UNIVERSITI PUTRA MALAYSIA

SYSTEM DYNAMICS ANALYSIS OF THE IMPACT OF PADDY AND ENERGY SUBSIDIES WITHDRAWAL ON PADDY SECTOR

SITI 'AISYAH BAHARUDIN

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By

SITI 'AISYAH BAHARUDIN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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August 2015

Chairperson : Fatimah Mohamed Arshad, Prof., Datin Paduka, PhD
Faculty : Economics and Management

Paddy is a staple food for Malaysians while paddy production has been the main economic activity for many farmers. Despite government intervention in the paddy production, low paddy productivity has been one of the main issues that affect farmer's income. In addition, increasing world crude oil price will directly lead to an increase in domestic fuel price for paddy machine. Indirectly, it also affect the fertilizer price and paddy sector.

Previous research has pointed out the rationales of subsidies withdrawal, such as; insufficient paddy production, market imperfection and profit loss from paddy sale. However, the analysis by most research did not integrate all factors and deemed as unable to provide comprehensive analysis of the problem. Moreover, the analysis did not address the issue of increasing energy prices and its effect on energy usage level in paddy production. Hence, this study focus on four main objectives; (i) to formulate the share of energy use by activity and sources in the paddy sector; (ii) to simulate a change in world crude oil price on the paddy productivity and expenditure; (iii) to simulate the impact of paddy and fuel subsidies removal on the expenditure and farmers' income; and (iv) to simulate the impact of various policy scenarios on the paddy sector.

Energy use is important in paddy production because it requires energy in all production activities, both in direct and indirect energy use. There are four main activities involved such as land preparation, planting, crop management and harvesting. The direct energy use is in the form of fuel and human labour, while the indirect energy is required in the application of fertilizers, pesticides and seed. Hence, this study is required to formulate the shares of energy use in the paddy sector using Energy Analysis (EA) methodology. Besides, this study calls for simulation of System Dynamics (SD) methodology on the (i) implication of change in world crude oil price; (ii) the impact of paddy and energy subsidies withdrawal; and iii) alternative policy to improve paddy sector.

Energy analysis shows that higher energy use will increase paddy productivity. However, once the usage level reaches its maximum threshold, the productivity level will decline. Crop management activities show the highest energy use at 67%, followed by land preparation (21.7%), harvesting (10%) and planting (1.3%) activities. Fuel is the highest direct energy user, while fertilizer proves to be the highest consumer of indirect energy. Energy efficiency level for paddy production is 4.08.

System dynamics model is used to identify the underlying problematic structure by modelling the land use, productivity, consumption, input, allocation input, farmer's income, expenditure, farm cash, energy use, farm and technology practices sub-models. The simulation results have replicated the historical data, in which an increase in world crude oil price shows an increasing paddy expenditure by 3.8%. However, a 1% increase in fuel price will increase the fertilizer price

by 3.4%. This shows that the actual cost of paddy production is more higher if the paddy price is not subsidised. Meanwhile, simulation result for removal of both paddy and fuel subsidies indicates a drop in paddy productivity by 10.3% compared to the decrease in income by 17.9%. The decline in productivity has inherently increased the import by 17.5%, hence reduces self-sufficiency level (SSL) by 10.3%.

The main objectives of the paddy policy is to increase the SSL through increasing productivity and farmers' income, while reducing the dependency on imported rice. With this, researcher has examined the effect of future policy scenarios which are examines the implications of the removal of paddy and fuel subsidies together with the implementation of policy scenario (PS); (i) PS1 (R&D in new paddy variety); (ii) PS2 (PS1 + R&D in organic farming); (iii) PS3 (PS1 + PS2 and improved farm practices); and (iv) PS4 (PS1 + PS2 + PS3 and adaption of technological practices). Based on the alternative policy scenarios, scenario PS4 gives the highest result compared to other policy scenarios with almost all variables increase up to 40% from the Base Run. Within the 15 years of simulation period, productivity is approximated to increase by 6.5 tonnes/ha and rice SSL is expected to increase by 79%.

