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Energy use in paddy production: NKEA’S estate in MADA area

(Penggunaan tenaga dalam pengeluaran padi: Ladang NKEA di kawasan MADA)

Siti ‘Aisyah Baharudin* and Fatimah Mohamed Arshad**

Keywords: energy use, NKEA's estate, paddy production, MADA

Abstract

This study was conducted to determine the energy use in the production of paddy in NKEA’s estate in Muda Agricultural Development Authority (MADA), Malaysia for season 1/2012 – 2/2012. Data were collected through questionnaires and in-depth interviews with managers of NKEA’s estate under province I in the MADA area. The calculation of energy usage is comprised of fuel energy, human energy, fertilisers, pesticides and seed. An energy analysis of paddy production in NKEA’s estate in MADA indicates that the planting practices are largely dependent on direct seeding (75%) and transplanting (15%). The energy input-output ratio is 6.28 for the direct seeding and 6.18 for transplanting. Results show that the total energy input for transplanting (19,972.37 MJ/ha) is higher than the input used in direct seeding method (19,659.21 MJ/ha). Meanwhile, the total output for paddy production is 12,3505 MJ/ha. The study indicates that among the activities involved in the direct seeding cultivation technique, fuel energy usage is highest in land preparation (38%), followed by harvesting (25%), post-harvest (15%), crop management (14%) and planting (6%). High energy input could increase the input risk in paddy production as the increase in world oil prices has a direct impact on the domestic prices of fuel and indirect effect on fertiliser prices. These findings suggest the need to decrease dependency on energy which could be done either through efficient use of energy or utilising organic input.

Introduction

Energy is important in agriculture in terms of crop production and agro processing for value added. Human, animal and machinery are extensively used for crop production in agriculture. Energy use depends on mechanisation level, the quantity of active agricultural worker and cultivable land. Energy requirements in agriculture are divided into two groups: direct and indirect energy usage. Direct energy is essential in performing various tasks related to crop production processes such as post-harvest, land preparation, planting, crop management, irrigation, harvesting and transportation of agricultural inputs. Energy that is used directly at farms and fields are fuel, electricity and human energy. On the other hand, indirect energy consists of energy used for fertiliser, pesticides, seeds and farm machinery.

Paddy production is one of the most energy intensive production systems as reported by Singh et al. (1990). As a result of increasing world crude oil and fertiliser prices, input costs will increase.

*PhD student, Faculty Economic and Management, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor
**Faculty Economic and Management, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor
E-mail: humairay_13085@yahoo.com

The increase in input costs will reduce the use of inputs and paddy yields. On the other hand, if there is excess input usage, energy efficiency will also be reduced. Analysis on energy efficiency, which is shown by the input-output ratio, should be conducted to evaluate the economic interaction and amount of energy used. Yet, the question now is on the level of energy consumption in the paddy production process in the MADA area.

In this context, a research work was undertaken to study the pattern of energy use in the MADA area with the following objectives: (1) to analyse total energy usage in paddy production with comparison planting practices (direct seeding and transplanting technique), (2) to identify the level of energy used at different stage of paddy production, and (3) to identify the types and sources of energy in paddy production.

NKEA paddy estate

Muda Agricultural Development Authority (MADA) is the largest paddy granary area in Malaysia. It covers 125.155 ha of which nearly 96.558 ha is allocated for paddy cultivation. The area is located in the state of Kedah and Perlis, involving the Muda Irrigation Plan. It is supervised with respect to province I – IV with 27 localities or *Pertubuhan Peladang Kawasan* (PPK) (*Table 1)*. The planted zone in the MADA area represents almost 50% of the total paddy granary area (389,544 ha). MADA area contributes around 37% of total paddy production in Malaysia. In 2012, total paddy production in MADA area was 956.417 metric tonnes (t), while total rice production increased by 4.8% (28.662 t) (MADA 2012).

