



**UNIVERSITI PUTRA MALAYSIA**

***MODELING FOR ENERGY OPTIMIZATION IN WETLAND PADDY  
PRODUCTION IN NORTH-WEST SELANGOR, MALAYSIA***

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**By**

**ALIYU MUAZU**

**Thesis Submitted to the School of Graduate Studies, Universiti  
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of Doctor of Philosophy**

***June 2015***

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Doctor of Philosophy

**MODELING FOR ENERGY OPTIMIZATION IN WETLAND PADDY  
PRODUCTION IN NORTH-WEST SELANGOR, MALAYSIA**

By

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**June 2015**

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In Malaysia, rice is the staple food for the populace and a source of income to the majority of the rural dwellers. The country relies on imported rice to argument the shortfall in local production vis-à-vis demand. The locally produced rice cost more than similar grade of imported rice. Reducing production cost and enhancing paddy productivity are achieved through optimum use of resources, to which on-farm energy analysis plays a central role by addressing issues of excess energy use.

In this study, a thorough on-farm evaluation of farm inputs and output was conducted in 40 farms with net cultivation land area of 27.005 ha at Block E5 Parit Lima Timur, Sungai Besar, North-West Integrated Agricultural Development Authority Selangor, to determine energy and cost efficiency of paddy production in the area and to develop a computer-based platform for appraising performance. The measured farm inputs were converted into energy values using appropriate conversion coefficients and the cost of inputs evaluated based on the prevailing market rate. The technical efficiency of the farms was determined using input oriented constant return to scale Data Envelopment Analysis (DEA) methodology. Quantification of excess energy used in the farms was done using DEA identified benchmarks. The benchmarking results were used to develop maximum yield predictive models for performance appraisal. A method of reference frequency was used to determine best paddy cultivation practices for enhanced paddy productivity. A motion study was conducted to evaluate the mechanization indexes of operations and in the development of fuel predictive models.

From the results of the study, at mean yield of 7625 kg/ha, the energy expenditure was 16,440 MJ/ha with energy intensity value of 2.16 MJ/kg. Cost-wise farmers in the study area expended about RM6658/ha and had a benefit-cost ratio of 1.37 and 1.68 with and without government subsidy respectively. Results from DEA analysis showed that about 18% (2915 MJ/ha) of the total energy input was used in excess of the required optimum. The excess use of energy ranges from 12% for machinery to 20% for fertilizer. Three best farms selected for their high reference frequency use less farm inputs and they have higher yield by about 19%, compared to the inefficient farms. The mean mechanization index (MI) for the cultivation was 0.92 and spraying operation with MI of 0.19, is identified as the most critical operation requiring mechanization priority. The developed multiple linear regression maximum yield predictive models revealed an inverse relationship between paddy yields with seed energy. A quadratic relationship exists between total optimum energy inputs with paddy yield. Resulting from this study, a novel decision support graphical user interface for computing optimum energy input and cost has been developed using Java programming language in NetBeans IDE release 7.2.1. The program is distributable in the form of an executable file with a computer hard disk space requirement of about 3.65 MB.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PEMODELAN UNTUK OPTIMIZATION TENEGA DALAM PAYA PADI  
PENGELUARAN ALAM BARAT LAUT SELANGOR, MALAYSIA**

Oleh

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Di Malaysia, beras adalah makanan ruji bagi penduduk dan merupakan sumber pendapatan kepada majoriti penduduk luar bandar. Negara ini bergantung kepada beras import kerana kekurangan dalam permintaan pengeluaran tempatan vis-à-vis beras keluaran tempatan lebih mahal daripada beras import gred yang sama. Mengurangkan kos pengeluaran dan meningkatkan produktiviti padi dicapai melalui penggunaan sumber optimum, yang mana analisis tenaga di ladang memainkan peranan utama dengan menangani isu lebih penggunaan tenaga. Dalam kajian ini, satu penilaian menyeluruh di ladang input ladang dan output telah dijalankan di 40 ladang dengan kawasan Tanah penanaman bersih 27.005 ha di Blok E5 Parit Lima Timur, Sungai Besar, Lembaga Utara-Barat Pembangunan Pertanian Bersepadu Selangor, untuk menentukan Tenaga dan kos kecekapan Pengeluaran Padi di kawasan itu dan untuk membangunkan satu platform berasaskan komputer untuk menilai prestasi. Input ladang diukur telah ditukar, ke dalam nilai-nilai Tenaga menggunakan pekali penukaran yang sesuai dan kos input dinilai berdasarkan kadar pasaran semasa. Kecekapan teknikal ladang-ladang telah ditentukan dengan menggunakan berorientasikan Input berterusan kembali ke skala Data Penyimpulan Analisis (DEA) metodologi. Kuantifikasi tenaga berlebihan yang digunakan di ladang-ladang telah dilakukan dengan menggunakan tanda aras Dea dikenal pasti. Penandaaran hasilnya digunakan untuk membangunkan hasil maksimum model ramalan bagi penilaian prestasi. Kaedah kekerapan rujukan telah digunakan untuk menentukan amalan penanaman padi terbaik untuk peningkatan produktiviti padi. Kajian motion telah dijalankan untuk menilai indeks jentera operasi dan dalam pembangunan bahan api model ramalan.

