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GHG Baseline Study

for:

Low Carbon Rice: Reducing Climate Impact of Rice Millers in Indonesia

SWITCH-Asia

Version: 1.1

Contents

Project Overview

Project Title

SWITCH-Asia Low Carbon Rice: Reducing Climate Impact of Rice Millers in Indonesia

Project Location

Five districts in East and Central Java

1. Madiun
2. Sragen
3. Ngawi
4. Klaten
5. Boyolali

Ricefield in Indonesia (Source: ricepedia.org)
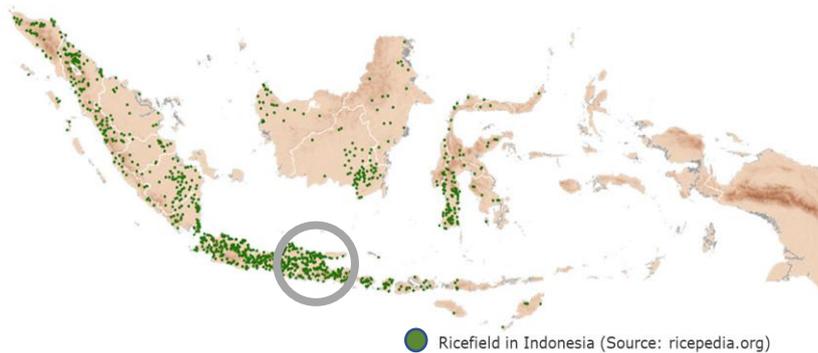
Figure 1: Location of districts in Indonesia

The mills in each district are summarized below in Table 1:

No	Rice Miller Owner	Address	Rice Mill
Madiun			
1	Yoyok K	Bongso Potro, Saradan	UD Karya Mandiri
2	Gunawan	Klumutan, Saradan	UD Sri Langgeng
3	Muh Maaruf	Lebak Ayu, Sawahan	UD Nawawi
4	Koko Supriyanti	Metesih, Jiwan	UD Aneka Usaha
5	Suparman	Kresek, Wungu	UD Berkang Abadi
6	Heri Setiawan	Tanjung Rejo, Madiun	UD Padi Murni
7	Sugiyono	Palur, Kebon Sari	UD Sempulur
8	Budi Winarto	Lembah, Delopo	UD Sinar Gani
Ngawi			
1	Kasdi	Ngale, Oraon	Kasdi
2	Sumarno Ang	Karangsari, Ngawi	UD Dewi Sri
3	Jarmi Purwadi	Kartoharjo, Ngawi	Jami Purwadi
4	Madirun		Madirun
5	Mujillah	Banjansari, Padas	Elissa Putri
6	Suyanto Wawan	Geneng, Geneng	UD Sri Mullur
7	Sugeng	Keniten, Geneng	Margo Lestari
8	Siswoyo	Guyung, Gerih	Sri Mulyo

Sragen			
1	Umar Arifudin	Craken Krebet, Masaran	Azzam Putra PT. Hadi Mulya Utama
2	Aslabar	Mlale, Jenar	Aslabar
3	Sriyati	Mlale, Jenar	Sri Rezeki
4	Puji Hastutik	Gabus, Ngrampal	Sabar Makmur
5	Nori Muhadi	Kedungupit, Sragen	Putra Pangestu
6	iin Dwi Astuti	Mojokerto, Kedawung	UD Candi Agung
7	Parmin Japar	Gabukan, Tanon	UD Lumbung padi
8	Nur Laela Permatasari	Jetak Pabrik, Sidoharjo	UD Sumber Agung
Klaten			
1	Ita Rahmawati	Ngunut, Tulung	UD Syaiful
2	Wibisono	Bero, Trcuk	UD Dadi Mulyo
3	Hanani	Kalangan, Pedan	Sarwo Makmur
4	Haryono	Karanglo, Kebonarum	UD Adi Putro
5	M Hafid Zulkarnain	Senden, Ngawen	Haidar Propatani
6	Agus Riyanto	Sorogaten, Tulung	UD Abdhol Riyanto
7	Mardini	Pandeyan, Jatinom	UD Najwa
8	Sujimin	Munggung, Karangdowo	UD Ngudi Makmur
Boyolali			
1	Retno Mardiasih	Tambak, Mojosongo	UD Tani Makmur
2	Leni Deritanti	Tambak, Mojosongo	Rumah Beras Ciansah
3	Nyndia Sulistyo	Tanjung Sari, Banyudono	UD Nyndia Karya
4	Khayatun	Tawangsari, Teras	UD Sumber Arum
5	Murbowo	Jenengan, Sawit	Koperasi APOB
6	Muhadi	Dlingo, Mojosongo	Pangudi Bogo
7	Dwi Sumino	Taangsari, Teras	CV. Songgo Langit
8	Tulus Budiono	Bangak, Banyudono	Kondang Untung

Table 1: Rice mills in each district

In the second year of the project, the implementation strategy was refined to provide consistent technical assistance to all participating rice mills while delivering customized interventions aimed at improving business operations and accelerating the adoption of low-emission processing practices. This differentiated approach was necessary because rice mills vary significantly in terms of financial capacity, operational independence, and readiness to implement emission reduction measures. Tailoring support ensured that each mill could progress effectively toward project objectives based on its specific context.