Economic Transformation Programme (ETP) is one of the government's efforts to transform Malaysia into a high income nation by 2020. This programme focuses on several key growth engines of the 12 National Key Economic Area (NKEA). NKEA is defined as a driver to potential economic activities that will directly and significantly contribute to Malaysia's economic growth. Paddy crop is one of agriculture sub-sectors with high growth potentials in NKEA. MADA has been directly involved with NKEA's agriculture project under the Entry Point Projects (EPP) 10: scaling and strengthening the productivity of rice cultivation in the MADA area. The main goal of this programme is to improve the average paddy yield at 8 t/ha by 2020 (MADA 2012).

NKEA paddy project was launched by MADA in October 2011, with an initial allocation of RM10.03 million (Manager, NKEA's estate in Province I, pers. comm. 2012) as the incentive payments to 2,932 farmers (group A) who participated in the NKEA for season 2/2011 covering an area of 5,016 ha. During the first year of its implementation, the farmers have achieved their gross average paddy yield of 5.091 t/ha as compared to the national average yield of 3.74 t/ha (*Table 2*).

Figure 1 shows the sequence of NKEA programme management. In addition, estate management is responsible for managing activities such as sales of paddy and

Table 1. Total farmer and estate by PPK for each province in MADA, 2012

Province	Locality	Planted area for NKEA estate (ha)	Farmer (NKEA)	Total of estate
I	5	1,101.443	724	24
II	9	1,479.695	851	46
III	6	1,124.559	697	28
IV	7	1,310.688	660	31
MADA	27 PPK	5,016.385	2,932	129

Source: PPK office for every province in MADA (2012)

Table 2. Project NKEA in PPK E-I, Province I (2012)

Locality	Farmer	Planted area		Average yield season 2/2011 (t/ha)	Average yield season 1/2012 (t/ha)
		ha	re		
Simpang Sanglang	32	75.668	262.946	6.89	7.78
Sg. Baru Timur	42	59.220	205.790	7.03	7.21
Pauh Kepala Batas	21	37.194	129.249	6.45	7.25
Banir Tembus	34	50.462	175.355	7.38	8.24
Tok Pulau	18	28.195	97.978	7.19	6.84
Total	147	250.739	871.318	6.98	7.55

Source: Interview with manager for NKEA's estate in Province I, 2012
Notes: Estate Banir Tembus get 'Best NKEA's Project Award' in 2011/2012 MADA
re = relong (1 relong = 0.3475 ha)

Figure 1. The flow of farm management system in NKEA (2012)

management of farmers' income, subsidies and incentives. MADA is responsible in making all management decisions, including the right to choose the compatible millers. On the other hand, MADA has the right to determine: i) selection of paddy seed varieties, ii) chemical control selection, iii) fertilizer selection, iv) selection of crop methods (direct seeding, transplanting), v) selection of paddy-sale (private factory/ BERNAS) and vi) management fees (*Figure 2*).

There are five MADA officers working in the NKEA's estate with different duties at hierarchical levels of land scale (i) estate manager, ii) assistant of estate manager, iii) clerk, iv) supervisor (one for each acreage of 50 ha) and v) estate worker (5 – 7 people for 50 ha). Project participants who are appointed by the PPK will be paid monthly salary in accordance to their contracts.