Dari hasil kajian, pada kadar hasil purata 7625 kg / ha, perbelanjaan tenaga adalah sebanyak 16,440 MJ/ha, dengan tenaga intensiti nilai 2.16 MJ/kg. Kos bijaksana petani di kawasan kajian dibelanjakan kira-kira RM6658/ha dan adalah nisbah faedah-kos GNT john 1.37 dan 1.68 dengan dan tanpa subsidi kerajaan masing-masing. Keputusan daripada analisis DEA menunjukkan kira-kira 18% (2915 MJ/ha) tenaga jumlah input telah digunakan melebihi optimum yang diperlukan. Penggunaan berlebihan tenaga ranges daripada 12% untuk jentera hingga 20% untuk baja. Tiga ladang terbaik dipilih untuk rujukan tinggi kekerapan kurangkan input ladang dan mereka mempunyai hasil yang lebih tinggi oleh kira-kira 19%, berbanding dengan ladang-ladang yang tidak cekap. Purata penggunaan jentera indeks (MI) untuk penanaman adalah 0.92 dan semburan operasi dengan MI daripada 0.19, dikenal pasti sebagai operasi kritikal terbesar yang memerlukan keutamaan kepada jentera. Maju regresi linear pelbagai maju hasil maksimum model ramalan mendedahkan hubungan songsang antara padi terhasil dengan tenaga biji berih. A hubungan kuadratik wujud di antara jumlah input tenaga optimum dengan hasil padi. Hasil daripada kajian ini, antara muka pengguna grafik sokongan keputusan novel untuk mengira input tenaga optimum dan kos telah dibangunkan dengan menggunakan bahasa pengaturcaraan Java dalam NetBeans IDE pelepasan 7.2.1. Program ini boleh diagihkan dalam bentuk fail boleh laku dengan komputer keras keperluan ruang cakera kira-kira 3.65 MB.

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I certify that a Thesis Examination Committee has met on 9<sup>th</sup> June, 2015 to conduct the final examination of Aliyu Muazu on his thesis entitled "Modeling for energy optimization in wetland paddy production in North-West Selangor" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Degree of Doctor of Philosophy.

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background of the study

Rice is a cereal crop grown and consumed on every continent of the world because of its adaptive capabilities which enables it to grow in areas of differing soil types and climatic conditions (Ferrero and Tinarelli, 2008). It ranks as the top major food crop in the world in terms of the production volume catering for the food requirements of more than half of the world population. The world production of rice in 2012 was estimated to be 719,738,273 tons harvested from 163,199,090 ha of farmlands with average yield level of 4.41 tons/ha (FAOSTAT, 2014). In the same year, Southeast Asian countries with combined rice production output of 217,174,887 tons accounted for about 30% of the world's total production

About 692,340 ha of arable land in Malaysia were subjected to rice cultivation in 2012. The country has eight rice granary areas which practice double cropping per year. The granary areas account for about 72% of lowland rice cultivated in the country (Najim et al., 2007). Considerable upland rice cultivation is also done in Malaysia (Hanafi et al., 2009). The year round rainfall distribution, tropical temperatures and high humidity serving as great assets supporting multiple paddy cropping systems in the country. In the past four decades successive governments in Malaysia have put emphasis on rice production being the national staple food, with a view to achieving self-sufficiency in the production. The emphasis on achieving self-sufficiency in rice production has led to considerable infrastructural developments. Such as construction of good access roads to paddy fields, irrigation/drainage facilities, provision of extension services, machinery packages, in addition to the subsidy and special incentive support packages, including guaranteed minimum price and bumper harvest prize to farmers. Despite the huge yearly budgetary expenditure dedicated to supporting paddy production, the average national yield of 3.782 tons/ha (FAOSTAT, 2014) is still about 10% lower than the world average.

