

## Supplemental Materials: GHG basic units used for the LCA analysis

Life Cycle Assessment approach was used to understand environmental impacts of each farming system. For LCA analysis, the fuel consumption, the cost of cultivation, nitrogen input and the yields of each crop were obtained from the interviews (Table 3).

Greenhouse gas (GHG) emissions (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O) from each farming system are calculated by the total use of energy (fuels and electricity), the amounts of fertilizers, agro-chemicals and plastic wastes. CH<sub>4</sub> and N<sub>2</sub>O emissions were converted into CO<sub>2</sub> emissions by global warming potential of each gas (CH<sub>4</sub>: 21, N<sub>2</sub>O: 310).

The following items were included for LCA analysis;

- a) Agricultural materials excluding fertilizers, ago-chemicals and energy)
- b) Energy inputs (fuels and electricity)
- c) Fertilizers
- d) Agro-chemicals (herbicides and pesticides)
- e) Plastic waste
- f) GHG emissions

### (1) Direct and indirect emissions from energy

Total fuel consumption was summed up from each cultivation activities and CO<sub>2</sub> and N<sub>2</sub>O emissions were calculated.

**Table S1. GHG emission basic unit per energy**

Type of energy	unit	CO <sub>2</sub> (g)	NO <sub>x</sub> (g)
Diesel	g L <sup>-1</sup>	2619	18.3
Electricity	g kwh <sup>-1</sup>	378	0.29

### (2) CO<sub>2</sub> absorption from crops

Carbon dioxide emission was calculated by the following formula.

$$\text{CO}_2 \text{ absorption (kg)} = \text{Dry weight of the yield} \times 0.4 \times 44 / 12$$

### (3) CH<sub>4</sub> and N<sub>2</sub>O emission/ absorption from soil

CH<sub>4</sub> and N<sub>2</sub>O emissions from the crop productions were calculated by the cultivation period and the area of each farm. These GHG emissions were converted into CO<sub>2</sub> equivalent

emissions.

**Table S2. CH<sub>3</sub> and N<sub>2</sub>O emission during the grain cultivation**

	CH <sub>4</sub> emission factor gCH <sub>4</sub> m <sup>3</sup> yr <sup>-1</sup>	N <sub>2</sub> O emission factor kg kg-N <sup>-1</sup>
Rice	16	0.0067
Wheat	-0.20	0.0049

(4) GHG emission from plastic wastes

The following GHG emissions from plastic wastes that were not recycled were calculated.

**Table S3. GHG emission basic unit from plastic waste**

	CO <sub>2</sub> kg-CO <sub>2</sub> kg <sup>-1</sup>	N <sub>2</sub> O kg-N <sub>2</sub> O kg <sup>-1</sup>
Plastic waste	2.6	0.00017

(5) CO<sub>2</sub> emissions from fertilizers and agro-chemicals

CO<sub>2</sub> emissions from fertilizers and chemicals were calculated based on their costs.

**Table S4. GHG emission basic units from different type of fertilizers**

	CO <sub>2</sub> emission factor g USD <sup>-1</sup>
Single fertilizer	9
Complex fertilizer	5.9
Organic fertilizer	2.4
Agro-chemicals	3.8

The system boundary was set from land preparation to shipping adjustment (Figure 4). The assessment was based on the guideline by the manual for Life Cycle Assessment of Agricultural Practice (NARO 2003).