Chemical Use in Tidal Lowland Agriculture

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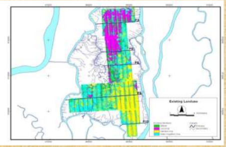
INTRODUCTION

Tidal lowland development in Indonesia aimed at supporting transmigration program and increasing rice production to compensate the conversion of irrigated farm land in Java (Suprianto et al., 2009; Schultz et al., 2005; Suriadikarta et al., 2001). After severe droughts in 1991, 1994, and 1997 which resulted in import of rice up to 4.5 million tons in each of these years, the objective of tidal lowland development has shifted from previously focused on transmigration to pushing up the productivity of rice in tidal lowlands. As a result, about 30 percent of the area suitable for rice has reached the productivity above 5 tons per ha. In addition, 10 percent of the area can be cultivated twice to three times a year. However, the negative impact of modern input use has emerged. As a consequence of chemical use, canal water which was previously used for various domestic needs is no longer safe, raising externality among farmers themselves. In addition, recent climate change that shifts planting season has increased the risk of pest and disease threats and confirmed the use of chemicals. This study aimed to investigate the use of chemicals and to consider its cost (including environmental cost) in rice production in tidal lowlands.



METHODOLOGY

- This study was carried out in Telang, a rice production center in tidal lowland area of South Sumatra, through a survey.
- Research sample of 500 farm households were randomly drawn from some 10,000 farm households, covering 12 secondary blocks (approximately 3,072 ha).
- Data were collected through field observation and structured interview.
- The effect of chemical use on rice production was analyzed using linear regression based on a Cobb-Douglas production function (Hair et al., 2010; Coelli, 1995) as the following:

$$\ln Y_i = \beta_0 + \beta_1 \ln SEED + \beta_2 \ln CHEM + \beta_3 \ln FERT + \beta_4 \ln LABOR + \beta_5 D_{WS} + \varepsilon_i$$

where *Yi* = total rice production in tons
SEED = seed used in kg
CHEM = chemical used in Rupiah
FERT = fertilizers used in Rupiah
LABOR = labor used in man days
Dws = dummy variable for 0 = without and 1 = with water service

RESULTS AND DISCUSSION

- The costs of rice cultivation were estimated based on per hectare rice cultivation in the first planting season (Table 1). The cost of pesticides accounts for 10.57 percent of the total cost. Among three types of pesticide, the cost of herbicide was the highest and accounted for 65.76 percent of total pesticide cost.

Table 1. Costs of rice cultivation per hectare in the study area

Inputs	Types of Inputs	Unit	Volume	Unit Cost (Rp)	Total Cost (Rp)
Seed	Rice seed	Kg	63.5	6,000	381,000
Pesticides	Herbicides[1]	n.a	n.a	n.a	344,770
	Insecticides[1]	n.a	n.a	n.a	72,480
	Fungicides[1]	n.a	n.a	n.a	107,000
Fertilizers	Nitrogen	Kg	220	1,300	286,000
	Phosphorus	Kg	121	2,300	278,300
	Potassium[2]	Kg	n.a	n.a	13,910
Labor	Land preparation	Man day	10	50,000	500,000
	Planting	Man day	4.5	50,000	225,000
	Fertilizing	Man day	2	50,000	100,000
	Controlling	Man day	2	50,000	100,000
	Harvesting[3]	Man day	51	50,000	2,550,000
Total					4,958,460

Notes:
1Various types with various unit (L, ml, Kg, gram, etc) such that only total cost is applied.
2Only few samples used this type of fertilizer such that average volume is not relevant.
3Consists of harvesting and threshing. Harvesting cost is in shared product with the ratio 1:7 (12.5% for labor, 87.5% for owner). Threshing cost is Rp 50 per Kg output. All of these expenses are made equivalent to man day.
n.a not applicable

- Herbicides were used during land preparation as pre-planting weeding and during growth stage as post-planting weeding. Insecticides were used incidentally according to the existence and intensity of insect attacks. Fungicides were used to control fungus and to enhance growth.
- Rice production varied from as low as 1.5 tons to as high as 79.2 tons of on-farm dried paddy due to the variation in area cultivated from as low as 0.25 hectare to as high as 12 hectares.
- The average production was 9.75 tons (standard deviation = 5.70 tons) and the average cultivation area was 1.84 hectares (standard deviation = 0.99 hectare).
- The average productivity was 5.35 tons per hectare on-farm dried paddy (standard deviation = 0.88 ton).

- Results of multiple regression analyses were presented in Table 2. The Cobb-Douglas model was robust based on the R2 statistics (Gujarati, 2003) and the overall model was statistically significant at 95 percent confidence interval.

Table 2. Regression coefficients and the value of t-test statistics

Variables	Coefficients	Std. Error	t	Sig.
(Constant)	-3.910	.212	-18.449	.000
Seed	.023	.026	.901	.368
Chemicals	.034	.018	1.828	.068*
Fertilizer	.128	.026	5.030	.000***
Labor	.782	.028	28.374	.000***
Water service (dummy variable: 0 = without; 1 = with)	.040	.013	3.026	.003***

Note:
Dependent variable is total rice production
All variables are in logarithmic, except water service.
R Square .936; F-test 57.083; Sig. of F-test .000
*Significant at 10% **Significant at 5%; ***Significant at 1%

- All coefficients are positive as expected. The coefficient of chemicals is positive and significant.
- As indicated by its coefficient, one unit increase in chemical used associated with 0.034 unit increase in rice production.
- Environmental cost of chemical use was estimated using avoidance cost (the cost of bottled water purchased to avoid contaminated canal water) which was Rp 11,520,000 per secondary block or Rp 45,000 per ha.
- This cost was expected to be recovered through the increase in production of 20 kg on-farm dried paddy per ha, assuming the price of Rp 2,250 per kg.
- This was equivalent to 0.37 percent increase in productivity, considering the average productivity was 5.35 tons per hectare.
- Based on the value of elasticity, 0.37 percent change in production was associated with 10.88 percent change in chemical use. Since the average cost of chemical use was Rp 524,250 per ha, the required change in chemical cost was Rp 57,038.
- Therefore, to recover the external cost of Rp 45,000 per ha requires Rp 57,000 additional cost of chemical per ha. This meant that the cost to recover the external cost of chemical use was higher than the externality itself.

CONCLUSION

- The use of chemical was currently unavoidable in tidal lowland rice cultivation due to present threat of pests and diseases and the increasing risk of pest and disease attacks due to the shift in planting season caused by climate change.
- Despite undervaluing the economic cost of chemical contamination in canal water, the use of avoidance cost is considered the most tangible since majority of farm households experienced this impact in tidal lowlands.
- The use of chemicals, especially herbicide, should be reduced and replaced by mechanical practice to control weed during pre and post planting.

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