Rice in Malaysia is not only the national staple food but as well its cultivation in the country is a source of employment/income to majority of rural dwellers. As much as 150,000 farmers depend exclusively on rice cultivation for their overall sustenance (Najim, 2007). Despite massive government support extended to rice farmers over the years through subsidy which virtually covers all farm inputs as mentioned in the preceding paragraph, the country is still not self-sufficient in rice production. Nearly one third of the country's rice requirement is met through import. Although according to FAOSTAT (2014), from 1970 to 2010 rice productivity in Malaysia rose from 2.386 t/ha to 3.782 t/ha (up 58.51%), however the area under rice cultivation declined 4.4% when it drops from 704,767 ha to

673,745 ha, population rose by 1.6 times and rice import jumped from 355,450 tons to 931,444 tons (i.e. increased 162.05%). Corresponding to these jumps, the rice import bill skyrocketed 10.91 times from \$42,011,000 in 1970 to \$500,369,000 in 2010, thereby straining the economy through foreign exchange depletion. Given the country's current population figures of 28,401,000 and per capita rice consumption of 110 kg/year, for the country to achieve 100% self-sufficiency from the present 73% sufficiency level, rice production must reach 3,216,100 tons from the present production level of 2,548,000 tons. Furthermore, given the present trend in annual population growth of 1.43% the country's population is projected to hit 32.56 million people by 2020. As such rice production must reach 3,581,600 tons by the said year in order to attain 100% self-sufficiency level. In other words for the country to be 100% self-sufficient in rice, production will have to be raised by 1,033,600 tons, up 40.57% from the current production level. Assuming the current land area under rice cultivation remains unchanged, average national yield must reach 5.32 tons/ha by 2020 if the country must be 100% self-sufficient.

Production increase is generally achieved by either increasing area under rice cultivation or increasing farm land productivity through optimization in the use of farm inputs or both. Increasing rice production in Malaysia through area expansion is not feasible because of limited arable land suitable for rice cultivation in the country. Malaysia is unable to have a breakthrough in terms of achieving 100% rice self-sufficiency level, because the recorded increases in rice productivity over the years was not commensurate with the decline of land under rice cultivation, population explosion and the change in the eating habit of the people. In order for the country to be fully sufficient in rice production, productivity must be increased tacitly in such a manner pursued by some countries with similar problems of dwindling land area under rice cultivation e.g. China which was able to raised production 74.37% by nearly doubling its rice productivity level.

Furthermore, it is worth mentioning here that rice production in Malaysia is expensive compared to what obtains in some neighboring countries. As a matter of fact the country lacks competitive advantage (Murad et al., 2008) in terms of local rice production and this suggests that paddy production is neither viable nor sustainable in the country (Man and Sami, 2009). Najim et al., (2007) claimed that imported white milled rice cost less by about RM590/ton compared to the cost of similar grade of rice produced locally. Assuming a total annual production of 2.4 million tons and a conservative production cost difference of only RM300/ton between local and imported rice in favor of imported rice, this translates into a staggering sum of RM720 million/annum in lost revenue to local paddy farmers. It represents a clear case of financial loss the side effects of which is multi-faceted and must not be allowed to go unchecked. Particularly that incidence of poverty is higher among paddy farmers in the country compared to other segments of the population engaged in other occupations. Study conducted by Man and Sami (2009) revealed that more than 35% of the farmers surveyed had income in the range of RM3000 – RM6000/annum with about 2 – 6 dependents. Increasing rice productivity will go a long way in enhancing the



quality of life for the farmers by increasing profitability, sustainability and above all self-reliance.

