Factsheet:

Insights from Primary Data Collection on Rice Food Loss in Vietnam

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1. Introduction

In our work conducted from 2022 to 2024, we focused on establishing Food Loss (FL) country profiles (Axmann et al., 2024). Since Vietnam lacked primary data on FL, we generated the FL data through modelling approach. FL data were derived using a bottom-up, mass-flow model (Guo et al., 2020), which integrates production data, outputs, imports, and exports at the country level. Estimates of losses at various stages of the supply chain were adopted from Porter et al. (2016) to calculate FL across Vietnam's production and trade systems. To assess FL-associated greenhouse gas (GHG) emissions, GHG emission factors from Porter et al. (2016) were applied to calculate emissions for each supply chain stage. Based on this study (Axmann et al., 2024), a key recommendation was to implement monitoring systems and/or collect primary data for hotspot food products and chain stages. This would help identify hotspots and develop FL reduction strategies with synergies for mitigating GHG emissions and optimizing nutrition, land-use, and water footprints.

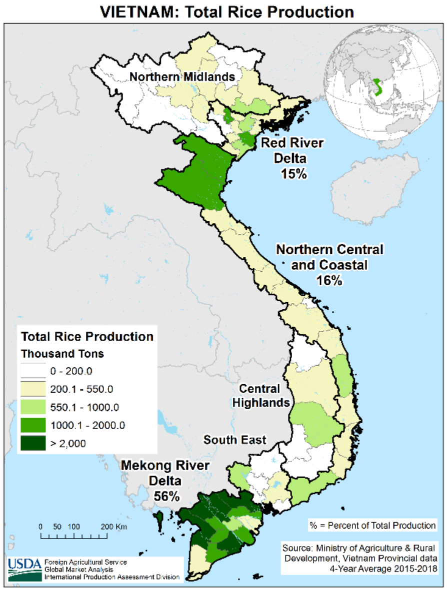
The results of this modelling study identified rice as an extremely critical food product with significant FL-related impacts, including greenhouse gas emissions, FL volumes, land use, water footprint, and protein loss. The results indicate that in Vietnam over 20% of rice produced is either lost or wasted at some point between harvest and the consumer stage. Given rice's significant impact across five key parameters, the authors chose it in 2024 as the focus of a targeted primary FL data collection initiative. This effort specifically concentrated on supply chain stages from harvesting to milling in the Mekong Delta.

This document provides a detailed exploration of the data collection methodology, the study's key findings, and their implications for policy and practice, with a particular focus on stakeholders within Vietnam's rice supply chain.

2. Approach

2.1 Data collection

For this research Cần Thơ University (CTU) in Vietnam prepared and carried out the collection of primary data. The data was collected in the Summer-Autumn period from July to September 2024. Data collection consisted of a combination of direct field measurements and interviews. Direct field measurements, to collect harvest loss (HL) and post-harvest loss (PHL) data, were conducted at 48 different farms in the Mekong Delta. Furthermore, interviews were conducted with the farmers from the same 48 farms where the field measurements were conducted, 3 operators of combined harvest machinery, 3 traders, and 4 millers. Farms, operators of combined harvest machinery, traders and millers were sampled via a network of 400 farmers (farmer club) in the Mekong Delta, which were contacted directly. The actors were sampled in the regions An Giang, Sóc Trăng, Bạc Liêu and Kiên Giang.

a) 

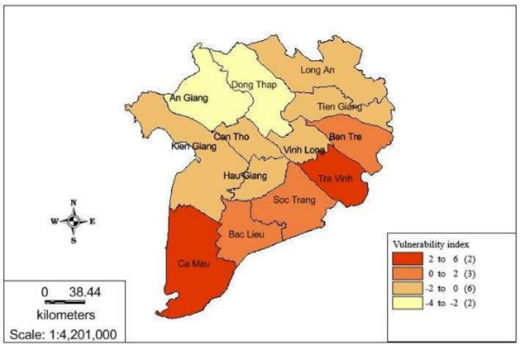
b) 

Figure 1: a) Map of rice production areas of Vietnam (Source: General Statistics office Viet Nam (2022). b) Provinces in the Mekong Delta (Source: Thuy & Anh, 2015)

The farmer interviews consisted of 128 interview questions regarding different farm- and farmer characteristics (FFC), such as seasonal calendar and production techniques, input use and yield, considerations on causes of PHL and recommendations for PHL reduction, and on-farm (P)HL rates (PHL%) (Table 1). Data on weather were not collected upfront, but (historic data) were collected later by region (or big city in region) online[1].