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

ANALISIS SISTEM DINAMIK TERHADAP KESAN PENARIKAN SUBSIDI PADI DAN TENAGA KEPADA SEKTOR PADI

Oleh

SITI 'AISYAH BAHARUDIN

Ogos 2015

Pengerusi : Fatimah Mohamed Arshad, Prof., Datin Paduka, PhD
Fakulti : Ekonomi dan Pengurusan

Padi adalah makanan ruji rakyat Malaysia manakala pengeluaran padi telah menjadi aktiviti ekonomi utama bagi kebanyakan petani. Disebalik campurtangan kerajaan dalam pengeluaran padi, produktiviti padi yang masih rendah telah menjadi salah satu isu utama yang menjejaskan pendapatan petani. Di samping itu, harga minyak mentah dunia semakin meningkat telah memberi kesan secara langsung kepada peningkatan harga bahan api domestik yang digunakan untuk mesin pengeluaran padi. Secara tidak langsung, ia turut memberi kesan kepada harga baja dan sektor padi.

Kajian sebelum ini menunjukkan rasional tentang penarikan balik subsidi seperti; pengeluaran padi yang tidak mencukupi, ketidaksempurnaan pasaran dan kerugian keuntungan daripada jualan padi. Walau bagaimanapun, analisis tidak menangani isu kenaikan harga tenaga dan kesannya terhadap tahap penggunaan tenaga dalam pengeluaran padi. Oleh itu, kajian ini memfokuskan kepada 4 objektif; (i) mengira penggunaan tenaga mengikut aktiviti dan sumber dalam sektor padi; (ii) simulasi perubahan harga minyak mentah dunia kepada produktiviti dan pengeluaran padi; (iii) simulasi kesan penarikan subsidi padi dan minyak kepada pengeluaran dan pendapatan petani; dan (iv) simulasi kesan pelbagai senarai polisi kepada sektor padi.

Penggunaan tenaga adalah penting dalam pengeluaran padi kerana ia memerlukan tenaga dalam semua aktiviti pengeluaran, samada secara langsung dan tidak langsung. Terdapat empat aktiviti utama iaitu penyediaan tanah, penanaman, pengurusan tanaman dan penuaian. Penggunaan tenaga langsung adalah bahan api dan tenaga manusia, manakala tenaga tidak langsung adalah baja, racun dan benih. Oleh itu, kajian ini diperlukan untuk mengira penggunaan tenaga dalam sektor padi menggunakan kaedah Analisis Tenaga (EA). Selain itu, simulasi kaedah Sistem Dinamik (SD) digunakan untuk melihat; (i) implikasi perubahan harga minyak mentah dunia (ii) kesan penarikan subsidi padi dan tenaga; dan (iii) alternatif polisi untuk meningkatkan sektor padi.

Analisis tenaga menunjukkan bahawa penggunaan tenaga yang lebih tinggi akan meningkatkan produktiviti padi. Walau bagaimanapun, sebaik sahaja tahap penggunaan mencapai had maksimum, tahap produktiviti akan menurun. Aktiviti pengurusan tanaman menunjukkan penggunaan tenaga yang paling tinggi pada 67%, diikuti dengan aktiviti penyediaan tanah (21.7%), penuaian (10%) dan penanaman (1.3%). Bahan api merupakan pengguna tenaga langsung paling tinggi, manakala baja membuktikan untuk menjadi pengguna tertinggi tenaga tidak langsung. Tahap kecekapan tenaga untuk pengeluaran padi adalah 4.08.