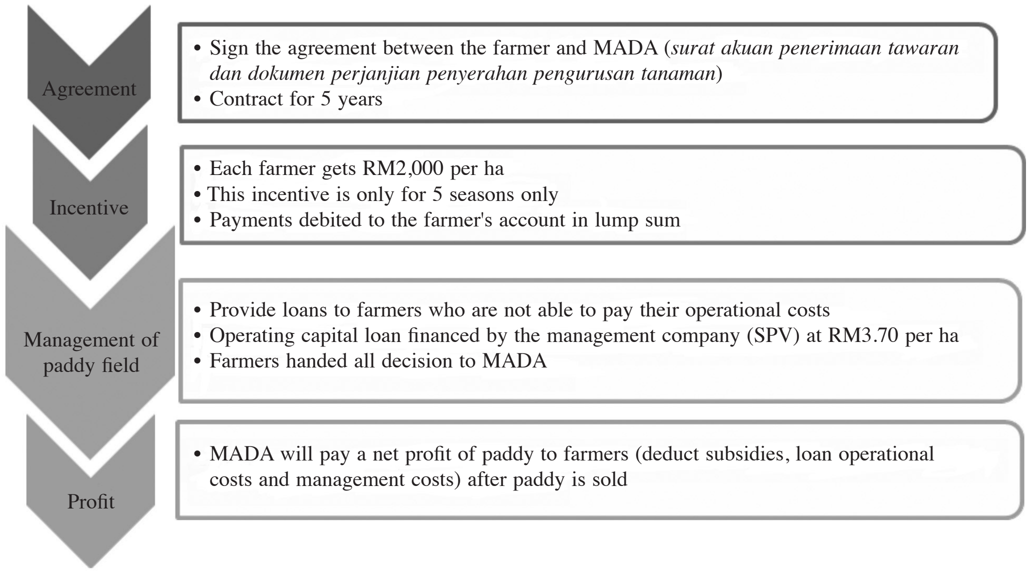
The average income for each estate member is RM6,000/ha and the average cost is RM3,000/ha. Operating cost for paddy plantation is RM3,170/ha. This cost includes the purchase of agricultural inputs (RM508/ha), land preparation (RM856/ha), labour wage (RM1,281/ha), harvesting and transportation (RM525/ha). Meanwhile, the management fee is set at RM70/t. Paddy price is RM1,050/t, in which payment for paddy sales will be made within 7 days and directly transferred into the farmers' bank accounts (interview with manager for NKEA's estate in Province I, 2012).

Methodology

Sampling

This study was conducted to determine the energy consumption in the production of paddy in the MADA area. Primary data are collected through the distribution of purposely-structured questionnaires, informal discussions and in-depth interviews with the MADA officers and NKEA estate manager for each province. The survey was carried out in selected granary areas in Perlis for the paddy production season in 2012. Field study on energy usage in the paddy production process was conducted in Province I area. The time period was based on season 1 and season 2 in 2012.

PKK will determine on the suitable paddy harvesting technique in all NKEA



Source: Interview with manager for NKEA's estate in Province I (2012)

Figure 2. *Registration process for estate paddy NKEA*

estates with the agreement from MADA. Estate is chosen based on the harvesting practice and seed choice. For this research, information on energy usage in PPK Jayadiri E-1 Simpang Empat Perlis estates under PPK's supervision was chosen as the focused NKEA paddy estate. The estate utilises direct seeding and transplanting practices, while using MR 219 seed type. The estate covers an area of 250.731 ha, equivalent to 4.4% of total paddy planting area in province E-1 (5,672 ha). A total of 147 out of 2,995 farmers (4.9%) have taken part in the project.

Energy conversion

Energy use is determined by the amount of energy input (direct and indirect) used in paddy cultivation. Direct energy use involved in this study is the fuel (petrol and diesel) and human energy. Meanwhile, indirect energy use includes fertiliser, pesticides and seeds. The input-output energy of paddy production is estimated by employing suitable conversion equivalent coefficients as shown in *Table 3*.

Energy value of paddy production is calculated by multiplying the amount of energy use with the relevant conversion factors [Modified equation from Flinn and Duff (1985)]. Unit used is Mega-Joules per hectare (MJ/ha). Output is rice yield while inputs are fuel, human energy, seed, fertilisers and pesticides such as equation (1) and (2) below;

1. Calculation for energy output (OE);

$$OE\ (MJ/ha) = Y \times EE \qquad (1)$$

Y = Rice yield (kg/ha)
EE = Rice energy equivalent (MJ/kg)

2. Calculation for energy input (IE);

$$IE = (FE \times EE) + (HE \times EE) + (TF \times EE) + (TP \times EE) + (TP \times EE) \qquad (2)$$

IE = Energy input (MJ/ha)
FE = Fuel (litre/ha)
HE = Human energy (h/ha)
TF = Fertiliser (kg/ha)
TP = Pesticide (kg/ha)
SE = Seed (kg/ha)
EE = Energy equivalent for each input (MJ)

The efficiency of energy use and net energy for paddy production were calculated as equation (3) and (4) below;