Two key categories of rice mills were defined: **(1) Leading (Unggulan) rice mills** and **(2) Aspiring (harapan) rice mills**. *Leading rice mills* are characterized by stronger financial capacity and operational independence, enabling a higher level of commitment to emission reduction initiatives. Initially, the sampling framework included two mills per

district, totaling ten mills across five districts. In the second year, this was expanded to eight mills per district, resulting in a total of forty mills across the same five districts.

Project Description

The project seeks to determine greenhouse gas (GHG) emissions from the main target group of rice millers in the above mentioned five District.

The project began with a baseline study conducted in December 2022. The baseline data was collected from the sampled rice millers. The study will end with an endline study after the study period at the end of 2024.

Project Proponents

The project is funded by the SWITCH-Asia programme, through the European Commission. This programme aims to support sustainable development, contribute to economic prosperity and poverty reduction in Asia and Central Asia, and contribute to a transition towards a low-carbon, resource-efficient and circular economy.

Preferred by Nature is the lead recipient and project co-implementer. Preferred by Nature is a non-profit organisation working to support better land management and business practices that benefit people, nature and the climate in 100+ countries.

KRKP (Koalisi Rakyat untuk Kedaulatan Pangan; People's Coalition for Food Sovereignty) is a project co-implementer and is an experienced coalition that has worked on projects related to rice issues, especially in efforts to encourage policy changes. KRKP has the capacity related to lobbying and advocacy, project management, mapping and engagement of stakeholders, and campaigns. KRKP's network and members are located in each of the five districts.

Perpadi (Perkumpulan Penggilingan Padi dan Pengusaha Beras Indonesia) ; Indonesian Rice Millers and Traders Association) is a project co-implementer and is an integrated association of rice milling and trading-type companies, with national scope of operation. It has the capacity to mobilise rice milling communities and rice traders and direct their participation in developing and expanding agricultural industrialization to create the best of business comparative studies to different countries and technical assistance to improve rice milling efficiency and management of business.

Project Methods and Plan

Guidance

The study entails a baseline inventory of greenhouse gas emissions from the rice millers. The quantification process follows guidance as detailed by the Greenhouse Gas Protocol, the GHG Protocol Corporate Accounting and Reporting Standard, and more specifically the GHG Protocol for Project Accounting.

The GHGP divides emissions into three types:

Scope 1: Direct GHG emissions from sources that are owned or controlled by millers such as combustion for process equipment.

Scope 2: Indirect GHG emissions from purchased energy, such as electricity.

Scope 3: Indirect GHG emissions either upstream or downstream as a consequence of the millers' activities.

Emission factors will be sourced as appropriate throughout the study, relevant to project location and scope.

Project Boundaries

The project includes small rice mills in the five regions. System boundaries are established through financial and operational control parameters. Therefore, all miller activities are included for which they pay fuel or own, and all other emissions included for which they have operational control. The study follows a cradle-to-gate approach, which includes all emissions from sourcing of rice to the miller's exit gate. This is to exclude any activities performed after those at the mill, such as transport to customers or packaging or processing not done at the mill.

GHG Sources

A GHG source is any process that releases GHG emissions into the atmosphere.

The five sources as listed in the GHG Protocol for Project Accounting will be followed:

I.   Combustion emissions from grid-connected electricity
II.   Combustion emission from on-site generation of energy
III. Industrial process emissions
IV.   Fugitive emissions
V.   Waste emissions

Specific to the rice sector, and contextualized to the scope and focus of the study these GHG sources can be categorized into their Scope 1, 2 and 3 categories as shown in Table 2 below:

Emission Categories	Stages
Scope 1	
Combustion of fuels for process (owned vehicles, motors, wood pellets)	Milling – Threshing, Drying, Husker, Blower, Separator, Polisher, Transport of Co-products
Scope 2	
Purchased electricity (pumps, motors, lighting)	Milling – Threshing, Weighing, Drying, Packaging
Scope 3	
Employee commuting	Milling
Emissions from by-products (if destroyed)	Milling - Separator
Purchased goods and services (plastic packaging)	Milling – Packaging

Table 2: Emission categories by scope

Data

Calculations were made using 2023 data, collected at the beginning of 2024.

Reduction Targets

After the baseline study, and after an implementation phase of two years, an endline study will be conducted. The target is to achieve 15% reduction in absolute greenhouse gas emissions over the course of the study by 2024 through reduction interventions.

The GHG Reduction will be communicated in t CO_2eq where the reduction is calculated as GHG Reduction = Σ [Baseline Emissions – Project Activity Emission Reductions].

Collection Process

The sample of rice producers will be chosen with five mills sampled in the five districts. This stratified sampling ensures each district is represented, while allowing for random sampling from the farms and mills to ensure generalizability. It follows the sampling method applied internally of $0.8* \sqrt{n}$ where n is the population being studied.