Model sistem dinamik digunakan untuk mengenalpasti struktur rmasalah asas oleh model penggunaan tanah, produktiviti, permintaan, input, peruntukan input, pendapatan petani, perbelanjaan, kas ladang, penggunaan tenaga, amalan ladang dan amalan teknologi sub-model. Keputusan simulasi telah mereplikasi data sejarah, di mana peningkatan harga minyak mentah dunia menunjukkan perbelanjaan padi meningkat sebanyak 3.8%. Walau bagaimanapun, peningkatan 1% dalam harga bahan api akan meningkat harga baja sebanyak 3.4%. Ini menunjukkan bahawa kos sebenar pengeluaran padi adalah lebih tinggi jika harga padi tidak disubsidikan. Sementara itu, hasil simulasi untuk penghapusan kedua-dua subsidi padi dan bahan api menunjukkan penurunan dalam produktiviti padi sebanyak 10.3% berbanding dengan penurunan dalam pendapatan sebanyak 17.9%. Kemerosotan dalam produktiviti sememangnya telah meningkatkan import sebanyak 17.5%, dengan itu mengurangkan kadar sara diri (SSL) sebanyak 10.3%.

Objektif utama polisi padi adalah untuk meningkatkan SSL melalui peningkatan produktiviti dan pendapatan petani, di samping mengurangkan pergantungan kepada beras import. Dengan ini, penyelidik telah mengkaji kesan senario polisi pada masa depan yang mengkaji implikasi penghapusan subsidi padi dan bahan api bersama-sama dengan pelaksanaan polisi senario (PS); (i) PS1 (R&D benih padi); (ii) PS2 (PS1, R&D pertanian organik); (iii) PS3 (PS1, PS2 dan amalan ladang yang baik); dan (iv) PS4 (PS1,PS2,PS3 dan adaptasi amalan teknologi). Berdasarkan alternatif senario, senario PS4 memberikan hasil yang paling tinggi berbanding dengan senario polisi lain dengan hampir semua pembolehubah meningkat sehingga 40% daripada dasar asas. Dalam masa 15 tahun tempoh simulasi, produktiviti dianggarkan meningkat sebanyak 6.5 tan/ha dan SSL dijangka meningkat kepada 79%.

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Thank You.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Fatimah Mohamed Arshad, PhD
Professor
Faculty of Economics and Management
Universiti Putra Malaysia
(Chairman)

Shaufique Fahmi Sidique, PhD
Associate Professor
Faculty of Economics and Management
Universiti Putra Malaysia
(Member)

Kusairi Mohd Noh
Associate Professor
Institute of Agricultural and Food Policy Studies
Universiti Putra Malaysia
(Member)

____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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Name and Matric No.: Siti 'Aisyah Baharudin (GS29002)

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LIST OF ABBREVIATIONS AND ACRONYMS

AP	Approved Permits
APM	Automatic Pricing Mechanism
APMM	*Agensi Penguatkuasaan Maritim Malaysia*
ASEAN	Association of Southeast Asian Nations
ATM	*Angkatan Tentera Malaysia*
ATV	Aviation Turbine Fuel
AV	Aviation Fuel
BAU	Bussiness as usual
BERNAS	*Padiberas Nasional Berhad*
CLD	Causal Loop Diagram
CPI	Consumer Price Index
DAN	*Dasar Agromakanan Negara*
DJBMN	*Dasar Jaminan Bekalan Makanan Nasional*
DOS	Department of Statistic
DOA	Department of Agriculture
EA	Energy Analysis
ECM	Energy Commission Malaysia
EIA	Energy Information Administration
EPP	Entry Point Projects
ETP	Economic Transformation Programme
FAO	Food and Agriculture Organization
FFDP	Five-Fuel Diversification Policy
GDP	Gross Domestic Product
GMP	Guaranteed Minimum Price
GPS	Global Positioning System
GSR	Government Subsidy Rice
HYV	High Yield Variety
IADA	Integrated Agricultural Development Area
IADA BLS	Barat Laut Selangor Integrated Agricultural Development Area
IADA KETARA	Northen Terengganu Integrated Agricultural Development Area
IADA K.S	Kemasin Semerak Integrated Agricultural Development
IADA KSM	Kerian-Sungai Manik Integrated Agricultural Development Area
IADA P.P	Pulau Pinang Integrated Agricultural Area
IADA S.P	Seberang Perak Integrated Agricultural Development Area
KADA	Kemubu Agricultural Development Authority
KDRM	*Jabatan Kastam Diraja Malaysia*
KFC	Kentucky Fried Chicken
LPG	Liquefied petroleum gas
LPN	*Lembaga Padi dan Beras Negara*
LPP	*Lembaga Pertubuhan Peladang*
MADA	Muda Agricultural Development Authority
MARDI	Malaysian Agricultural Research and Development Institute
MOA	Ministry of Agriculture
MSE	Mean square error
NAFAS	*Pertubuhan Peladang Kebangsaan*
NAP	National Agricultural Policy
NDP	National Depletion Policy
NEP	New Energy Policy
NPK	Nitrogen, Phosphorous and Potassium
NKEA	National Key Economic Area
NRE	Non-Renewable Energy
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries

PDRM	*Polis Diraja Malaysia*
PF	Precision Farming
PGK	Poverty Line Income
PJBM	*Program Jaminan Bekalan Makanan*
PPK	*Pertubuhan Peladang Kawasan*
RE	Renewable Energy
RMSPE	Root-mean-square-percent error
RON	Petrol's Research Octane Number
R&D	Research and Development
SD	System Dynamics
SBPKP	*Skim Baja Padi Kerajaan Persekutuan*
SFD	Stock and Flow Diagram
SIPP	*Skim Insentif Pengeluaran Padi*
SSHP	*Skim Subsidi Harga Padi*
SSL	Self-Sufficiency Level
SST	*Super Special Tempatan*
ST	*Super Tempatan*
TNB	*Tenaga Nasional Berhad*
UPP	*Unit Pencegah Penyeludupan*
USDA	United States Department of Agriculture
WTO	World Trade Organization

LIST OF UNITS

Btu	British thermal units
'C	Celcius
cm	Centimeter
dmnls	Dimensionless
ft	Feet
ft^3/s	Cubic feet/second
g	Technology
g	Gram
GJ	Giga-Joules
gm	Gram milimeter
h	Hours
ha	Hectare
hp	horse power
kcal	kilocalorie
kg	Kilogram
km	Kilometre
K_2O	Potassium
ktoe	Kilotonne of oil equivalent
kva	Kilovolt amps
kWh	kilowatt/hour
L	Liter
m	Meter
MJ	Mega-Joules
ml	Milliliter
mm	Millimeter
MT	Metric Tonnes
N	Nitrogen
P_2O_5	Phosphorus
re	Relong
RM	Ringgit Malaysia
USD	United States Dollar

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter introduces the agriculture and energy sector in Malaysia, followed by an overview of the paddy and rice industry with focus on the use of energy in the production sub-sector. The problem statement, objectives and justification of the study are discussed after.

1.2 Agriculture and Energy Sectors

The agriculture sector is imperative to a nation's development as it produces food for nourishment of its people. However, in Malaysia, the share of the sector in Gross Domestic product (GDP) had declined from 22.9% in 1980 to only 8.6% in 2013. The energy sector, on the other hand, contributes a significant 13.1% which is mainly sourced from export earnings of crude petroleum. This represents a contribution towards government revenue and national economy amounting to RM68.3 billion, of which upstream activities including petroleum and gas represent 7.6% of total GDP. Given the rising global energy demand and economic growth, contribution from the oil and gas industry is expected to increase further by approximately 20% over the next 5 years until it reaches RM81.9 billion of total GDP in 2015 (DoS, 2013).

1.3 Paddy and Rice Industry in Malaysia

The average consumption of rice per capita is 245 grams/day and its accounts for 29.8% of energy and 20% of protein (FAO, 2006). Rice is weighted 3.07% in the calculation of Consumer Price Index (CPI). The importance of paddy and rice sector can be seen through government policies implemented each year. In 1946, the government introduce rice stockpile as emergency reserve and buffer stock to overcome supply shortages after the war and stabilize price (Pletcher, 1989)[1].

