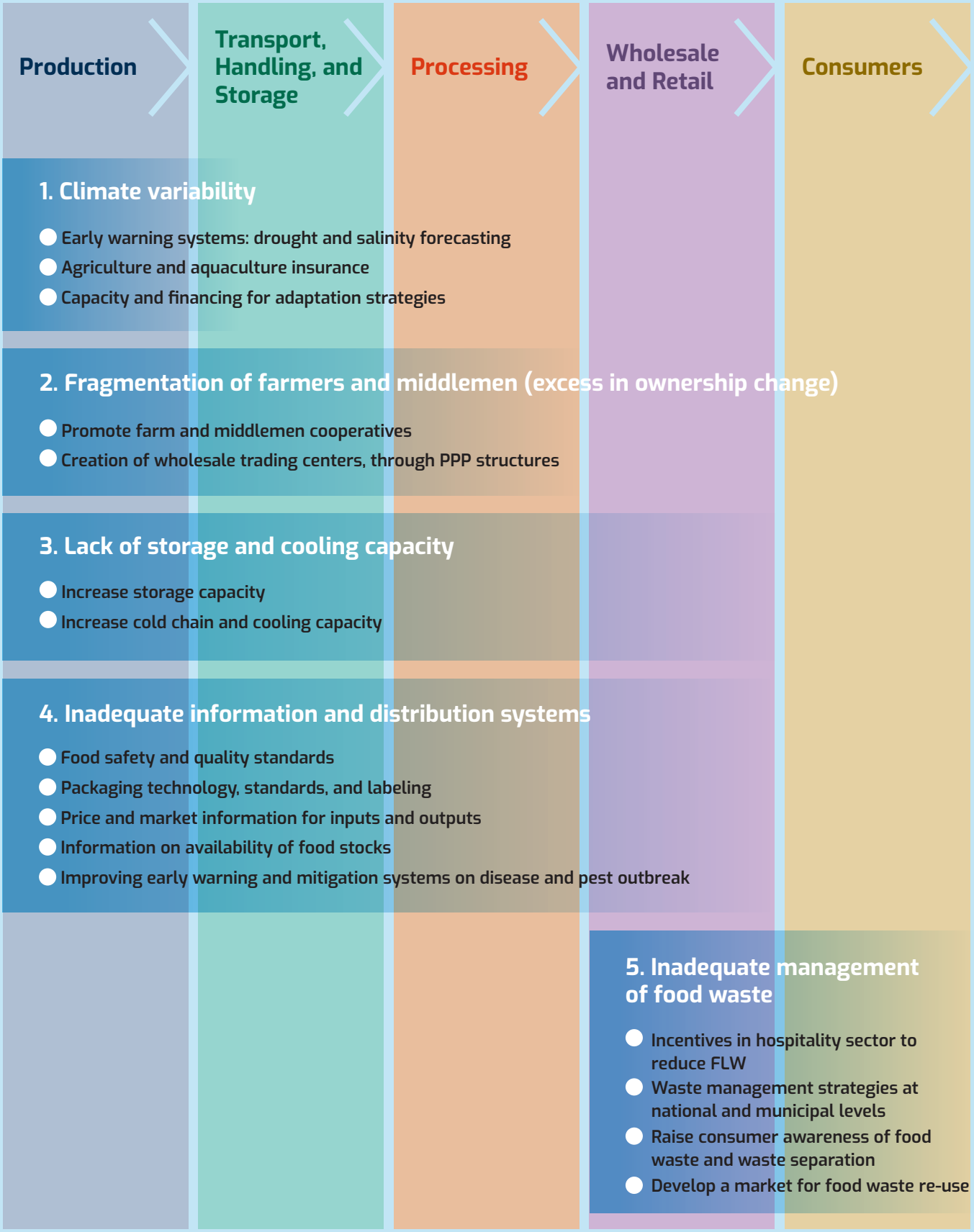
Vietnam has a fragmented agricultural and aquaculture sector. The high number of micro-farms and middlemen, who add little value to the trade, reduce the efficiency of the food system and increase food losses due to a longer supply chain with excessive transactions and changes in ownership.[28] This fragmentation also leads to more opportunities for bacterial contamination. To counteract these inefficiencies and losses, Vietnam has prioritized the formation of cooperatives, and the Ministry of Agriculture, along with the Vietnam Cooperative Alliance, set a 2020 target to ensure that at least 15,000 of over 22,000 agricultural cooperatives are operating effectively.[28] Over the last three years, between 2,000 and 2,500 cooperatives were established per year in Vietnam, and projections suggest that Vietnam will have around 60,000 cooperatives with 20 million members by 2030.[30] Despite these advances, pressing challenges to establishing highly functioning cooperatives remain: limited market access, inadequate governance and management, and underdeveloped infrastructure, among others.[31] Establishing an enabling legal framework will be crucial for farmers to gain access to loans, other financial mechanisms, and to facilitate access to wholesale trading centers and the export market. Promoting wholesale trading centers between different transactions would also improve information on demand, supply, and prices, as well as reducing the "distance" between transactions, helping reduce FLW within the trading system.