An initial data screening checklist was developed (see Appendix A) to help the different stakeholders assemble the relevant data and enter some initial figures. This then informed inputs to a detailed excel calculator, to gather the Scope 1, 2 and 3 relevant emissions data. The entire process is supported by the team's technical specialists to help the millers as they need guidance. Finally, a on-site visit to the millers will cross-check gathered data with interviews so data can be verified and validated.

All records will be stored on the project team's SharePoint folders and not made public.

Quality Control

To ensure high quality of the collected data, the project will follow the five main principles of the GHG Protocol for Project Accounting.

Relevance: ensuring data that is collected, emissions factors applied, and methods are relevant to the project scope, intended outcomes and study scope.

Completeness: all baseline and endline data is collected based on study scope and system boundaries as described.

Consistent: methods, estimations, assumptions, and data are consistent allowing for generalizable and comparative outcomes.

Transparent: ensuring that data, analysis, and calculations are clearly documented for review.

Accuracy: strive for as accurate as possible data and estimations as practical and support farmers and millers with knowledge and guidance to share accurate data

Conservativeness: when estimations or uncertainty is introduced, use conservative values to overestimate rather than underestimate carbon footprint.

Roles and Responsibilities

Project Team

Contact Person	Responsibility
Angga Maulana Yusuf amaulana@preferredbynature.org	Project Manager and Lead, Preferred by Nature
Sucipto Kusumo Saputro ssaputro@preferredbynature.org	Project Secretary, Agriculture Specialist and Technical Expert, Preferred by Nature
László Szoboszlai lszoboszlai@preferredbynature.org	Carbon Footprint Specialist, Preferred by Nature

Table 3: Project member

Calculated GHG

Total Annual Emissions by Mill

Each mill's operations data was collected for 2024 through on-site interviews. The data was summarized into Scope 1, 2 and 3 categories. There ended up being no burning of co-products, and instead all are sold to others past the gate, resulting in no emissions within scope from the co-products.

The following Table 4 summarizes the total GHG's emissions by each mill:

No	Participant	Operating time (days in a year)	Scope 1				Scope 2	Scope 3		Total Annual Emissions (kgCO2e)
			Diesel (kgCO2e)	Wood Pellets (kgCO2e)	Transport of Co Product (kgCO2e)	Oil (kgCO2e)	Electricity (kgCO2e)	Employee Commuting (kgCO2e)	Plastic Packaging	
	Madiun									
1	UD Karya Mandiri	288	8.994	8.557		-	14.995	103	4.893	**37.542**
2	UD Sri Langgeng	288	13.492	23.039		-	47.121	62	7.907	**91.621**
3	UD Nawawi	288	44.972	-		27	18.743	113	12.026	**75.882**
4	UD Aneka Usaha	288	17.989	-		264	386	578	4.516	**23.732**
5	UD Berkang Abadi	288	39.576	3.291		66	1.877	413	4.424	**49.646**
6	UD Padi Murni	300	-	34.284		-	57.593	3.438	16.380	**111.695**
7	UD Sempulur	96	-	-		-	1.599	-	988	**2.588**
8	UD Sinar Gani	96	-	4.388		27	313	28	1.471	**6.227**
	Ngawi									
1	UD Sri Wahyuni	288	19.833	-		198	1.084	330	3.294	**24.739**
2	UD Dewi Sri	144	-	9.874			6.092	96	729	**16.790**
3	Jami Purwadi	75	4.685	-		110	290	-	553	**5.638**
4	Madirun	288	-	-			31.446	99	2.476	**34.021**
5	Elissa Putri	132	65.959	9.051		792	452	-	1.495	**77.749**
6	UD Sri Mullur	288	12.592	-		330	1.084	136	4.954	**19.097**
7	Margo Lestari	96	2.998	1.097		110	6.981	34	201	**11.421**
8	Sri Mulyo	96	5.996	1.317			964	31	171	**8.479**
	Sragen									
1	Azzam Putra	288	32.380	23.039		107	8.377	445	599.040	**663.389**
2	Aslabar	168	41.974	11.520		-	1.084	1.769	54.600	**110.947**
3	Sri Rezeki	240	63.711	16.456		165	2.169	2.320	260.000	**344.822**
4	Sabar Makmur	168	-	9.600		-	22.514	301	90.922	**123.336**
5	Putra Pangestu	144	22.486	8.228		528	2.169	1.263	32.760	**67.435**
6	UD Candi Agung	144	-	8.228		-	20.949	62	46.426	**75.665**
7	UD Lumbung padi	288	53.967	23.999		330	542	516	65.520	**144.874**
8	UD Sumber Agung	168	11.543	11.520		40	361	53	10.941	**34.456**
	Klaten									
1	UD Syaiful	288	28.857	-		82	723	1.691	3.848	**35.202**
2	UD Dadi Mulyo	240	33.729	3.291		264	14.057	-	1.002	**52.344**
3	Sarwo Makmur	144	17.989	-		330	8.905	103	1.503	**28.830**
4	UD Adi Putro	192	9.594	-		528	676	138	906	**11.841**
5	Haidar Propatani	264	-	-		264	772	-	3.171	**4.207**
6	UD Abdhol Riyanto	288	12.592	-		82	772	722	5.388	**19.556**
7	UD Najwa	288	-	19.748		-	29.386	1.392	4.030	**54.556**
8	UD Ngudi Makmur	288	-	19.748		-	85.486	1.372	14.377	**120.983**
	Boyolali									
1	UD Tani Makmur	288	17.989	-		231	144	1.667	4.313	**24.344**
2	Rumah Beras Ciansah	240	26.234	-		330	723	206	2.004	**29.497**