In Malaysia, rice is a security crop under government control to ensure sufficient staple food for all Malaysians. After its independence in 1957, rice became the staple food for Malaysia despite the dire situation experienced by the rice industry (Dano & Samonte, 2005). The government therefore introduced three main objectives from independence to the 1970s to achieve self sufficiency level, namely by double cropping, promoting cooperatives and more regulated trading activities to increase farmer income and managing import prices and prices to producers to protect consumer welfare (Fatimah, 1982).

The National Agricultural Policy (NAP) I (1984-1991) was introduced to enhance the rice SSL to the range of 80-85%. The policy aimed to emphasize on new land development and consolidation of uneconomic sized land (Fatimah et al., 2007). Although NAP I managed to achieve its SSL and income improvement target, it failed due to high production cost. In addition, provision of intensive land usage and competition led to a reduction in production level (Habibah, 2007). NAP II (1992-1997) stressed on the improvement in human resource development, private sector participation and R&D in agriculture. The government decided to confine paddy production in areas already equipped with irrigation facilities namely granary area. Eight granary areas were designated as permanent producing areas in order to realize a minimum SSL at 65% (Amin, 2007).

The NAP III (1998-2010) was introduced when the country was severeely affected by the 1997 Asian financial crisis. Food security and sustainable use of natural resources were the major concerns of the NAP III, handled with two approaches, agro-forestry and product-based. Agro-forestry approach focused on the efforts to reduce the usage of arable land and raise land productivity. The product-based aimed to increase competitiveness and profitability within the agricultural sector (Habibah, 2007). *Dasar Agromakanan Negara* (DAN) (2011-2020) aimed for a

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[1] In 2008, government announced to revise to rice stokpile at 292,000 tonnes. In 2010, in 2010, rice stockpile is 239,000MT

production growth target of 1.6% per year due to increase in population but, rice production growth was 1.3% per annum in current year. The variables used to measure this are productivity improvements and cropping intensity. Productivity should increase from about 4.0 tonnes/ha in 2010 to 5.0 tonnes/ha in 2020 while in cropping intensity from 142% in 2010 to 157% by 2020 (an average frequency of cultivation of 1.42 times per year in 2010 to 1.57 times per year by 2020) (MoA, 2012a).