Questions for the operators of combined harvest machinery, traders and millers included information on company characteristics (CC): capacity, type of machinery and transportation used, PHL% estimates, thoughts on causes of PHL and potential solutions. Table 1 summarizes the type of data that was collected per actor in the supply chain

Table 1: Data collection

Farmer	Operators of combined harvest machinery	Traders	Millers
• Farmer- and farm characteristics (FFC) • On-farm (P)HL rate (PHL%) estimates • Considerations on causes and recommendations for PHL reductions • On-farm field measurement (PHL%) • Weather data[1]	• Company characteristics (CC) • PHL rate (PHL%) estimates per activity • Considerations on causes and recommendations for PHL reductions	• Company characteristics (CC) • PHL rate (PHL%) estimates per activity • Considerations on causes and recommendations for PHL reductions	• Company characteristics (CC) • PHL rate (PHL%) estimates per activity • Considerations on causes and recommendations for PHL reductions

[1] https://www.worldweatheronline.com/bac-lieu-weather-history/vn.aspx

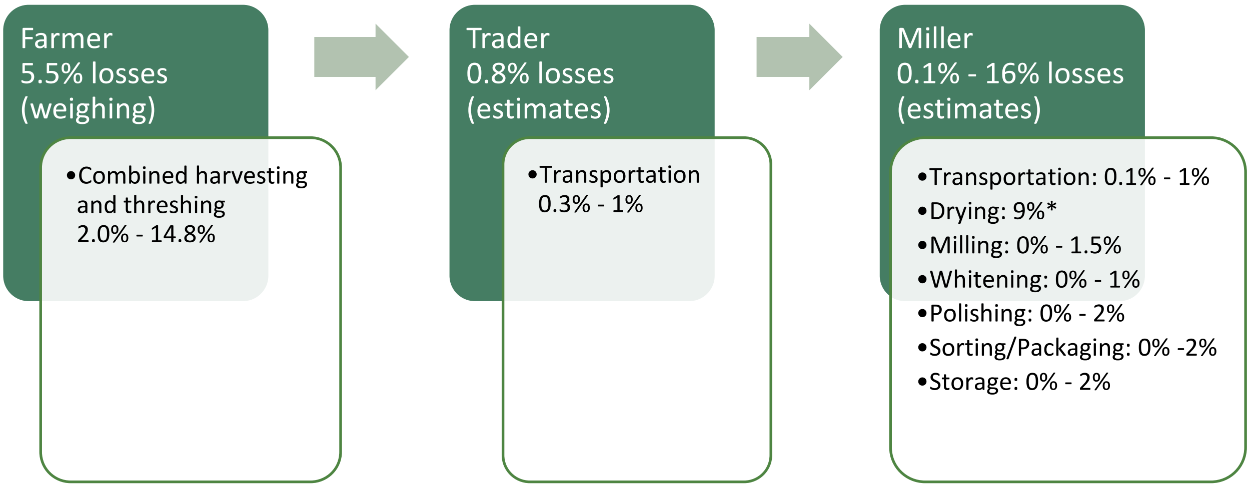
The on-field measurements were conducted by taking 3 field samples per farm, and weighing and counting the rice grains. Measurement points included before harvesting (moisture content, and rate of filled grains, unfilled grains, immature grains and damaged grains in the panicles) and after harvesting (rice grains dropped in rice straw and stubble, dropped grains in the wheel line and dropped grains in the rice straw line).

3. Results

3.1 Overview of PHL in the supply chain

Results from on-farm field measurement of (P)HL% from farmers, and the PHL% estimates provided by operators of combined harvest machinery, traders, and millers, are presented in The PHL% for the activity drying is only provided by 1 miller. The other 3 millers did not provide an estimate of the PHL% of this specific activity. It is unknown if moisture loss is included or excluded in this number.
Figure 2. Further details and analyses of causes are given in following sections.

The results from the farmers were based on the on-farm field measurements and PHL% estimates from farmers and operators of combined harvest machinery, while the results from the traders and millers were only based on PHL% estimates of the actors themselves. The PHL per activity shows the minimum and maximum values that were collected.



