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## Greenhouse gas emission from freight transport-Accounting for the rice supply chain in Vietnam

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### Abstract

The freight transport related greenhouse gas emission has been increasing quickly in Vietnam. Vietnamese government is aiming for CO<sub>2</sub> reduction, which focuses on accurate definition of the contribution of different industry sectors to greenhouse gas emission. The objective of this paper is a summary of studies on transport emission factors in Vietnam and other countries in the world. As a consequence, the conclusion on emission factors currently used in Vietnam is generated. The study takes the rice industry in Vietnam as an example sector for the detailed examination of total emission. The preliminary results show that nearly 100 tons of CO<sub>2</sub> were emitted from freight movement in the rice industry in 2011, approximately 0.8% of total CO<sub>2</sub> emission borne by freight transport sector of Vietnam. Besides, modal shift from the road to inland waterway transport in the rice supply chain can bring benefits for not only the rice industry but also environmental protection.

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### 1. Introduction

Freight transport plays an increasingly important role in the socio-economic development of Vietnam. The growth rate of freight transport volume (in ton) and freight transport performance (in ton.km) is 15% and 13.3% in the period of 2001-2011, respectively [3]. The rapid growth in freight transport sector has revealed some certain limitations. In particular, a large proportion of goods are transported by road (i.e. 88% of manufactured goods). More significantly, transport sector (including freight and passenger) is accounting for 25% of total emission of Vietnam. Within the transport sector, 92% of CO<sub>2</sub> emission is originated from road transport and only about 5% from waterborne transport. So far, there have been very few specific researches on the emission (per ton.km) of freight transport modes in Vietnam. The accountings for vehicle emission are often referred to the standards of other countries and adapted for Vietnamese transport conditions.

Stemming from these above issues, the research is carried out with following objectives: (i) Conducting the literature

review on emission research in Vietnam and other countries in the world; (ii) Finding the methodology to account for emission in the Vietnamese rice supply chain.

In order to reach such objectives, a mixed methodology is adopted in this research. It consists of a literature review, surveys, observations, and quantitative analysis in Vietnamese rice supply chain. The research process starts with collecting data broadly from literature on freight transport in general and emission factors by freight transport modes in particular. Next, a field survey on the rice supply chain in the Mekong Delta (Vietnam) has been implemented to investigate rice transport volume, rice transport mode used, route choice, frequency and lead time. As a consequence, the study develops a framework for estimation of emission and applies it to calculate total amount of CO<sub>2</sub> emission of the rice supply chain.

### 2. Literature review on transport emission factors

A review on the literature has shown that, transport emission factors have been mentioned in various researches of many countries in the world. These factors are much

influenced by the transport modes (road, inland waterway, rail), and the size and age of the vehicles deployed. Specifically, the bigger the vehicle fleet, the lower emission per unit of service shall be; the older the vehicles, the more amount of fuel the vehicles use. The Netherlands is one of the first countries offer the statistic results on CO<sub>2</sub> emission factors for long distance freight transport as in Table 1.

Table1.CO<sub>2</sub> emission for long distance freight transport in the Netherlands, 2010

Type of vehicles	CO <sub>2</sub> emission factor (g/ton.km)
Truck (more than 20 tonnes)	90-120
Truck Trailers	60-80
Inland shipping (1350 tonnes)	40-70
Inland shipping (5500 tonnes)	20-40

Source: [1]

Besides, those transport modes reflect relatively small scale. CO<sub>2</sub> emission of truck (at 90-120g/ton.km) is nearly twice as that of inland shipping (40-70g/ton.km). These estimates are for the Netherlands and widely applied in European countries. Actually, the transport system in Europe is developing for long-term compared to other regions in the world. Especially, they devote considerable resources for vehicle and maintenance infrastructure. Therefore, emerging countries, Vietnam as for example, are suggested to apply higher emission factors due to low quality of vehicle and infrastructure [1]

For long-distance bulk freight transport, the emission factors for each freight transport mode are presented belows:

Table 2.CO<sub>2</sub> emission factors for long distance bulk freight transport, 2000.

Transport modes	CO <sub>2</sub> emission factors (g/ton.km)
Truck (> 20 tonnes)	60-80
Truck Trailer	50-75
Freight train (diesel)	25-50
Inland vessel (< 250 tonnes)	100-160
Inland vessel (250-400 tonnes)	45-75
Inland vessel (400-650 tonnes)	40-60
Inland vessel (650-1000 tonnes)	25-55
Inland vessel (1000-3000 tonnes)	25-50
Inland vessel (> 3000 tonnes)	15-25
Sea bulk carrier	5-15

Source: [8]

The emission data on bulk freight transport revealed the relevant practice in Vietnam. This is because the fact that bulk transport is accounting for a large proportion (76%) in total freight transport of Vietnam [9]. Apart from that, bulk cargo is mostly transported by inland waterway with relatively small scale (under 250DWT). Based on the Table 2.2, road freight emission factor is about 60-80g/ton.km and 15-160g/ton.km for inland waterborne. This figure also shows that inland shipping seems to be more effective when vessel size reaches the level of larger than 250DWT.