3. COOLING & REFRIGERATION ALONG VALUE CHAIN

In rural areas of Vietnam, where fish is bought at local fish markets, the supply chain is relatively short and efficient. In urban areas, however, the supply chain becomes longer, with more intermediaries exchanging the food along the way. This longer, less efficient supply chain necessitates the use of cooling and refrigeration, especially for seafood and perishables, to avoid losses due to quality degradation and food safety issues. A well-designed cold chain infrastructure, planned holistically from farm to retail or consumer, provides adequate cooling at each step of the food supply chain. This is key to preserving food quality, preventing microbial contamination, increasing shelf life, and ultimately reducing losses. In order to minimize greenhouse gas emissions from the cold chain, which could offset gains from reduced losses, it will be critical to consider the integration of cooling solutions that use renewable energy resources as well as energy efficient technologies. Vietnam's expected increase in mean temperature of 1-2˚C and a 180%

FIGURE 2. **Drivers of food loss and waste along the value chain in Vietnam for rice and catfish**

● Policy Intervention Strategy



increase in the number of heatwaves by 2050 will have a substantial impact on the demand for cold chain and cooling peak loads.[32] Around 80% of the demand for cold chains currently comes from the food sector, and this demand will be further compounded by the expected increase in food spending on perishables as well as seafood exports in the coming decades. Despite having quadrupled in the last 10 years, Vietnam's cold chain market remains fragmented, with only 14% of producers using some form of cold chain solution.[33] With high demand from seafood exports and retail, the cold chain market is more developed in the South region. About 95% of the design capacity for cold storage around Ho Chi Minh City and surrounding provinces is used for aquaculture.[34] Although the capacity of rented cold storages doubled between 2012 and 2018 to over 600,000 pallets, most of the high-quality facilities have an occupancy rate of above 90%, which maintains steep prices.[35] Likewise, refrigerated transport is still in its infancy, comprised of about 700,000 refrigerated trucks and terminal tracks, with a limited number of solid actors in the market.[36] In order to meet growing urban food and seafood export demands, Vietnam will need to continue to develop its cold chain capacity to avoid unnecessary losses and implement the *more from less* strategy.

4. STANDARDS, INFORMATION, & DISEASE OUTBREAK MITIGATION

Inadequate or unenforced standards, coupled with a lack of real-time information, increase losses and waste both at the consumer level and near the farm in Vietnam. Specifically, challenges regarding food safety standards, and unavailable pricing, market, and disease outbreak information for farmers, are leading to losses and waste in Vietnam.

1. Within the last decade, Vietnam has faced significant reputational and financial damage stemming from food safety issues, internationally with rejected exports, as well as domestically with consumers losing confidence in food. Estimates suggest that unsafe food costs Vietnam $740 million per year in productivity.[37] A portion of this impact is attributed directly to economic losses related to food products being removed from domestic or export markets, thus becoming food waste. While the government is prioritizing national food safety and quality standards in response, challenges persist and success is limited at best. Food shopping habits have remained largely traditional in nature, the penetration of supermarkets is the lowest in the region, most processing occurs locally in micro or small enterprises, and the average farm size is very small. Vietnamese consumers are concerned with chemical contaminants, such as fertilizers, pesticides, and veterinary drugs, while the prevalence of microbial contamination, such as non-typhoidal *Salmonella*, remains high. Numerous government studies have indicated residue levels of heavy metals, pesticides, and antibiotics in tested food, causing consumers to lose confidence of food safety in certified products.[38] In addition to national food safety standards, Vietnam can increase consumer confidence, and lower consumer food waste levels, through standardizing packaging and labeling with adequate enforcement. As packaging production generates greenhouse gases, in addition to often becoming waste at the end of its lifecycle, sustainable and reusable packaging options should be considered to reduce the associated environmental footprint. Studies in Vietnam show that consumers' willingness to pay for perceived safer products ranges from 10-15% for "safety-labeled free-range chicken" to 60% more for certified chemical-residue-free greens, implying the importance of trust in labeling.[39]