* The PHL% for the activity drying is only provided by 1 miller. The other 3 millers did not provide an estimate of the PHL% of this specific activity. It is unknown if moisture loss is included or excluded in this number.
Figure 2: Overview of PHL% in the rice supply chain

3.2 On-farm PHL

The quantitative on-farm field measurements showed an average PHL% of 5.5% on-farm (stdev=3.1%, n=47; one outlier was excluded from the dataset). Besides, farmers and operators of combined harvest machinery estimated the PHL% for the different seasons. The farmer estimates were in line with the quantitative field measurements (Table 2).

Table 2: PHL% at farm level in different seasons.

Season	Field measurements (N=47)	Farmer estimates	Operator of combined harvest machinery estimates
Winter-Spring		2.6%	2.9%
Summer-Autumn	5.5%	5.7%	4.4%
Autumn-Winter		3.9%	3.8%

3.3 Causes of PHL

3.3.1 Causes of PHL mentioned by the actors

Parallel on the field measurements farmers, operators of combined harvest machinery, traders and millers were asked about the causes of PHL per activity. Weather, particularly rain and flooding, was the most frequently cited cause across the supply chain. Other significant causes included poor equipment quality and operational inefficiencies. Table 3 provides all causes of PHL per activity mentioned by the different actors.

Table 3: Causes of PHL per activity

Activities	Causes
Cultivation	- Bad weather, rain and flooding (farmers & operator of combined harvest machinery) - Delayed harvesting, rice being overripe (farmers)
Harvesting	- Bad weather, rain and flooding (farmers & operator of combined harvest machinery) - Old, sparse cutting machines/ rice mixed with straw (operator of combined harvest machinery) - Fast machine operation/short cutting (farmers & operator of combined harvest machinery) - Handling of rice and tying the bags (operator of combined harvest machinery)
Transport	- Bad weather, rain or moisture (trader & Miller) - The operation of carrying and sucking rice up and down (trader & miller) - Prolonged transportation time (trader & miller) - Shaking or impact during transportation (miller) - Old or torn rice bags (miller)
Drying	- Drying process not meeting quality standards reducing rice quality (miller) - Spillage on the floor during loading/unloading from drying (miller) - Low quality of paddy rice (miller)
Milling, whitening and polishing, and sorting and packing	- Low quality of paddy rice (miller)

Storage	- Inadequate storage conditions (miller) - Low quality of paddy rice (miller) - Termites and insects (miller)

3.3.2 Analysis of variables influencing PHL at farm level

Applying a generalized linear model (since some variables are factors) in SPSS leads to the conclusion that (most likely) two extra inputs (weather related to harvest planning, harvesting speed of machine) are required to model all data simultaneously. By eliminating some of the variance in these two variables, an explained adjusted variance equal to 0,524 when predicting the reduced set of data points, which is relatively high in PHL modelling. Main inputs driving the model are type of seed, the number of days after sowing that the rice fields are drained for harvest and the amount of owned land by the farmer. Although the data set is quite small the model seems to work well and has a proper logic (Soethoudt er al., 2024).

3.4 Recommendation for reduction

The recommendation for PHL reduction per activity are provided in Table 4. Recommendations to improve the quality of the paddy, such as selecting sturdy plant varieties, use right inputs and using good farming practices were the main intervention for improving PHL during cultivation, while harvesting-, transportation and processing PHL can be reduced by selecting the right timing and settings, and using good practices and technology.

Table 4: Recommendations for PHL reduction per activity

Activities	Recommendations
Cultivation	- Select robust plant varieties and varieties suitable for each cropping season - Apply appropriate, and balanced, fertilizer dosage, including reduced nitrogen application - Apply appropriate and right amount of pesticides and fungicide (tilt) - Reduce risk of rice falling over by harden the soil - Apply alternate wetting and drying farming practice, which involves periodically draining rice fields, rather than keeping them continuously flooded.
Harvesting	- Harvest timely and determine the exact time for harvesting (morning, sunlight, dry weather) - Dry rice field before harvesting time (>10 days) - Select the best performing combine harvesters - Reduce speed of the combined harvester (cutting- and blower speed), and operate the combine harvester slowly. Adjust the settings when needed, including adjusting the blower speed of the combine harvester based on whether the rice is standing or has lodged
Transport	- Transport timely and in the morning - Contract capable transportation agencies
Drying	- Apply advanced drying technologies and dry timely
Milling	- Check and adjust the miller setting regularly

Whitening and polishing	- Distribute water and temperature appropriately, and check and adjust the polisher settings regularly
Sorting and packing	- Rice packing should be done carefully - Select good package technology
Storage	- Use good quality bags to store rice - Control insects and rodents

4. PHL impact variables

4.1 Total volume of PHL in the Mekong Delta and nationally

The total production volume of paddy rice in Vietnam is estimated at 42.7 million tons in 2022, of which 23.5 million tons (55%) is produced in the Mekong Delta (General Statistics Office Viet Nam, 2022). For the different seasons specifically, the spring- and autumn season crop are mainly produced in the Mekong Delta (Table 5).