#	Mill	Days	Diesel	Wood pellets	Transportation	oil	Electricity	Employee Commuting	Plastic packaging	Total
3	UD Nyndia Karya	288	11.693	5.266		41	1.804	413	41.184	**60.400**
4	UD Sumber Arum	288	31.481	8.426		33	757	309	1.381	**42.387**
5	Koperasi APOB	216	6.746		-	55	1.325	271	892	**9.289**
6	Pangudi Bogo	192	-	6.583		33	663	-	1.318	**8.596**
7	CV. Songgo Langit	288	24.735	6.583		33	1.807	1.733	1.797	**36.687**
8	Kondang Untung	288	17.989	-	497	198	1.807	1.083	1.095	**22.670**
	Average of Mills	226	17.569	6.928	497	151	9.975	582	32.872	68.079

Table 4: Total GHG emissions by mill

The average of mills figure is only based on data included in the scope of this study and does not seek to present an average emissions per small-medium rice mill figure that can be generalized to other mills outside of the scope of this study. It is meant to be used to compare the results of each individual mill to the average of the study. All results are in kg of CO2e annually.

There has been a clear decline in diesel use, and currently the largest emissions come from packaging of the emissions as also shown in Figure 2 below:
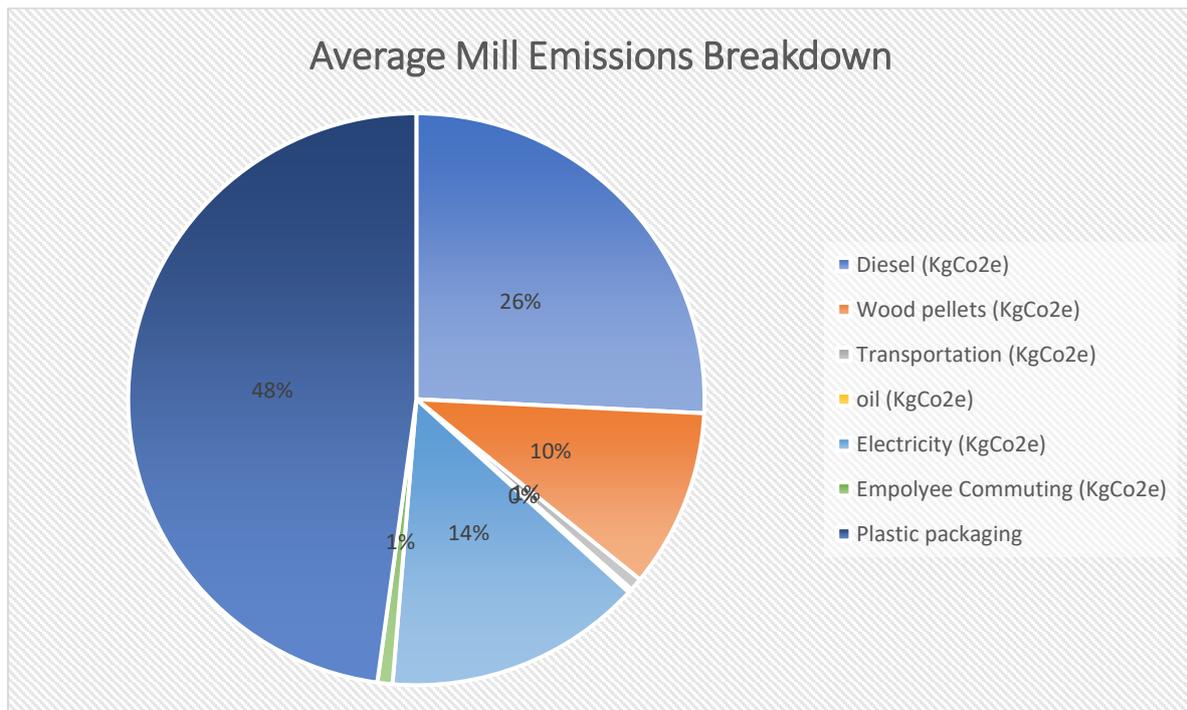
Figure 2: Average mill emissions breakdown

As different mills had differing days of operation, these annual results are not immediately comparable, and thus in the next sections the results will be summarized in terms of emissions by days of operation and emissions by a product intensity unit.