2. Farmers in Vietnam have limited access to real-time information on market conditions, pricing of crops, and disease and pest outbreaks. As a result, farmers hedge against these risks based on historical information instead of current conditions. This leads to surplus crop left in the field due to unfavorable economic conditions or crop failure from disease or pest epidemics. With access to early warning systems and real-time information, farmers can make informed planting, investment, and mitigation decisions to reduce avoidable losses that stem from risk hedging activities.

5. URBAN WASTE MANAGEMENT

With 36% of the population in urban areas today,[40] growing to 57% by 2050,[41] urban waste is a critical issue that Vietnam is tackling through its National Strategy of Integrated Solid Waste Management Up to 2025, Vision Towards 2050. Vietnam's large cities face food waste challenges regarding infrastructure, enforcement, and consumer awareness. In addition to the burgeoning urban population, Vietnam's tourism industry is growing significantly, accompanied by an influx of tourists that are boosting the growth of the hospitality sector, compounding municipal food waste levels that are already high from the domestic population. Large hotels in Vietnam, like in other Asian countries, are already measuring FLW and developing strategies to address it. Given the importance of the hospitality industry in Vietnam, adapting some of the successful practices of larger hotels to the myriad of smaller accommodation and restaurant units could be an effective area of focus to reduce FLW on a larger scale.

The urban waste collection system is decentralized and highly fragmented in Vietnam, coupled with minimal capacity for enforcement of regulation. In Ho Chi Minh City alone, 60% of waste collecting routes are dominated by 4,000 private sector collectors and 1,500 public sector collectors.[42] In addition, inadequate separation of food waste inhibits composting, facilities for which are largely not operating at full capacity. This is in part due to low profitability from low-quality product (due to lack of at-source separation) in conjunction with high production costs. Current biogas production in Vietnam occurs at the household scale in rural areas from husbandry byproducts. While only a few cities collect methane and other gases from dumping sites, the high proportion of food waste in landfills presents a large opportunity for waste-to-energy production in Vietnam.[43] To maximize the benefits of food waste and a circular economy approach, municipalities will also need to prioritize urban consumer awareness of food waste, not only to lower waste rates, but also to enable maximal reuse. Alongside the retail and HRI sectors, municipalities could work to further develop food donation and recycling systems that match real-time demand with excess supply. Improved waste management from fork to landfill in urban areas is necessary to ensure Vietnam meets its Paris Climate Agreement and urban centers are curbing pollution and natural resource degradation.

Inadequate or unenforced standards, coupled with a lack of real-time information, increase losses and waste both at the consumer level and near the farm in Vietnam.

Key Conclusions and Next Steps

CONCLUSIONS

- Vietnam's future food needs will be driven by a booming urban population, growth in the tourism industry, and the need to sustain exports. Rural demand for food is expected to decline. Historical gains in agricultural output came at the cost of environmental degradation and pollution, which is now an unsustainable model for Vietnam, as it has maxed out natural resources. As shown by the Global Framework, the best strategy to increase food availability for urban centers and exports through reduced FLW would be to cut FLW in half at every stage of the rice and catfish food supply chains. This will be neutral with respect to natural resources and greenhouse gas emissions.
- Since most impacts on policy goals are very small in magnitude, it is acceptable to consider a reduction of food loss and waste as neutral for farmer welfare, exports, and natural resource stress, and clearly positive in improving food availability, which matters for urban centers. While reductions in greenhouse gas emissions are evident in the case of catfish, the Framework shows that reducing losses and waste in the rice value chain is not an effective way to reduce GHG emissions because impacts are minimal or slightly negative.
- To implement this strategy, policymakers should focus on the farm to urban fork and landfill supply chain. The supply chain is currently not up to the task of delivering the high quality and quantity needed by urban centers and exports, and the policy