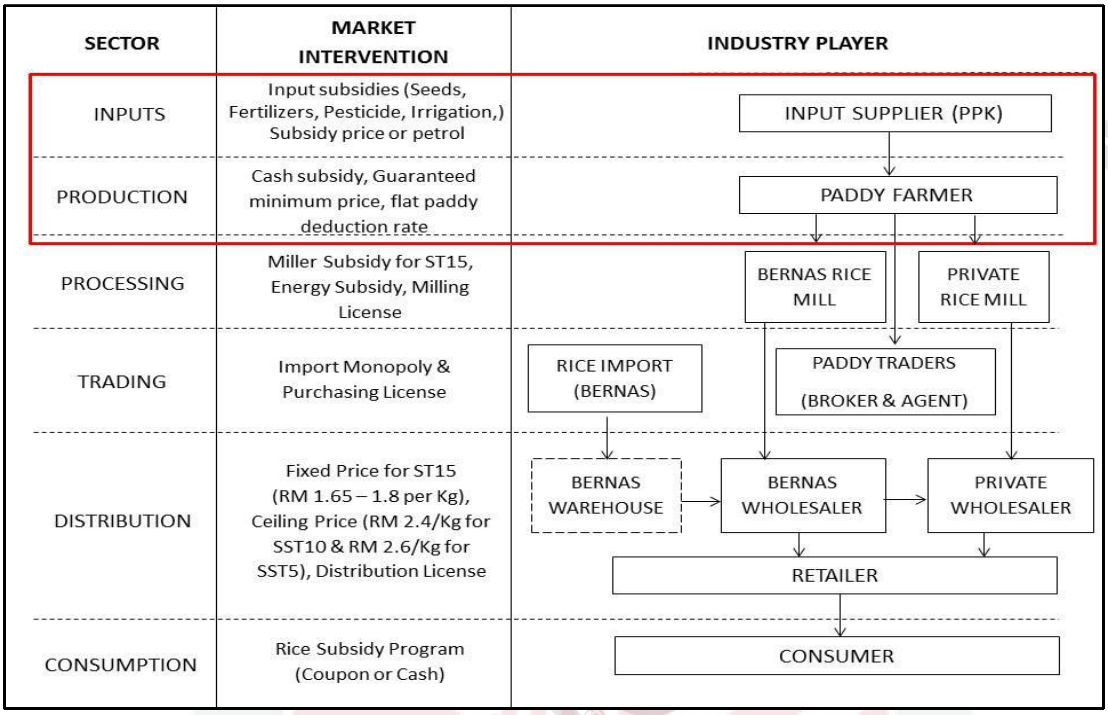

Figure 1.1 Paddy and rice supply chain in Malaysia
(Source: Fatimah, 2011)

There are currently a number of government interventions in the paddy production stages starting from input, production, milling and sub-sector trading (see Figure 1.1). Malaysia introduced various programs to increase paddy and rice production, including the subsidization of input and output prices and the establishment of research and development institutions for paddy production. The subsidy program was introduced with the intention to ease farmers' production cost and enhance food production.

Previous studies have proven some weaknesses of this intervention. Barker & Hayami (1976) stated that fertilizer subsidy for rice sector is more efficient than rice price support in terms of benefit-cost ratio. They also noted the lower cost incurred by the government in using the subsidies program to achieve the rice SSL. Pletcher (1989) claimed that Malaysia needs to separate paddy production policies from the income support policies in order to solve its paddy and rice problems. After the introduction of paddy price subsidy (also known as cash subsidy), farmers' income increased by 35% per ha for every season. Fertilizer subsidy, however, failed to reduce rice production cost due to rising costs of other inputs such as labour, machinery and land rent (Amin, 1989). Despite controlling the expenditure factor, productivity had not increased much and rice SSL is still low, currently being at 72% (DoS, 2015).

1.4 Energy use in Paddy Production

The terms of energy is varies according to different scholar. Agriculture scholar define energy in term of direct and indirect energy. The direct energy used is in the form of fuel, electricity and human labour. Indirect energy is required mainly in the production and application of mineral and chemicals fertilizers to improve crop yields (Bundschuh & Chen, 2014). Energy is important in paddy sector for crop production and agro processing for added value. Energy is used to perform various tasks in crop production processes such as post-harvest, land preparation, planting, crop management, irrigation, harvesting and transportation of agricultural inputs. Energy use depends on the level of mechanization, energy price, quantity of active workers and cultivability of land. In

2010, the usage of energy in Malaysia's agricultural sector reached an estimated 1,074 kilotonne of oil equivalent (ktoe), both from direct and indirect sources. Yet, the figure is trival when compared to the energy use in other production sectors in Malaysia (ECM, 2011).

Malaysia adopts an open economy policy which allows for the development of a strong economy and growth in per capita income. Nonetheless, as a small and open economy, Malaysia is susceptible to external shocks such as the 2008 financial crisis. Hiking international food price and the shortage of food in early 2008 have imposed a challenge to the national paddy sector. The increase in average world crude oil prices from USD69.08 per barrel in 2007 to USD101.56 per barrel in 2009 saw accompanied escalation in world food commodity prices, resulting in increases in input costs and hence the cost for food production (FAO, 2012).

1.5 Problem Articulation

Issue 1: The share of energy use in the paddy production
Paddy sector is reported by Soni et al., (2013) to be one of the energy consumption requires at all stages of production. According to an FAO statement, countries with higher energy use tend to have higher agricultural yields (FAO, 2000). Energy use includes fuel for running machinaries, electricity for irrigation, fertilizer for improving soil fertility, pesticides for paddy pests control and seeds for planting.