Production Process Map

The process map below shows the different steps in the rice milling operations at the various mills surveyed as part of the study:
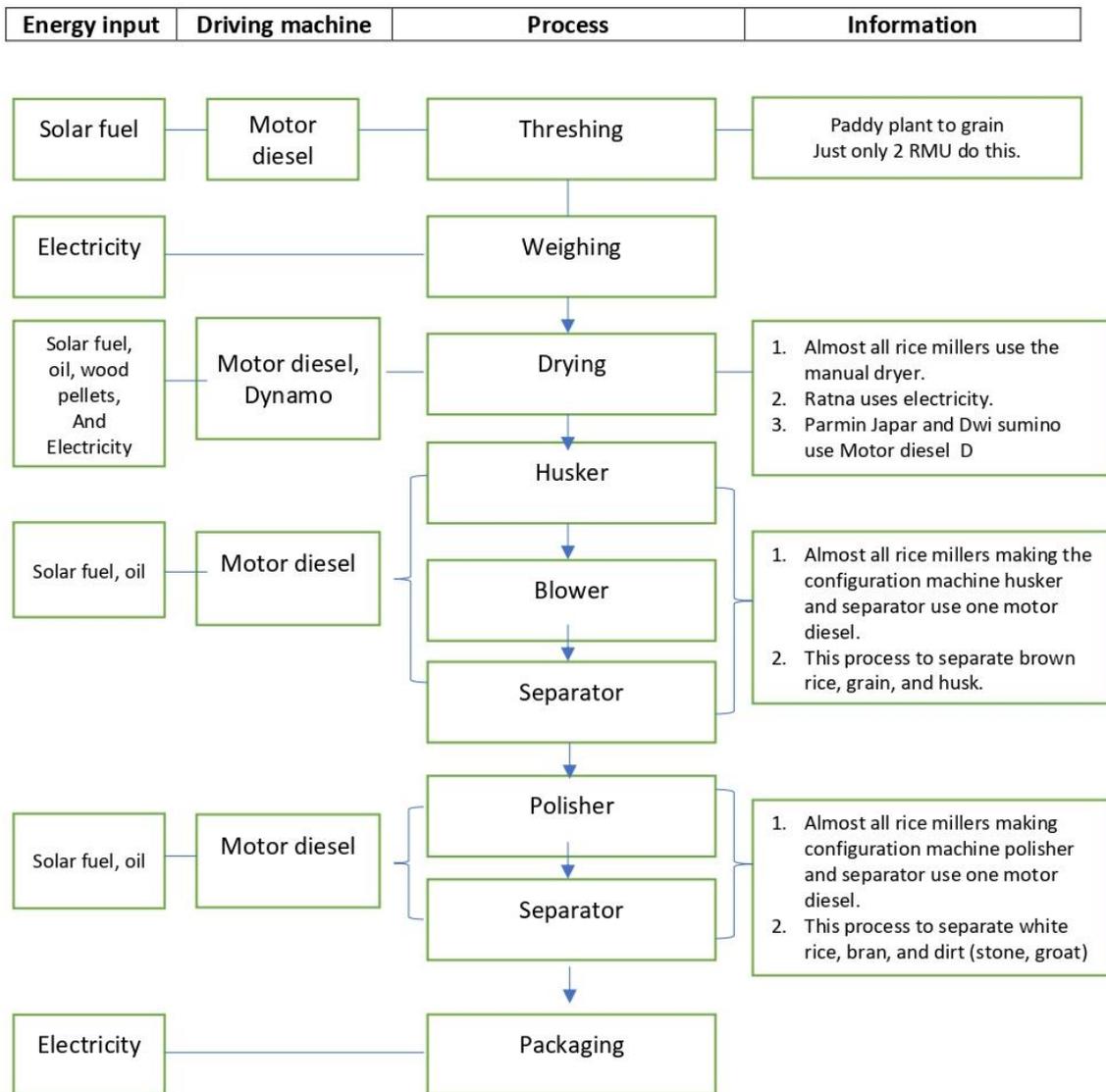
Process grain to brown / white rice

Energy input	Driving machine	Process	Information
Solar fuel	Motor diesel	Threshing	Paddy plant to grain Just only 2 RMU do this.
Electricity		Weighing	
Solar fuel, oil, wood pellets, And Electricity	Motor diesel, Dynamo	Drying	1. Almost all rice millers use the manual dryer. 2. Ratna uses electricity. 3. Parmin Japar and Dwi sumino use Motor diesel D
		Husker	
Solar fuel, oil	Motor diesel	Blower	1. Almost all rice millers making the configuration machine husker and separator use one motor diesel. 2. This process to separate brown rice, grain, and husk.
		Separator	
		Polisher	
Solar fuel, oil	Motor diesel	Separator	1. Almost all rice millers making configuration machine polisher and separator use one motor diesel. 2. This process to separate white rice, bran, and dirt (stone, groat)
Electricity		Packaging	

Figure 3: Production process map

It is notable that all mills use diesel motors for their processes. Drying is done manually by all except one mill. Electricity is therefore only used for some lower intensity work such as weighing, packaging and lighting of the mills.