recommendations focus on improving its capacity and efficiency. Promising areas of intervention include (i) early warning systems for farmers to reduce climate variability risks as well as disease and pest outbreaks that lead to losses; (ii) reducing fragmentation and the associated large number of transactions that take place through effective and efficient cooperatives will mitigate losses and enable further integration into the export market; (iii) improving storage and cooling capacity, especially for perishables, will be critical to increasing both quantity and quality of food for urban centers and exports; (iv) establishing and enforcing food safety standards and labeling to ensure the delivery and availability of high quality, safe food for domestic and tourist consumption; (v) increasing consumer and hospitality industry awareness, especially in urban centers, of food waste and food waste separation, in conjunction with formalizing the food waste collection and processing will enable Vietnam's booming urban centers to more efficiently manage its massive food waste challenge, reduce methane emissions, and find productive reuses, such as for waste-to-energy or animal feed purposes.

- Vietnam's commitments under their NDC include cutting GHG emissions by 8% below business as usual between 2020 and 2030, and by up to 25% conditional on international support. Whereas the current framework for delivering on NDC targets has adaptation through agricultural interventions, addressing FLW would help Vietnam deliver both its mitigation and adaptation targets. There is room in Vietnam's NDC commitments to describe this in more detail.

NEXT STEPS

Reducing food loss and waste is a promising strategy that can contribute to key policy goals of Vietnam. While impacts on farmer welfare, exports, and natural resource stress are neutral, reductions in loss and waste always have a positive impact on food availability at a lower cost.

These results indicate that reducing food loss and waste bears potential benefits for Vietnam and identifies the tradeoffs between competing policy goals implied by reductions in waste at different stages of the supply chain. Going forward, the design of Vietnam's food loss and waste strategy should be based on a careful analysis of alternative interventions, their associated costs, benefits, feasibility of implementation, and effectiveness in reducing losses and waste, as well as the public and private investments necessary for its implementation. This could also mean conducting an analysis across a broader range of commodities as per Vietnam's interest.

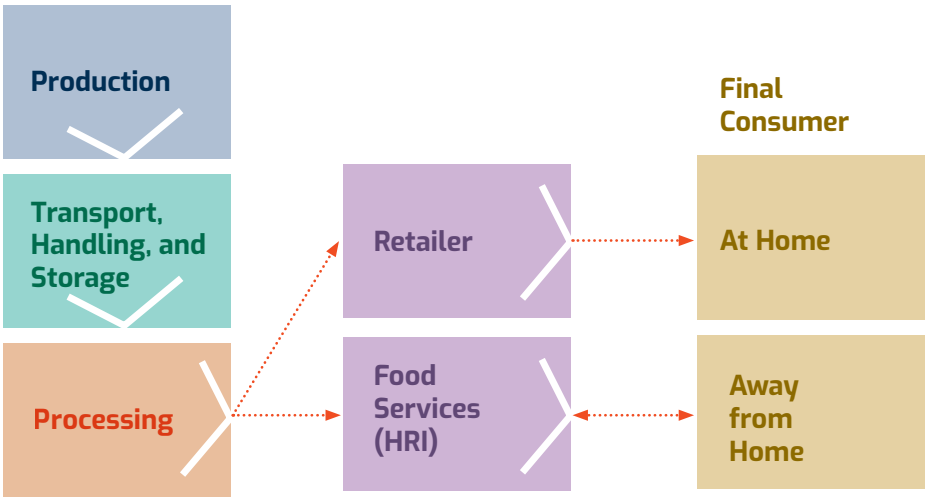
Technical Annex: Global Framework

This technical annex summarizes the analytical structure of the Global Framework. Detail is provided on the modeling approach and key assumptions, describe the calibration of the model to the status quo, outline how the model generates simulation results for the different policy scenarios, and consider impacts on total resource stress in the case of an open economy.

MODEL STRUCTURE

The length, structure, and distribution of food loss and waste rates along the food supply chain of a country have important implications for food loss and waste reduction policies.[44] The stylized model under the Global Framework captures six distinct stages in the food supply chain (see Figure 1). These include post-harvest losses at the farm level, as well as food loss and waste generated in transportation, handling and storage (THS), processing, retailing, hotels, restaurants and institutions (HRI), and at-home vs. away-from home consumption. The model highlights that interventions at one level of the chain (such as a reduction in waste rates at the retail level through improved food storage systems) can impact market prices which in turn leads to indirect effects on other stages of the supply chain. Capturing these indirect effects is critical in providing a holistic and realistic assessment of food waste reduction policies.