Table 3. Energy equivalents of inputs and output in paddy production

Type (unit)	Energy equivalent (MJ/unit)	Source
Output-Rice (kg)	17.00	Pishgar-Komleh et al. (2011)
Input		
1. Fuel	47.80	Pishgar-Komleh et al. (2011)
a) Diesel (litres)		
b) Petrol (litres)	46.30	Pishgar-Komleh et al. (2011)
2. Human energy	2.00	Mittal et al. (1985)
3. Fertiliser	78.10	Pishgar-Komleh et al. (2011)
a) Nitrogen (N) (kg)		
b) Phosphorus (P_2O_5) (kg)	17.40	Pishgar-Komleh et al. (2011)
c) Potassium (K_2O) (kg)	13.70	Pishgar-Komleh et al. (2011)
d) Manure (kg)	0.47	Stout (1990)
4. Pesticides	85.00	Pishgar-Komleh et al. (2011)
a) Herbicides (kg)		
b) Insecticides (kg)	229.00	Pishgar-Komleh et al. (2011)
c) Fungicides (kg)	115.00	Pishgar-Komleh et al. (2011)
d) Rodenticides (kg)	28.60	Pishgar-Komleh et al. (2011)
5. Seed (kg)	14.70	Pishgar-Komleh et al. (2011)

3. $$\text{Energy ratio} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}} \quad (3)$$

4. $$\text{Net energy} = \text{Energy output (MJ/ha)} - \text{Energy input (MJ/ha)} \quad (4)$$

Results and discussion

Paddy production in MADA area requires energy at all stages of production, with direct and indirect energy use. There are five main activities involved in the production of paddy such as land preparation (tillage and land levelling), planting (direct seeding and transplanting machinery), crop management (applying fertilisers, spraying pesticides), harvesting and post-harvest. The threshing process in the MADA area is not included in the paddy cultivation as it is done in the rice mill.

Planting of seeds can be done either by i) Direct seeding – broadcasting pre-germinated rice seeds directly into the field manually using a row seeder, or ii) Transplanting – It begins with planting 25 – 35 days seedlings into the main field by manual (human labour) or machinery (transplanter) using seedlings sown on trays.

Direct energy is used by paddy machinery through diesel and petrol usage. Meanwhile, indirect energy use occurs mainly through the production and application of fertilisers, pesticides and seeds required to improve crop yields. Energy use in the irrigation was not involved in this study because it is borne by the government.

Based on *Table 4*, fertiliser uses the highest energy level in the spread seeding and transplanting techniques at 388.5 kg/ha. This is due to the high chemical fertiliser usage among MADA farmers as compared to organic fertiliser. It is also influenced by subsidies of NPK fertiliser by the government. In terms of oil utilisation, transplanting technique consumes higher fuel at 117.23 litres/ha compared to direct seeding at 111.17 litres/ha. The same goes with human energy at 37.1 kg/ha and 44.3 kg/ha for both planting techniques. Seeds used are assumed to be of the same type, which is MR 219.

MR 219 has become the preferred choice among NKEA estates because it is cheaper and easily cultivated. On the other note, human labour is usually recruited

Table 4. Energy rate for paddy production in NKEA's estate (2012)

Planting practices	Fuel (litre/ha)	Human energy (h/ha)	Fertiliser (kg/ha)	Pesticide (kg/ha)	Seed (kg/ha)
Direct seeding	111.17	37.1	388.5	10.43	1.92
Transplanting	117.23	44.3	388.5	10.43	0.52

from Bangladesh, Thailand and Myanmar. The machine takes 1 h to do transplanting work in a 0.3475 ha area. Two machines run for 5 h each day to transplant an area of 3.475 ha.

Figure 3 and *Table 5* show the total energy consumption by activity in the paddy production in NKEA's estate in the MADA area. Crop management activities accounted for the highest percentage of energy usage at 77% of the 79% total energy used, caused by the fertilisers that are used to enhance the production of potassium (K_2O) in the MADA area which totals up to 1,528.9 MJ/ha. Findings showed that there were no apparent differences between direct seeding and transplanting techniques, both at 283.3 MJ/ha and 596.5 MJ/ha respectively. Diesel usage by the transplanter is considered as low at 12 litres/ha while human energy is 8.6 h/ha, in comparison to 6 litres/ha of diesel consumption and 1.4 h/ha human energy used in direct seeding technique.