Emissions by Functional Unit of Product and Day of Operation

The following Table 5 shows the emissions per kg of rice produced (kgCO2e/kg of total rice) combining the amount of brown and white rice at the various mills. Therefore, the functional unit in this study is 1 kg of rice processed at the mill. As the co-products (husk, bran, groat) are not destroyed but instead sold to others past the 'gate' they do not generate any emissions and are not part of the functional unit.

No	Participant	Operating time (days in a year)	White Rice (Kg/year)	Brown Rice (Kg/year)	Total Rice (Kg/year)	Emissions per kg of Rice (kgCO2e/year)
	Madiun					
1	UD Karya Mandiri	288	864.000		864.000	**0,043**
2	UD Sri Langgeng	288	2.304.000		2.304.000	**0,040**
3	UD Nawawi	288	2.880.000		2.880.000	**0,026**
4	UD Aneka Usaha	288	576.000	221.400	797.400	**0,030**
5	UD Berkang Abadi	288	1.008.000		1.008.000	**0,049**
6	UD Padi Murni	300		5.250.000	5.250.000	**0,021**
7	UD Sempulur	96	288.000		288.000	**0,009**
8	UD Sinar Gani	96	288.000		288.000	**0,022**
	Ngawi					
1	UD Sri Wahyuni	288	518.400	345.600	864.000	**0,029**
2	UD Dewi Sri	144	95.904		95.904	**0,175**
3	Jami Purwadi	75	112.500		112.500	**0,050**
4	Madirun	288		479.808	479.808	**0,071**
5	Elissa Putri	132		435.600	435.600	**0,178**
6	UD Sri Mullur	288		959.904	959.904	**0,020**
7	Margo Lestari	96	40.032		40.032	**0,285**
8	Sri Mulyo	96	31.968		31.968	**0,265**
	Sragen					
1	Azzam Putra	288	5.760.000		5.760.000	**0,115**
2	Aslabar	168		1.680.000	1.680.000	**0,066**
3	Sri Rezeki	240		6.000.000	6.000.000	**0,057**
4	Sabar Makmur	168		2.184.000	2.184.000	**0,056**
5	Putra Pangestu	144		1.008.000	1.008.000	**0,067**
6	UD Candi Agung	144		1.152.000	1.152.000	**0,066**
7	UD Lumbung padi	288		2.016.000	2.016.000	**0,072**
8	UD Sumber Agung	168	672.000	1.260.000	1.932.000	**0,018**
	Klaten					
1	UD Syaiful	288	648.000		648.000	**0,054**
2	UD Dadi Mulyo	240	240.000		240.000	**0,218**
3	Sarwo Makmur	144	360.000		360.000	**0,080**
4	UD Adi Putro	192	192.000		192.000	**0,062**
5	Haidar Propatani	264	924.000		924.000	**0,005**
6	UD Abdhol Riyanto	288	1.440.000		1.440.000	**0,014**
7	UD Najwa	288	864.000		864.000	**0,063**
8	UD Ngudi Makmur	288	1.728.000	2.880.000	4.608.000	**0,026**
	Boyolali					
1	UD Tani Makmur	288	864.000		864.000	**0,028**
2	Rumah Beras Ciansah	240	480.000		480.000	**0,061**
3	UD Nyndia Karya	288		1.584.000	1.584.000	**0,038**
4	UD Sumber Arum	288	252.000	252.000	504.000	**0,084**

No						
5	Koperasi APOB	216	216.000		216.000	**0,043**
6	Pangudi Bogo	192	384.000		384.000	**0,022**
7	CV. Songgo Langit	288		576.000	576.000	**0,064**
8	Kondang Untung	288		117.000	117.000	**0,194**
	Average of Mills	226	890.030	1.577.851	1.310.803	0,072

Table 5: Emissions per kg of rice produced by mill

As the above Table 5 indicates, the emissions ranged from 0.005 – 0,218 kgCO2e/kg of rice. The average comes out to be 0.072 kgCO2e/kg or rice processed at the mills.

To make the results of the mills comparable, the total annual emissions were also divided by the days each mill operates in a year. Therefore, here the unit is emissions per day of operation or kgCO2e/day in 2024. The results are shown in Table 6 below:

No	Participant	Operating time (days in a year)	Emissions (kgCO2e)	Emissions per day of operation (kgCO2e)
	Madiun			
1	UD Karya Mandiri	288	37.542	**130**
2	UD Sri Langgeng	288	91.621	**318**
3	UD Nawawi	288	75.882	**263**
4	UD Aneka Usaha	288	23.732	**82**
5	UD Berkang Abadi	288	49.646	**172**
6	UD Padi Murni	300	111.695	**372**
7	UD Sempulur	96	2.588	**27**
8	UD Sinar Gani	96	6.227	**65**
	Ngawi			
1	UD Sri Wahyuni	288	24.739	**86**
2	UD Dewi Sri	144	16.790	**117**
3	Jami Purwadi	75	5.638	**75**
4	Madirun	288	34.021	**118**
5	Elissa Putri	132	77.749	**589**
6	UD Sri Mullur	288	19.097	**66**
7	Margo Lestari	96	11.421	**119**
8	Sri Mulyo	96	8.479	**88**
	Sragen			
1	Azzam Putra	288	559.040	**2080**
2	Aslabar	168	110.947	**660**
3	Sri Rezeki	240	344.822	**1.437**
4	Sabar Makmur	168	123.336	**734**
5	Putra Pangestu	144	67.435	**468**
6	UD Candi Agung	144	75.665	**525**
7	UD Lumbung padi	288	144.874	**503**
8	UD Sumber Agung	168	34.456	**205**