So far, there have been a few studies on the validation of transport emission factors for Vietnam. Among them, the laboratory of Internal Combustion Engine, Hanoi University of Technology [5] conducted emission measurement of some vehicle samples representing vehicle fleet to correct emission data in Hanoi. However, the limitation of this research is not

taking into account the real driving behaviour and traffic situation in Hanoi. Some initial results are presented in Table 3.

Following this research, trucks remain as the most serious mode with such emission into the environment as CO, HC, NO<sub>x</sub>. Only CO<sub>2</sub> emission of truck is lower than bus. It should be noted that those data are mostly collected and calculated in the urban areas, without considering the long-distance freight transport.

Table 3.Emission factors of vehicles in Hanoi, 2005

Type of vehicle	CO <sub>2</sub> emission factor (g/veh.km)	CO emission factor (g/veh.km)	HC emission factor (g/veh.km)	NO <sub>x</sub> emission factor (g/veh.km)
Motorcycle	39.6	8.72	1.7	0.34
Car	205.5	3.07	0.27	0.71
Truck	1,077.4	18	4.9	31.6
Bus	1,277.3	6.9	0.2	11.5

Source: [7]

In 2013, the World Bank has launched a preliminary estimate on the emission factors of the two dominant freight transport modes of Vietnam based on the findings of literature review and expert judgment. Especially, these factors are adapted to the specific situation of Vietnam. The detailed result is as follows:

Table 4.Estimates of CO<sub>2</sub> emission factors of freight transport modes of Vietnam

CO <sub>2</sub> emission factors	2010	2030
Average emission factor of truck (gCO <sub>2</sub> /ton.km)	110	80
Average emission factor of inland waterway (gCO <sub>2</sub> /ton.km)	71	50

Source: [1]

These data will be underlying input data for the quantitative analysis in the example sector which presents in the following section

### 3. Accounting for CO<sub>2</sub> emission in the Vietnamese rice supply chain

Vietnam is known as the second largest rice exporter in the world. Half of the Vietnamese rice is produced from the Mekong Delta, and 90% of Vietnam's rice export comes from this area. It can be said that the rice procurement and distribution in the Mekong Delta is a typical representative of the Vietnamese rice industry. In general, the freight transport infrastructure system in the Mekong Delta is dominated by two modes, inland waterway (IWT) with 58.9% and road with 34.2% [6]. The region is generously endowed with extensive networks of rivers, lakes and canals. Therefore, IWT has always been its primary mode of transportation in the region. Road transportation is mainly conducted in some arterial highways and often fragmented by canals.

The Mekong Delta has been contributing to over 50% of the total rice volume of Vietnam. There are two types of rice supply chain in the Mekong Delta: domestic and export rice

supply chain. The Fig.1 shows the relationship among key stakeholders of the rice supply chain.

After harvesting, farmers sell almost paddy (93.1%) to collectors. In the Mekong Delta, collectors are a very important and indispensable component in the rice supply chain. They often use small boats to visit the field and collect paddy/rice.

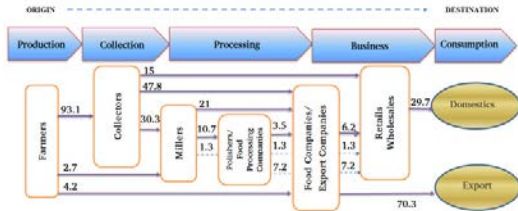


Fig.1. Rice supply chain in the Mekong Delta [4]

Collectors resell paddy/rice to millers (30.3%) for milling and polishers (47.8%) for polishing. Only 15% of total volume are processed directly by the collectors and then transported to wholesale and retail for domestic consumption. Once the rice milling and polishing process is finished, rice either is delivered to food/export companies (21% and 3.5%) or to domestic wholesales and/or retailers (1.3% and 7.2%). So far, up to 70% of rice volume in the Mekong Delta is for export, while only nearly 30% are consumed domestically.

IWT and road are considered as the main transportation modes in the rice industry. Motorcycles are used mainly for purchasing the material inputs such as fertilizers, pesticides (see Fig.2).

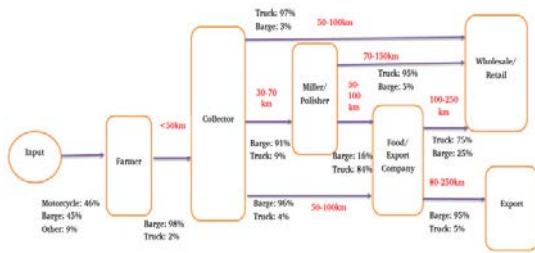


Fig.2. Transport modes used in the rice supply chain

It becomes apparent that IWT is very popular in transporting rice to export ports whereas road is primarily used to distribute rice to domestic market. Currently, the share of IWT and road transportation in the rice industry is 90% and 10%, respectively [4]. However, road transportation is forecasted to increase quickly when road infrastructure network of the Mekong Delta is improved and upgraded remarkably in the period of 2020-2030. Particularly, the change in the road modal share of the rice industry is projected as Fig.3.