Total energy input for paddy production in the MADA area is 19,659.21 MJ/ha for direct seeding and 19,972.37 MJ/ha for transplanting. Based on the energy sources in *Figure 4*, fuel is a major consumer of direct energy at 5,108.6 – 5,407.4 MJ/ha, because of the tractor's capacity requires a high amount of fuel to operate the production activity on the paddy field. Human energy gives lower contribution to the total direct energy use by 74.2 – 88.6 MJ/ha for both planting methods. However, fertilisers are major contributors to indirect energy consumption by 13,690.9 MJ/ha followed by pesticides (757.28 MJ/ha) and seed (28.22 MJ/ha).

The amount of paddy yield for NKEA estate was 7.265 t/ha in 2012. The total output for paddy production in MADA area was 12,3505 MJ/ha. Energy efficiency is calculated based on the ratio between total output and total input, where Soni et al. (2013) stated that the efficient energy level for the crop is between 0.21 – 13.7. It is assumed that, if the efficiency level is greater than 1, then there is excess energy in the production. The results show that the output-input ratio is 6.28 for direct seeding and 6.18 for transplanting technique. Net energy usage for both planting methods are 10,3845.79 MJ/ha and 103,532.63 MJ/ha respectively. This ratio indicates that farmers in the MADA area yield paddy at least six times more than the inputs used in the production process.

Analysis conducted by Bockari-Gevao et al. (2005) in Tanjung Karang, Selangor shows the input output ratio is 8.86, due to differences in the samples and selection of energy input in paddy production. Farm mechanisation in Thailand shows that energy efficiency is 6.5 MJ/ha (Soni et al. 2013). Meanwhile, analysis by Jiragorn (1995) shows different energy use in different planting methods (transplanting and direct seeding). Total energy input for direct seeding (69%) is higher than transplanting method (23%). Meanwhile, the total input ratio for transplanting (4.5) is higher than direct seeding (2.7). Total output ratio for rice to total input shows diminishing returns in which it decreases to 1.2 for the transplanting system and 0.3 for the direct seeding.

Iqbal (2008) studied on energy input including 12 activities from land cleaning to threshing in Bangladesh. The output-input energy ratio in respective to the activity categories are 3.6, 3.9, 4.14, 3.93, and 4.05. They find that power tiller farming is the

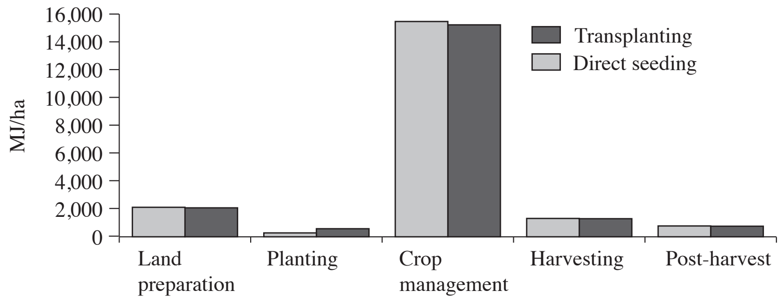


Figure 3. Energy use (MJ/ha) by activity in paddy production (2012)

Table 5. Energy use (MJ/ha) by activity in paddy production (2012)

Activity	Technique	Fuel	Human energy	Fertiliser	Pesticides	Seed	Total
Land preparation		2063.5	25.8	–	–	–	2089.3
Planting	Direct seeding	280.5	2.8	–	–	–	283.3
	Transplanting	579.3	17.2	–	–	–	596.5
Crop management		700.9	31.4	13690.9	757.28	28.22	15208.7
Harvesting		1299.2	2.8	–	–	–	1302.0
Post-harvest		764.3	11.4	–	–	–	775.7
Total	Direct seeding	5108.6	74.2	13690.9	757.28	28.22	19659.2
	Transplanting	5407.4	88.6	13690.9	757.28	28.22	19972.4