Considering the abundant water resources, productive land (though greatly limited) and the performance of high yielding rice varieties introduced in Malaysia which are key factors in boosting rice production, the country has the potential to increase rice productivity not only to achieve self-sufficiency level but as well become a net rice exporting country. The average annual rainfall in the country is well above 2,500 mm higher than in China, Thailand, Australia, Vietnam and Myanmar and is a huge competitive edge over these countries. The rice varieties introduced in the country by the Malaysian Agricultural Research and Development Institute (MARDI), particularly the MR219 and MR220, are high yielding and so far are doing well and have potential output of up to 10 tons/ha. At individual farm level, reported cases of bumper harvest greater than 8 tons/ha exist. With a total annual land area of 673,745 ha dedicated to rice cultivation, if the national average rice yield is raised to 6 tons/ha, the country's rice output will hit 4 million tons, and this could easily place Malaysia in the league of rice exporting nations even at the face of population growth. The major drawback to realizing this being the huge differences in rice yield recorded at the granary areas. For example whereas the farmers IADA North-west Selangor obtained mean yield above 5 tons/ha, in other irrigation schemes example at Kemasin Semerak, the farmers obtained yield as low as 2.877 tons/ha (DOA, 2010). The high disparity in rice yield across the country continues to be a strong barrier for its quest to achieve the desired 100% self-sufficiency in rice production with the given limited paddy cultivation area.

The huge difference in yield particularly at farm levels is worrisome, hence its nature need to be investigated, causes determined and remedial actions effectively proffered. The best viable approach is to conduct a thorough on-farm input and output audit (energy analysis) study, which will cover all the operations involved in wet paddy cultivation, in the most productive irrigation scheme in the country. In this way the technical efficiency of the farmers involved in the study along with their cultivation practices would be uncovered. So that the practices of the most efficient farmers among them, could serve as models for the less performing farmers to adopt, especially by farmers operating in the less productive irrigation schemes in the country. This becomes necessary because any meaningful improvement, in rice productivity will only be achieved through effective and efficient application of available farm inputs. In a nutshell, a possible way of raising farm productivity at reduced cost is through optimum use of resources, to which on-farm energy analysis plays a central role by addressing the issues of excess energy utilization. Energy analysis is a sure methodology for providing synthesized information, useful to both farmers and agricultural policy makers, regarding best practices capable of promoting optimum energy resource utilization, rice productivity and profitability. It has especially been identified as a valuable tool for computing financial savings and fossil fuel conservation (Lu et al., 2010).

In crop production, energy analysis is usually performed to determine where and how energy is being used, the information obtained is then used to improve efficiency and reduce costs. For the information to be of great importance to the farmers however, a critical performance assessment methodology is required to expose level of inefficiencies in the farms in their use of energy inputs, and in suggesting appropriate practices to remedy wastage and make the occupation profitable. Such capabilities are found in Data Envelopment Analysis (DEA), which is a mathematical programming model applied to observation data and it provides a way of obtaining empirical estimates of relationships (Cook and Zhu, 2005). It is an excellent and easily to used methodology for modeling operational processes for performance evaluations. Unlike traditional statistical approaches used to evaluate farmers' performance relative to an average farmer (central tendency), it compares each farmer with the best farmers (frontier approach). DEA is most useful when a comparison is intended against best farmers and it opened up possibilities for use in scenarios that have been resistant to other approaches. Particularly in complex cases with an unknown relationship between inputs and outputs (e.g. ability to quantify effects of varying energy inputs on rice yield) involved.

DEA has found wide application in the area of energy optimization studies in agriculture for its ability to benchmark farmers and in identifying their technical efficiencies. It was used in energy optimization studies for canola production (Unakitan et al., 2010 and Mousavi-Avval et al., 2011), kiwi production (Mohammadi et al., 2011), apple production (Mousavi-Avval et al., 2011b) and broiler production (Heidari et al., 2011b). In DEA there are a number of producers also called decision making units (DMUs) using varying levels of inputs to generate varying levels of outputs. The basic idea behind DEA is that the efficiency of a DMU can be determined by the ratio of its weighted output and weighted input. DEA attempts to determine which of the DMUs are most efficient and point out specific inefficiencies of other DMUs. In crop production the DMUs are the participating farms in the study.

## **1.2 Statement of the problem**

Rice production involves several energy expending operations which include seed selection, seedbed and land preparation, planting, weeding, fertilizing, pest management, harvesting, threshing, drying and irrigation activities. These operations are conducted using energy from different sources including human, fuel, machinery, fertilizer, pesticides and seeds. Generally, in crop production energy is used directly in operating machinery and equipment, and indirectly through the application of fertilizer and agro-based chemicals. Availability of the right energy in sufficient quantity, at the right time, is a prerequisite for the timely completion of rice production operations, which is a key to securing maximum yield. In order to achieve maximum benefits, farmers must have the correct energy mix at the right time. Too much energy input signifies uneconomic production and therefore waste, which may lead to decrease or loss in benefit, increase in global warming and pose some stress on the environment. Too little energy than

required, makes it difficult to attain maximum productivity level to guarantee the required level of food sufficiency.