Figure 1: Stages of the Vertical Food Supply Chain



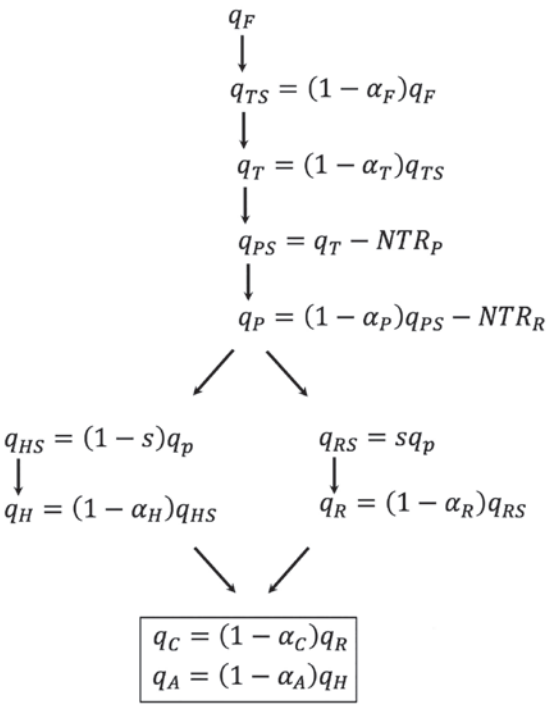
The model shows that the direction and magnitude of the indirect effects depends on the interaction of supply and demand elasticities at each level of the chain. The price elasticity of consumer demand in particular plays a key role in determining the effects of policy interventions at different stages of the supply chain. Assumptions regarding international trade are also shown to be critical. The model therefore considers three trade scenarios: a closed economy, a small open economy (in which the country exerts little influence

on world prices) and a large open economy. For the latter, the elasticity of export supply (import demand) facing the country[45] versus the elasticity of import demand (export supply) of the country[46] are found to have important implications for the changes in producer welfare after an exogenous reduction in waste rates at the farm or THS level.

STATUS QUO: CALIBRATION

The model takes as given the initial farm sales (q_F) and prices (p_F) for a given country and commodity context, and uses data on waste rates (α) to infer the resulting prices and quantities at each subsequent stage of the supply chain down to the consumer level. Figure 2 illustrates the transmission of quantities along the supply chain. For example, the quantity of food reaching THS is given by $q_{TS} = (1 - \alpha_F)q_F$, i.e. the quantity of farm sales adjusted for post-harvest losses. The model also allows for trade of pre-processed (NTR_P) and processed (NTR_P) food and takes into account the retail share which determines the split of food passing through retail versus HRI.

Figure 2: Transmission of Food Along the Supply Chain



Downstream prices are derived in a similar way, taking waste rates, disposition costs and intermediary margins into account. To capture the effect of policy interventions on GHG emissions, the model calculates the amount of total emissions from both total production and consumption (including the amount wasted), and from the disposition of waste itself.

In order to be able to run policy simulations, the model assumes functional forms for trade, farm supply and consumer demand. It also assumes that trade curves are linear while farm supply and consumer demand are of the Constant Elasticity of Substitution (CES) form. The model then calibrates these functional forms to market data for the given country and commodity setting.

POLICY SCENARIOS: SIMULATION

Margins, food loss and waste rates, disposition costs and taxes are considered exogenous in this setup and can be shocked to reflect alternative policy interventions. In line with Vietnam's commitment to reducing food waste by 50%, the main intervention of interest are policies which halve the exogenous rate of waste **(α)** at different parts of the supply chain. For each considered scenario, the Global Framework endogenously determines the resulting farm price and quantity which ensure market clearing at all stages of the supply chain and balance trade between the considered country and the rest of the world.

The model then calculates impacts on a series of outcome measures of interest including food security (as measured by effective consumption prices which represent retail prices the consumer faces adjusted for consumer waste), farmer welfare, total waste, imports and GHGEs. Crucially, by jointly taking into account all stages of the supply chain and assessing impacts on several outcome measures at the same time, the model is able to speak to the tradeoffs that result from different food waste reduction policies.

OPEN ECONOMY SCENARIO, FARMER WELFARE, AND GLOBAL RESOURCE STRESS

Under the Global Framework, the small open economy case provides a buffer against losses in producer welfare (which occur in the case of a closed economy) but increases local resource stress (as measured in the amount of farm production) in response to a reduction in farm level food loss and waste rates. However, the increase in local resource stress is partially offset by a reduction in resource stress in the rest of the world.