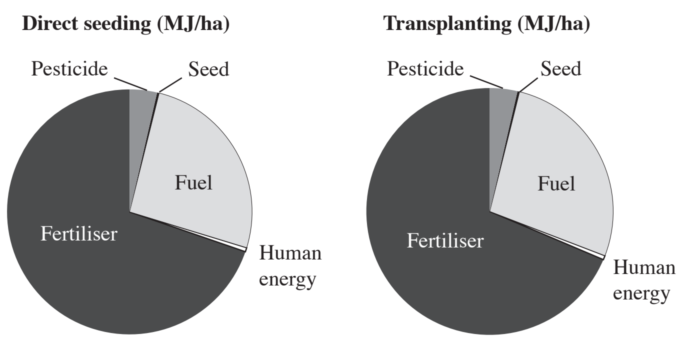


Figure 4. Direct and indirect energy use in paddy production (2012)

most efficient farming method than draft animal because of its high energy input at 4.02 MJ/ha. Another study on paddy production is proposed by Fazlollah et al. (2011). His finding shows total energy used in traditional farming is higher than the semi-mechanised farming with 67,356.28 MJ/ha and 67,217 MJ/ha respectively. Energy ratio and productivity for both systems are 3 – 3.08 and 0.111 – 0.116. Energy ratio shows a better use of input energy and more efficient in semi-mechanised farming.

Conclusion

This study is conducted to analyse energy usage in different planting practices (transplanting and direct seeding). Total energy input for transplanting is higher than direct seeding technique. Meanwhile, energy efficiency level for direct seeding is higher than those of transplanting. Fertilisers and fuel show the highest contribution towards energy usage in paddy estates in the MADA area. The use of high energy input can contribute to the input risk in paddy production as the increment in world oil prices has a direct impact on domestic prices of fuel and indirectly towards fertiliser prices. Therefore, to improve energy efficiency, several recommendations can be proposed to improve crop production without increasing the production cost. Firstly, to reduce NPK fertiliser subsidies and replace by the use of organic fertilisers. Secondly, by increasing efforts to encourage farmers to adopt proper farming practices. Thirdly, by using new machinery which can improve energy efficiency and reduce fuel consumption in paddy production. Research on farmers in MADA area needs to be conducted to identify the differences between energy efficiency levels among farmers that have joined the paddy estates and the farmers that do not join the estates.

Acknowledgement

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Abstrak
Kajian ini dijalankan untuk menentukan penggunaan tenaga dalam pengeluaran padi di kawasan estet NKEA Lembaga Kemajuan Pertanian Muda (MADA), Malaysia bagi musim 1/2012 –2/2012. Data telah dikumpulkan melalui soal selidik dan temu duga secara bersemuka dengan pengurus estet NKEA bagi wilayah I di MADA. Input dalam pengiraan penggunaan tenaga termasuk tenaga bahan api, tenaga manusia, baja, racun perosak dan benih. Analisis tenaga pengeluaran padi di estet NKEA di MADA menunjukkan bahawa amalan penanaman adalah bergantung kepada tabur terus (75%) dan mengubah (15%). Tenaga nisbah input-output adalah 6.28 untuk kaedah tabur terus dan 6.18 untuk mengubah. Hasil kajian menunjukkan bahawa jumlah input tenaga untuk mengubah (19,972.37 MJ/ha) adalah lebih tinggi daripada input yang digunakan dalam kaedah tabur terus (19,659.21 MJ/ha). Sementara itu, jumlah pengeluaran bagi pengeluaran padi ialah 123,505 MJ/ha. Hasil kajian juga menunjukkan bahawa antara aktiviti yang terlibat dalam teknik penanaman tabur terus, penggunaan tenaga bahan api adalah yang tertinggi dalam penyediaan tanah (38%), diikuti oleh penuaian (25%), lepas tuai (15%), pengurusan tanaman (14%) dan penanaman (6%). Input tenaga yang tinggi boleh meningkatkan risiko kepada penggunaan input dalam pengeluaran padi kesan kenaikan harga minyak dunia yang mempunyai kesan langsung kepada harga domestik bahan api dan kesan tidak langsung kepada harga baja. Penemuan ini menyarankan keperluan untuk mengurangkan pergantungan kepada tenaga sama ada melalui peningkatan kecekapan amalan sawah atau penggunaan input organik.