Modern paddy cultivation in Malaysia involves the use of different types of machinery that are powered through the combustion of fossil fuel, which is subsidized by government. Information on the quantity of fuel use could easily indicate the future fuel cost the farmers will have to contend with, in the absence of the government subsidies and encourage them to adopt farming practices that will optimize fuel use more rigorously. Furthermore, data generated on the fuel consumption by the machinery in performing field operations, could be used to develop fuel predictive models, for use at farm level by the farmers and in quantifying the level of carbon dioxide (CO<sub>2</sub>) emissions due to fuel use in rice cultivation. From an environmental point of view, any reduction in fuel use, in rice cultivation will have a commensurate positive effect on the reduction of CO<sub>2</sub> emissions thereby promoting sustainable production. As for the government, information about fuel consumption will allow them to know the exact additional financial burden a farmer is likely to face with each reduction in subsidy, and the potential price hike on rice and rice products in the market. In this way, adequate provisions could be made to cushion the undesired effects of additional economic burden on the consumers. Furthermore, information about fuel consumption per unit area will enable government to evaluate its commitments in meeting ratified international conventions (such as Kyoto Convention) on GHG emission reduction from rice production sector. The country is a signatory to Kyoto protocol with commitment to reduce greenhouse gas emissions by 40% in 2020 (Shafie et al., 2011).

The lack of enough labor force in the paddy cultivation sector is another area of great concern both to farmers and agricultural policy makers because of its strong influencing effects on production cost and the need for achieving timeliness in completion of critical farm operations in order to avoid undue losses. In the last two decades labor availability in agriculture in Malaysia has declined by about 21.83% from 1,901,000 people in 1993 to 1,486,000 people in 2013 (FAOSTAT, 2014). Presently, studies have shown imported white milled rice cost less compared to similar grade of rice produced locally. One way to reduce production cost is by mechanizing operations with the highest human labor engagement in paddy production. The need for human labor in agriculture reduces with an increase in the level of mechanization (Baruah and Bora, 2008). Complete information about the level of machinery inclusion in each operation is required for effective assessment of farm mechanization status for paddy production system. Such information has the potentials to reveal critical operations requiring mechanization, so as to enhance paddy yield through efficient and timely completion of operations. With correct farm machinery of appropriate power ratings, availability of water for irrigation and proper planning, paddy cropping intensity per year could be increased, thereby boosting the annual production.

Currently, there are no documented studies regarding the extent of the machinery involvement in typical direct seeding wetland paddy cultivation systems, in Malaysia. Information about the level of machinery involvement



at each level of paddy cultivation could be used by the agricultural policy makers in their tasks of making comprehensive farm mechanization plan for the country, in line with the rapid modernization and industrialization going on in the country. The developments are increasingly making paddy production less attractive to the educated youths partly because of the perceived field work drudgeries and the widely acknowledged low income earned by paddy farmers compared to earnings made by segment of the society engaged in other occupations.

Another area of concern is in the used of mineral fertilizer and chemical pesticides. Although rice yield is said to increase with an increase in fertilizer input (Fan et al., 2005), excessive application of nitrogen fertilizer pollutes the environment, ground water and may lead to surface erosion and the leakage of nitrogen (Ya-Guang et al., 2010). Considering the fact that about 2/3<sup>rd</sup> of the country's annual fertilizer requirements are met through imports, high price change for fertilizer in the global market may likely affect the level of subsidy offered by government on fertilizer to farmers. With or without subsidy, paddy farmers must make profit and continue to make profit for them to remain in the occupation. Profit making and its consolidation are only possible when inefficiencies in the system are eliminated – i.e. the need for optimum resource utilization. The optimum use of fertilizer is necessary in order to promote sustainable rice production at reduced cost. With an on-farm energy study, the amount of fertilizer required to achieve maximum yield could be ascertained through a modeling approach. Such a modeling work in direct seeding paddy cultivation is lacking in the database.