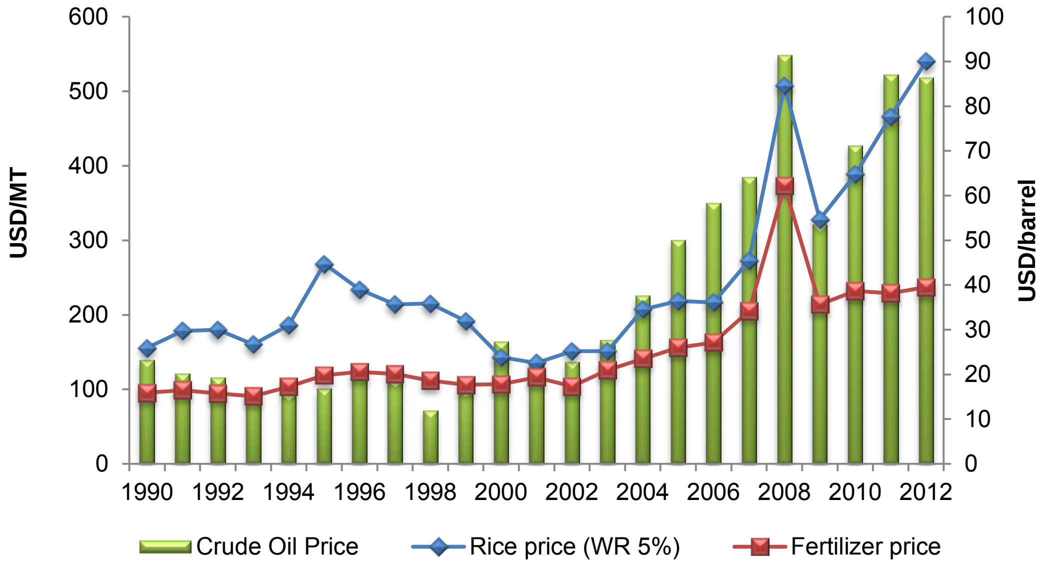

Figure 1.2. Price of crude oil (USD/barrel), fertilizer and rice (USD/MT) in world market (1990-2012)
(Source: InflationData.com, (2013) and FAO, (2012))

A strong correlation of movement between world crude oil prices, fertilizer and rice prices. Hence, an increase in the petroleum price is expected to affect farmers' input expenditure, productivity and income. The contribution of energy into the paddy production has to be established before estimating the impact on the sector. <u>What is the share of energy use by activity and sources in paddy production?</u>

Issue 2: Change in fuel prices
Fuel and fertilizers are agricultural inputs in paddy production. Fuel is needed for operating paddy machineries such as tractors and harvesters, while fertilizers are important for keeping the soil for paddy crop fertile (Bundschuh & Chen, 2014). Farmer's expenditure includes fuel (petrol and diesel), input (fertilizer, pesticides and seed) and labor cost. The international price increase in fuel and food has direct impact on production cost and domestic prices. Malaysia is shown to have unprecedented increase in energy prices in Figure 1.3. This is due to high demand from all economic sectors (ECM, 2011).