The effect on producer welfare is driven by the fact that a small country cannot affect world prices at the stage of the supply chain where trade occurs, which partially insulates the domestic agents against indirect effects from price changes. To illustrate the effect on the total world resource stress, consider the case of a small country importer. A reduction in farmer loss rates in this case leads to an increase in farm production (and hence local resource stress) but a reduction in imports. Since a decrease in local imports must result in an equal and offsetting reduction in exports by the rest of the world, production in the rest of the world must also decrease, which partially offsets the local resource stress. The degree to which the reduction in imports offsets the effect on total resource stress depends on relative supply/demand elasticities in the rest of the world, and on relative loss and waste rates between the local country and the rest of the world at the farm and pre-processed level.

ENDNOTES

1 World Bank (2017). *Country Partnership Framework for the Socialist Republic of Vietnam for the Period FY18-22.* Washington. URL:http://documents.worldbank.org/curated/en/173771496368868576/Vietnam-Country-partnership-framework-for-the-period-FY18-FY22

2 World Bank (2016). *Transforming Vietnamese Agriculture: Gaining More from Less.* Vietnam Development Report. Washington, D.C. URL:https://openknowledge.worldbank.org/handle/10986/24375

3 Ibid.

4 World Bank (2017).

5 United Nations (2018). *2018 Revision of World Urbanization Prospects.* Department of Economic and Social Affairs, Population Division: New York. URL:https://population.un.org/wup/

6 Ibid.

7 World Bank (2016). *Transforming Vietnamese Agriculture.*

8 Petra Schneider, Le Hung Anh, Jörg Wagner, Jan Reichenbach, and Anja Hebner (2017). *Solid Waste Management in Ho Chi Minh City, Vietnam: Moving towards a Circular Economy?* MDPI Sustainability Journal: 9, 286; doi:10.3390/su9020286

9 World Bank (2017). *Country Partnership Framework.*

10 Brun, Julien and Mattos, Roberto (2018). *The shocking reality. Food Losses in Vietnam.* CEL Consulting. URL:https://www.cel-consulting.com/single-post/2018/08/10/Food-Losses-in-Vietnam-the-shocking-reality
World Bank Open Data (2018)
World Resources Institute – WRI – CAIT Climate Data Explorer (2018). URL:https://www.wri.org/our-work/project/cait-climate-data-explorer
FAO, IFAD, UNICEF, WFP, and WHO (2020). *The State of Food Security and Nutrition in the World.* URL: http://www.fao.org/3/ca9692en/online/ca9692en.html#

11 FAOSTAT (2017). *Food and agriculture data.* URL:http://www.fao.org/faostat/en/#home

FAOSTAT (2011). *Global food losses and food waste: extent, causes, and prevention.* URL:http://www.fao.org/3/mb060e/mb060e.pdf

FAO GLOBEFISH (2019). Viet Nam pangasius farmers reap bumper profits in 2018. URL:http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/1199470/

General Statistics Office of Viet Nam (2017). Agriculture, Forestry, and Fishing indicators. URL:https://www.gso.gov.vn/default_en.aspx?tabid=778

WRI - World Resources Institute. *Food Loss and Waste Protocol.* URL:http://www.flwprotocol.org/

Henriksson PJG, Heijungs R, Dao HM, Phan LT, de Snoo GR, Guinée JB (2015). *Product Carbon Footprints and Their Uncertainties in Comparative Decision Contexts.* PLoS ONE 10(3): e0121221. https://doi.org/10.1371/journal.pone.0121221

12 CTCN – Climate Technology Centre and Network (2019). Cost-benefit assessment of mitigation options in rice production: data compilation, tools and training within the Vietnamese context. Response Plan – Terms of Reference. Hanoi, Vietnam. URL:https://www.ctc-n.org/system/files/response_plans/final_signed_response_plan_viet_nam.pdf

13 UN Comtrade Database (2017). URL:https://comtrade.un.org/db/ce/ceSearch.aspx

14 CTCN (2019).

15 World Bank (2013). *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience.* Pg. 69. A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC: World Bank.