	Klaten			
1	UD Syaiful	288	35.202	**122**
2	UD Dadi Mulyo	240	52.344	**218**
3	Sarwo Makmur	144	28.830	**200**
4	UD Adi Putro	192	11.841	**62**
5	Haidar Propatani	264	4.207	**16**
6	UD Abdhol Riyanto	288	19.556	**68**
7	UD Najwa	288	54.556	**189**
8	UD Ngudi Makmur	288	120.983	**420**
	Boyolali			
1	UD Tani Makmur	288	24.344	**85**
2	Rumah Beras Ciansah	240	29.497	**123**
3	UD Nyndia Karya	288	60.400	**210**
4	UD Sumber Arum	288	42.387	**147**
5	Koperasi APOB	216	9.289	**43**
6	Pangudi Bogo	192	8.596	**45**
7	CV. Songgo Langit	288	36.687	**127**
8	Kondang Untung	288	22.670	**79**

Average of Mills		226	51.495	234

Table 6: Emissions per day of operation by mill

The results here do not show any significant outliers. The average comes to 234 kgCO2e/day of operation at the mills.

In order to make the three units of measurement (total annual emissions, emissions per kg of rice, emissions per day of operation) comparable, the following Table 7 ranks each mill in the respective measured unit.

No	Participant	Total Annual Emissions (kgCO2e)	Rank	Emissions per kg of Rice (kgCO2e/year)	Rank	Emissions per day of operation (kgCO2e)	Rank	Overall Score	Overall Rank
	Madiun								
1	UD Karya Mandiri	37.542	23	0,043	17	130	21	61	19
2	UD Sri Langgeng	91.621	33	0,040	15	318	30	78	30
3	UD Nawawi	75.882	31	0,026	9	263	29	69	24
4	UD Aneka Usaha	23.732	14	0,030	12	82	11	37	10
5	UD Berkang Abadi	49.646	25	0,049	18	172	23	66	22
6	UD Padi Murni	111.695	35	0,021	6	372	31	72	26
7	UD Sempulur	2.588	1	0,009	2	27	2	5	2
8	UD Sinar Gani	6.227	4	0,022	7	65	5	16	3
	Sragen								
1	UD Sri Wahyuni	24.739	16	0,029	11	86	13	40	12

2	UD Dewi Sri	16.790	10	0,175	35	117	15	60	16
3	Jami Purwadi	5.638	3	0,050	19	75	8	30	7
4	Madirun	34.021	19	0,071	30	118	16	65	21
5	Elissa Putri	77.749	32	0,178	36	589	36	104	39
6	UD Sri Mullur	19.097	11	0,020	5	66	6	22	4
7	Margo Lestari	11.421	7	0,285	40	119	17	64	20
8	Sri Mulyo	8.479	5	0,265	39	88	14	58	14
	Ngawi								
1	Azzam Putra	663.389	40	0,115	34	2.080	40	114	40
2	Aslabar	110.947	34	0,066	28	660	37	99	36
3	Sri Rezeki	344.822	39	0,057	22	1.437	39	100	37
4	Sabar Makmur	123.336	37	0,056	21	734	38	96	35
5	Putra Pangestu	67.435	29	0,067	29	468	33	91	32
6	UD Candi Agung	75.665	30	0,066	27	525	35	92	33
7	UD Lumbung padi	144.874	38	0,072	31	503	34	103	38
8	UD Sumber Agung	34.456	20	0,018	4	205	26	50	13
	Klaten								
1	UD Syaiful	35.202	21	0,054	20	122	18	59	15
2	UD Dadi Mulyo	52.344	26	0,218	38	218	28	92	
3	Sarwo Makmur	28.830	17	0,080	32	200	25	74	27
4	UD Adi Putro	11.841	8	0,062	24	62	4	36	9
5	Haidar Propatani	4.207	2	0,005	1	16	1	4	1
6	UD Abdhol Riyanto	19.556	12	0,014	3	68	7	22	4
7	UD Najwa	54.556	27	0,063	25	189	24	76	28
8	UD Ngudi Makmur	120.983	36	0,026	8	420	32	76	28
	Boyolali								
1	UD Tani Makmur	24.344	15	0,028	10	85	12	37	10
2	Rumah Beras Ciansah	29.497	18	0,061	23	123	19	60	16
3	UD Nyndia Karya	60.400	28	0,038	14	210	27	69	24
4	UD Sumber Arum	42.387	24	0,084	33	147	22	79	31
5	Koperasi APOB	9.289	6	0,043	16	43	3	25	6
6	Pangudi Bogo	14.593	9	0,038	13	76	9	31	8
7	CV. Songgo Langit	36.687	22	0,064	26	127	20	68	23
8	Kondang Untung	22.670	13	0,194	37	79	10	60	16

Table 7: Mills ranked by indicators.