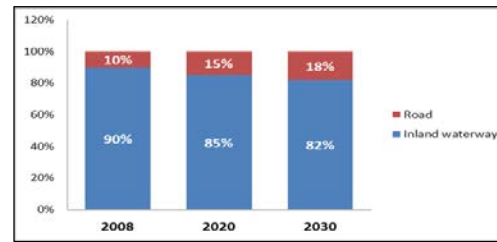


Fig.3. Freight modal share in the rice industry in the Mekong Delta [6]

Based on the detailed analysis of the rice supply chain in the Mekong Delta and estimates of freight transport emission factors given by the World Bank (2013), the study develops a framework for accounting CO2 emission of the rice industry as follows:

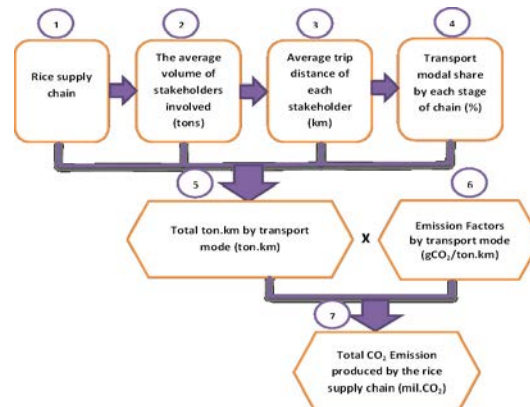


Fig.4. Accounting framework for CO2 emission in the industry

Detailed equation is presented as follows:

$$Q_E = \sum_i^n TK_i * EF_i$$

$$Q_E = \sum_i^n (Q_a * P_{(i)} * D_a) * EF_i$$

$Q_E$ : Total volume of CO2 emission

$TK_i$ : Total ton.km by transport mode i (ton.km)

$EF_i$ : Emission factors of transport mode i (g/ton.km)

$Q_a$ : Total volume of stakeholder a involved in the rice supply chain (e.g. Collectors, Millers, Polishers, Transport Companies, etc.) (Ton/year)

$P_i$ : Modal share of transport mode i (%)

$D_a$ : Average trip distance of the stakeholder a (km)

Accounting results on total CO2 emission of the rice supply chain are detailed in the Table 5. Road freight transport of the supply chain is discharging about 74,000 tonnes CO2, close to three times that of inland waterway. Totally, there are nearly 100 tons of CO2 emitted from freight movement in the rice industry in 2011, approximately 0.8% of total CO2 emission borne by freight transport sector of Vietnam [2].

Table 5. Accounting for CO2 emission in the Vietnamese rice supply, 2011

Stakeholders	Volume/stakeholder/year (tons)
Farmer	8.40
Collector	1700
Miller	4948
Polisher	1300
Transport company	3528
Wholesale	1200
Retail	240
Average trip distance	Km
Collect paddy/rice by collector	30
Distance to miller/food company	60
Local transport in the MK Delta	100
Distance from the MK Delta to HCM City	20
Emission Factors (EFs)	gCO2/ton.km
Truck	110
Inland waterway	71
CO2 produced in the rice supply chain	tons CO2
From the road transport	73944.1
From inland waterway transport	24598.7
Total	98542.8

The modal shift from road to inland waterway transport applied in the rice supply chain reveals a positive implication for reducing CO2 into the environment. In particular, when reducing the road modal share to 10%, 25% and 50%, the total CO2 emission of the whole chain also decreases to 3%, 6% and 14%, respectively. At the same time, it is assumed that the CO2 price in the world market is 15USD/ton (<http://www.vietnamplus.vn>), financial effectiveness for the rice supply chain is prone to increase in light with the reduction of road freight modal share. The detail is shown in the Table 6.

Table 6. Estimation results from freight modal shift (road to inland waterway) in the domestic rice supply chain

	Share of road transport (%)	Share of IWT transport (%)	CO2 emission reduction (tons CO2/year)	Financial efficiency of emission reduction (USD)
Current rice supply chain	70%	30%		
Reduce 10% of road transport	60%	40%	2,383	35,750

Reduce 25% of road transport	52%	48%	5,243	78,650
Reduce 50% of road transport	33%	67%	13,108	196,624

#### 4. Conclusions

The problems of freight transport system in Vietnam necessitate the studies on environmental impact assessment of this system so that to form effective freight transport management schemes. The current work of this study has contributed to review on freight transport emission researches and propose the estimation framework of the total CO2 emission in different scenario of the rice supply chain. The preliminary results show that CO2 volume emitted by the rice industry is now approximately 0.8% of total CO2 emission borne by freight transport sector of Vietnam. Especially, the modal shift from the road to inland waterway transport in the rice supply chain can bring benefits for not only the rice sector but also environmental protection

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