Table 5: Production of paddy per season in the Mekong Delta and Vietnam

	Mekong Delta (million tons)	Vietnam (million tons)
Spring paddy	10.7	20.7
Autumn paddy	12.0	14.5
Winter paddy	0.9	8.2

Based on the minimum and maximum estimated and measured PHL for the summer-Autumn (autumn) crop, Winter-Spring (spring) crop and Autumn-Winter (winter) crop, the total PHL in the primary production is calculated between 1.0 – 1.1 million tons for the Mekong Delta. Assuming that all rice farms use mechanized combine harvesters in Vietnam, using the same PHL% in the other regions of Vietnam, the total PHL in the primary production sector are estimated to be between 1.6 – 1.8 million tons/year.

It is expected that the actual on-farm PHL fractions are higher than the fractions measured in this study for diverse reasons. Firstly, the farmers in this pilot all used mechanized combined harvest and threshing machinery. Farmers in the Mekong Delta are known to be mechanized, while it other areas in Vietnam this is not the case. Mechanization can reduce PHL significantly (Hien and Nghi, 2016). The same conclusion was also found in a study a study in Nigeria were they reduced PHL from 16.5% to 2% (Castelein et al., 2022). Besides, farmers with smaller rice plots cannot use these machinery properly and need to perform these activities manually. Secondly, drying of paddy is conducted off-farm in the sample of farms from the Mekong Delta. In the past, sun-drying was used, but the intensive adoption of mechanical dryers reduced the rice PHL (Hien and Nghi, 2016). Drying is currently mainly conducted by companies such as millers.

The International Production Assessment Division (IPAD) of the Foreign Agricultural Service of the USDA stated that from the total rough paddy production (42.7 million tons) is converted to 26.7 million tons milled rice, in 2022.[2] This is a volume reduction of 37%, which includes moisture loss (drying; when moisture of paddy rice is decreased by 1%, the weight of paddy rice will decrease with 1,2%[3]), separation of the paddy into white rice kernel, husk and bran (1 kg of dry rice is 0.48-0.6 kg white rice[3]), and PHL that occurred in the different activities (transportation, dying and milling). Based on the PHL%

[2] https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=VM&crop=Rice
[3] Data from interviews with millers

provided by the traders and millers in this study, the PHL volume for transportation and processing is estimated to be 5.4 million tons including drying and 1.7 million tons excluding drying in Vietnam.

In the rice supply chain, it is estimated to have a total PHL volume between 7.0 and 7.2 million ton including the estimated PHL% of drying (between 16.4% and 16.9% of total production) and between 3.3 and 3.5 million tons excluding the estimated PHL% of drying (between 7.7% and 8.3% of total production).

4.2 Translation of PHL to other impact variables

The total annual PHL in Vietnam's rice supply chain (including PHL% estimate for drying) is estimated between 7.0 – 7.2 million tons. This can be translated into other impact factors such as GHG emissions, water use, land use and protein loss. The PHL associated variables for the supply chain from production till and including processing were estimated at 7.8 – 8.0 million ton CO_2-equivalent (GHG emissions), 9.716 – 10,040 million m^3 water use, 1,159,527 – 1,198,165 hectares land use, and 537,443 – 555,352 tons protein loss (Table 6). In the Vietnam Country factsheet, the associated GHG emissions for rice and products was calculated at >12 million tons for the entire supply chain. The estimated number in the table below is from farmer till miller and is slightly lower compared with the previous results. The other impact variables are therefore also slightly lower compared to the results presented in the Vietnam country factsheet (Axmann et al., 2024). However, the off-farm PHL includes a large insecurity affected by the PHL% for the drying activity.