Similarly although the significant contribution of chemical pesticides in improving paddy productivity is well documented however, on the one hand, it is obvious that an excessive use of pesticides, apart from polluting the environment, has some negative effects on the growing paddy plants in terms of their growth and survivability. On the other hand, using the pesticides below recommended dose may cause the pests to mutate and becomes resistant to the chemicals, leading to the need for increased application frequencies. The key to good pesticides management includes adherence to manufacturers' recommendations in terms of mixing ratio and dosage used per hectare, in addition to the employment of appropriate technology in performing the applications. One way of raising the farmers' awareness about their compliance level in the use of the chemicals, is by having a computing algorithm that could indicate the required volume of solution to use, while considering the recommended mixing ratio and application dose for the chemicals. This needed computing algorithm is to date not known to exist in the literature.

Since efficient management of resources in any production system relates the production of outputs with maximum economic returns. A mathematical model that relates inputs with outputs is used by researchers to gain insight into the responses of output due to changes in inputs, so that the most influential input variables are adequately managed for maximum yield. In crop production, yield is globally acknowledged to have a positive correlation with energy input (Singh, 1999). Knowledge of this relationship

stirs the interests of researchers towards performing energy analysis with a view to improving the performance of the production system through modeling. Several energy studies in crop production that link energy flows with crop yield are available in the literature. However, the currently available models do not predict the maximum yield a farmer should expect from a given level of energy inputs. Thus, it is desirable for a farmer to have a user-friendly model that can predict expected maximum yield from a given level of primary energy inputs (seeds, labor, machinery, fuel, fertilizer and pesticides). The model could readily serve as a tool for performance appraisal of previous paddy cultivations and quantification of the level of underperformance, so that appropriate remedial actions can be taken to improve future paddy productivity. To our knowledge, to date there is no energy study that have investigated optimum energy input in the direct seeding wetland paddy cultivation system and related it with the crop yield.

Considering all these challenges, a comprehensive on-farm energy audit study for direct seeding paddy cultivation targeted at optimizing the use of farm inputs, will be a welcomed development to farmers, as well as the agricultural policy makers in the country. The study results when integrated into a computer program, will not only help foster our understandings about the likely effect of changes in the energy mix on paddy productivity, but as well accord farmers the opportunity to make informed decisions in selecting energy mix to maximize crop productivity. To ensure food security and get rid of poverty among the paddy farmers, rice productivity must increase appreciably and at reduced cost. Therefore, an easy to use computing system is required to serve as a decision support system to the farmers in their quest to achieve higher yield with less use of farm inputs.

### **1.3 Research objectives**

The main aim of this research is to develop an energy optimization model for direct seeding rice cultivation system in Malaysia with due regards to farm size and cultural practices employed by the farmers.

The specific aims of the current study include:

1. Determine the energy inputs and production cost for direct seeding wetland paddy cultivation in Malaysia.
2. Develop a regression model for predicting maximum rice yield for given levels of energy inputs.
3. Develop a robust computer decision support program for computing optimum energy and cost requirements based on farmers' supplied paddy cultivation data.
4. Identify best agricultural practices with respect to optimum energy use and cost obligation to ensure sustainable paddy production.

#### 1.4 Scope of the study

Paddy farmers in Malaysia practice both direct seeding and transplanting system of cultivation, this study is limited to the direct seeding system of cultivation. Farmers practicing direct seeding system of paddy cultivation perform about eleven different types of operations namely: tillage, seeding, fertilizing, spraying, harvesting, slashing, liming, leveling, irrigation, dredging of drainages and foot path making activities in some seasons. The research is however, limited to evaluating six standard operations (tillage, seeding, fertilizing, spraying, harvesting and slashing) practiced by farmers in the study area. For the purpose of developing yield predictive models, the study utilized energy data from five operations (tillage, seeding, fertilizing, spraying and harvesting) because of their relationship with paddy yield.

Generally, the scope of the study is limited to developing computer based decision support program, for evaluating energy and cost expenditures in wetland paddy cultivation, so that wasteful uses of energy hence, cost expenditures therein, may be pinpointed and described more precisely vis-à-vis cultural practices of the farmers. The study while using measured farm input data, shall offer a complete platform for computing the various measures of energy and cost indicators; generate reports on machinery utilization, and to effectively appraise the performance of farmers in their use of energy resources.

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