16 General Statistics Office of Viet Nam (2017).

17 United Nations Commodity Trade Statistics Database (2017). UN Division of Statistics. URL:https://comtrade.un.org/db/ce/ceSearch.aspx

18 FAO GLOBEFISH (2019).

19 World Bank (2013).

20 Climate and Clean Air Coalition (2019). *Vietnam: CCAC Partner since 2017.* Accessed October 2019. URL:https://www.ccacoalition.org/ru/node/2172

21 World Bank (2013).

22 FAO (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. License: CC BY-NC-SA 3.0 IGO.

23 Nguyen, TN., Nguyen Thi Bich Vna, Nguyen Van Cuong, et al (2018). *Antimicrobial Residues and Resistance Against Critically Important Antimicrobials in Non-typhoidal Salmonella from Meat Sold at Wet Markets and Supermarkets in Vietnam.* International Journal of Food Microbiology.

24 Vagneron et. Al (2018). *Urban Consumer Preferences Regarding Organic and Safe and Environmentally-friendly Agro-based Products in Vietnam and Myanmar.* Asian Development Bank.

25 World Bank (2019). *Taking stock. Recent economic developments of Vietnam. Special focus: Vietnam's Tourism Developments. Stepping Back from the Tipping Point-Vietnam's Tourism Trends, Challenges, and Policy Priorities.*

26 Ibid.

27 Sotor, L., E. Simelton, B. Ole Sander and CH. Chu Thai (2016). *The drought and salinity intrusion in the Mekong River Delta of Vietnam – Assessment Report.* CGIAR Research Centers in Southeast Asia. Vietnam.

28 Brun, Julien and Mattos, Roberto (2018).

29 The Netherlands Agricultural Attaché Network (2018). *Vietnam aims to more effective agricultural cooperatives.* Ministry of Agriculture, Nature and Food Quality. URL:https://www.agroberichtenbuitenland.nl/actueel/nieuws/2018/04/18/vietnam-aims-to-more-effective-agricultural-cooperatives

30 Customs News (2019). *Enabling Legal Framework for Cooperatives' development needed.* Accessed: October 23, 2019. URL:https://customsnews.vn/enabling-legal-framework-for-cooperatives-development-needed-10454.html

31 ILO (2017). *Strengthening agricultural cooperatives in Viet Nam.* URL:https://www.ilo.org/global/topics/cooperatives/news/WCMS_545946/lang--en/index.htm

32 USAID (2017). *Climate Change Risk Profile: Vietnam.* URL:https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Vietnam%20climate%20risk%20profile.pdf

33 Brun, Julien and Mattos, Roberto (2018). *The shocking reality. Food Losses in Vietnam.* CEL Consulting.

34 FiinGroup (2019). *INFOGRAPHIC: Vietnam cold chain market 2019.* URL:http://fiingroup.vn/News/Detail/2910378

35 Stoxplus (2017). *Sector Overview: Vietnam Logistics Market 2017.* URL:https://www.amchamvietnam.com/wp-content/uploads/2017/09/StoxPlus_LOGISTICS_Amcham_Deck_final.pdf

36 FinnGroup (2019).

37 IFC (2018). IFC International Food Safety Forum. URL:https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/agribusiness/news/food+safety+forum

38 World Bank (2017). Vietnam food safety risks management: challenges and opportunities - policy note (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/157501490724011125/Vietnam-food-safety-risks-management-challenges-and-opportunities-policy-note

39 Jaffee, Steven, Spencer Henson, Laurian Unnevehr, Delia Grace, and Emilie Cassou (2019). *The Safe Food Imperative: Accelerating Progress in Low and Middle-Income Countries.* Agriculture and Food Series. Washington, DC: World Bank. doi:10.1596/978-1-4648-1345-0. License: Creative Commons Attribution CC BY 3.0 IGO

40 World Bank Open Data (2018). *Urban population.*

41 United Nations (2018).

42 Thi, N.B.D., N. T. Tuan, N.H.H. Thi. (2017). *Assessment of food waste management in Ho Chi Minh City, Vietnam: current status and perspectice.* Ton Duc University, International Journal of Environment and Waste Management. Pg. 112-113

43 P4G (2019). *Vietnam Materials Marketplace.* URL:https://p4gpartnerships.org/sites/default/files/2019-07/materials%20marketplace%20final%20report.pdf

44 "Waste" refers to both losses and waste along the value chain.

45 The country's share of the world market is a major factor determining the size of the trade elasticity facing a country.

46 The ratio of domestic production (consumption) to imports (exports) is a major factor determining the size of the trade elasticity of a country.