In the table 7 above, mills are ranked 1 to 40 based on the three measured units. Ranks from 1-10 are in green box, 11 -20 in yellow box, 21 - 30 in red box and 31 – 40 in orange box. Finally, their three measurements are summed up for an overall score, and then ranked overall based on the three measurements. The most carbon efficient mill in this case is the Haidar Propatani mill in Boyolali and UD Sempulur mill in Ngawi, These rankings may be useful when evaluating the processes at each mill to process the rice, and in particular how effectively diesel is used.

Challenges with Validation and Verification

The original study plan included collecting data from the mills through the submission of invoices, purchase order, receipts or data collection checklists. Upon the start of the study, it became apparent that the documentation management systems in place at the mills were rudimentary. There were no formal records shown or submitted for review.

Instead, all data was collected by on-site visits, through interviews with mill managers and surveys of the sites. The checklists were therefore populated by Preferred by Nature staff who had interviewed the stakeholders at the mills. This meant that the results could not be verified through the audit of recorded data. It is for this reason, one finding of this study is that mill managers should work to improve on their document and record management systems. By having more detailed records, the data quality can improve. Improved measurement may lead to improved management of processes and better comparison of intervention measures to a baseline scenario.

Next Steps

Upon completion of the baseline study, a variety of intervention measures are to be proposed and implemented by the project leaders. These intervention measures will be monitored and finally an endline study will be conducted at the end of 2025 to measure any changes in greenhouse gas emissions as a result of the intervention measures.

Appendix A: Checklist for Initial Data Collection

Preferred by Nature
Carbon Footprint Checklist

For Rice Millers in Central and Eastern Java

Instruction: This checklist serves to help collect the basic information of milling practices to allow for accurate data collection. The checklist is then meant to serve as a pre-assessment tool for a more detailed data collection phase. A data collection calculator Excel file sent separately will allow each entity to enter their relevant details to calculate their Scope 1, 2 and 3 carbon emissions.

Carbon Footprint Checklist	
Husk Management	How is the by-product husk managed (burned, sent to industry, etc)?
	Are there other by-product management practices on-site?
	What records of this management are available and how are they stored?

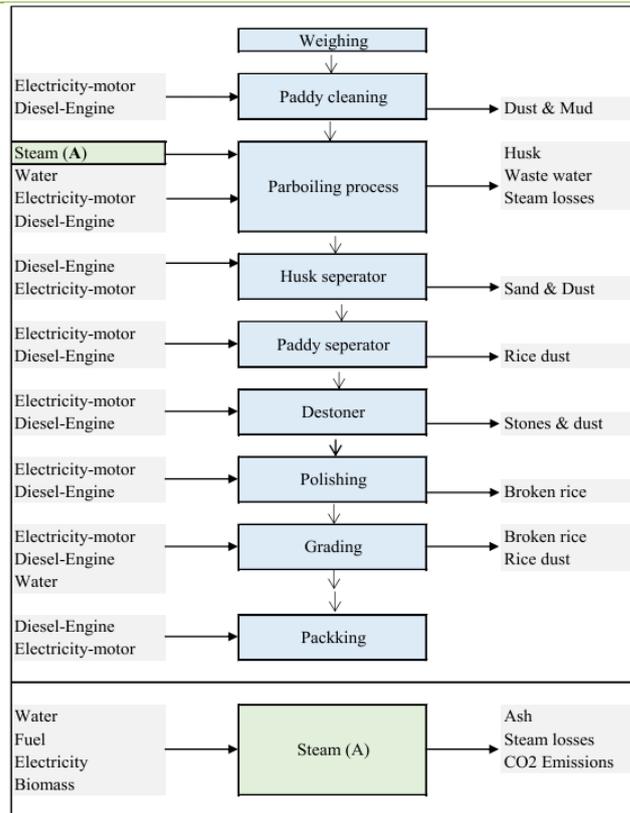|	
Milling	Please describe the steps of the milling process, and indicate where energy (fuel, steam, electricity, etc.) is used:
	Process; Energy Input
	;
	;
	;
	;
	;
	;
	;
	;
	Please see the example below:

Figure 2: Process flow diagram of rice mills

Source: Sivappirakasam, K., & Kulatunga, A. (2018). Life cycle assessment of rice processing.

What records of fuel consumption are available and how are they stored?	
How much fuel (e.g., diesel) were used in 2021:	
Are there any other fuel/energy sources on site (petrol, bioethanol, propane, solar panels, etc)?	
What records of this consumption are available and how are they stored?	
Is there any grid-supplied electricity being used?	
If yes, how many kWh used in 2021?	

	What is the grain loss rate at milling? (e.g., between 28-37%)
	What is the moisture content of the rice when it is bought?
	Is rice husk torrefaction being done at the mill? If yes, please indicate energy input.
	How is any waste handled (co-products)? Landfilled? Biomass burned? Any other uses of biomass?

Appendix B: Excel Sheet with Data Calculations

Attached Excel File with Calculations