Table 6: Impact variables associated with PHL

	On-farm	Off-farm (till and including processing)	Off-farm (till and including processing, excluding drying)
PHL volume	1.6 – 1.8 million tons	5.4 million tons	1.7 million tons
Associated GHG emissions (in CO2-equivalent)[a]	1.8 – 2.1 million tons	6.0 million tons	1.9 million tons
Associated water use[b]	2,240 – 2,564 million m^3 (including green, blue and grey water)	7,476 million m^3 (including green, blue and grey water)	2,348 million m^3 (including green, blue and grey water)
Associated land use[c]	267,305 – 305,943 hectares	892,222 hectares	280,179 hectares
Associated protein loss[d]	123,896 – 141,805 tons	413,547 tons	129,864 tons

[a] UNFCCC, 2018
[b] Mekkonen, 2010
[c] FAOSTAT, 2022
[d] Grande et al., 2024

5. Implications for policy and practice

Building on the findings, the following actions are proposed to address key issues in the rice supply chain:

Mechanization requires adequate capacity: Mechanization is considered to contribute to loss reduction, but it requires proper and sufficient machine capacity to effectively bridge the small harvest window during rains. Ensuring this capacity is critical to minimizing PHL during challenging weather conditions.

Miller focused data collection and infrastructure upgrade: Expanding data collection efforts at the milling stage will provide critical insights into the PHL occurring at this crucial supply chain point. The current dataset, derived from only four millers via interviews, might offer a limited perspective. Simultaneously, significant PHL during drying, identified as the largest contributor, require urgent attention. Modernizing drying technologies and creating improved storage facilities should be a priority. Public-private partnerships are essential to drive these advancements, ensuring effective and sustainable solutions.

Leverage FLW reduction to support climate goals: PHL reduction can significantly contribute to achieving climate goals, such as those outlined in the Paris Agreement. Mitigating greenhouse gas emissions linked to FLW should be a central component of policy strategies.

Enhance supply chain collaboration: Cooperation among stakeholders, including farmers, traders, and millers, can enable the sharing of best practices and pooled resources to improve efficiency and resilience.

Foster regional monitoring systems for tailored solutions: PHL patterns can vary significantly across regions. Establishing localized monitoring systems will ensure targeted interventions and efficient resource allocation, optimizing results across diverse contexts.

Explore cross-crop and cross-region adaptations: The high mechanization levels for rice in Vietnam and Southeast Asia contrast with many African countries where mechanization is limited. This study, coupled with the findings from Castelein et al. (2022) in Nigeria, underscores the potential role of mechanization in reducing rice PHL. It also highlights parameters and strategies that could inform PHL reduction in other crops with similar supply chain structures, especially non-mechanized crops. The findings of this study provide preliminary insights and starting points for further research to address systemic inefficiencies and explore strategies to reduce PHL globally across diverse supply chains.

6. Conclusion

From June to September field research was carried out in the Mekong Delta by researchers from Cần Thơ University (CTU). It included interviews with farmers, traders and millers and PHL measurements at farm level.

Key takeaways from the study are:

PHL of rice in the Mekong Delta: The study measured an on-farm PHL rate of 5.5% for rice at 47 farms in the Mekong Delta. While the percentage is relatively low, the absolute volumes are substantial, contributing to high greenhouse gas emissions.

Mechanization's role in reducing PHL: Mechanization, widely adopted in the Mekong Delta, is a critical factor in achieving the low PHL rates observed. PHL during transport and processing also remain significant, with an estimated rate of 13.1% including drying and 4.1% excluding drying.

Impact of weather and operations: Weather variability and operational factors, such as the speed of harvesting machines, have significant impacts on PHL. Farmers reported that delays due to weather or suboptimal machine settings often lead to higher PHL.

Low PHL at trader stage: With a PHL rate between 0.3% and 1%, PHL at the trader stage are very low, indicating high efficiency in this part of the supply chain.

Scalability and application beyond rice: The study's methodologies and findings offer a potential framework for addressing PHL in other crops and regions, particularly in non-mechanized systems. However, further research is needed to validate these insights and tailor strategies to different contexts.

GHG implications and policy alignment: Total annual PHL in Vietnam's rice supply chain is estimated at 7.0 – 7.2 million tons, with associated GHG emissions of 7.8 – 8.0 million tons CO_2-equivalents. Addressing this PHL can play a significant role in achieving climate goals, including commitments under the Paris Agreement.

Modelling PHL%: Using Generalized Linear Modelling seems an appropriate way of predicting the PHL% of paddy rice at farm level in the Mekong Delta. Important elements in this process are on the one hand accurate and a large number of field measurements, and on the other hand very specific local knowledge. Currently, main drivers such as weather conditions in relation to harvest planning and the harvesting speed should be added to the model. If these conditions are met, the performance will increase, and the approach can be copied to other products and countries.

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Colophon

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