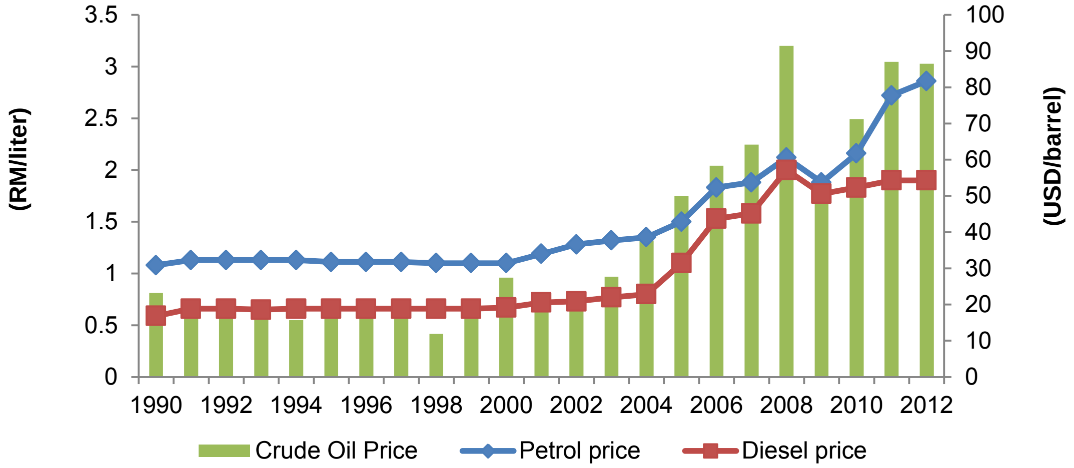

Figure 1.3. Domestic price for diesel and petrol (RM/liter) and World crude oil price (USD/barrel) (1990-2012)
(Source: InflationData.com, (2013) and MEIH, (2013)
Note: Domestic price equal to domestic market price including fuel subsidy

The share of fuel cost is 12.5% of the total paddy production cost, but the fertilizer cost is about 40% (currently subsidized by government) will be affected by the fuel increase indirectly. Growth in fuel price will affect paddy productivity and by farmers' expenditure. This brings the question of what is the impact of an increase in fuel price on paddy productivity and farmers expenditure?

Issue 3: Dependency on subsidies and government initiatives
Despite extensive market intervention, there is little development and no significant growth in the Malaysian paddy sector particularly with relation to its productivity issue. Paddy productivity refer to average paddy yield by paddy area. The average paddy yield in Malaysia is 3.6 tonnes per ha per season in 2012, lower than most countries (DoS, 2013b). Paddy productivity in Vietnam and China is 5.63 tonnes/ha and 6.7 tonnes/ha per season, respectively (FAO, 2012). There are evidences to show that, dependency on subsidies and government initiatives encourages inefficiency in the industry. Due to tight control, farmers do not respond to market signals such as increasing fuel prices and input cost.

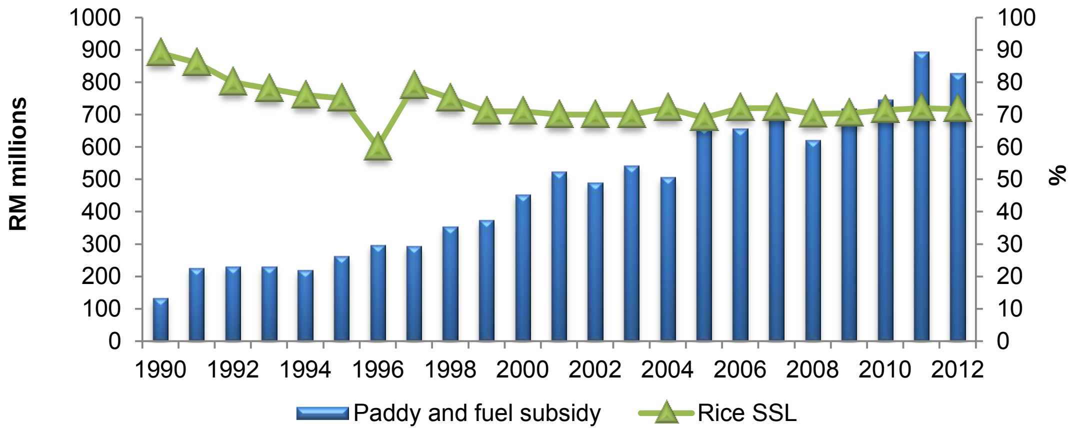

Figure 1.4. Malaysia, rice SSL (%) and subsidies of paddy and fuel (RM) (1990-2012)
(Source: DoS, various years, MoA, 2013 and KPDNK, 2013)

In Figure 1.4, paddy subsidy refer to payment transfer by government for fertilizer and paddy price subsidy (also known as cash subsidy). Meanwhile, fuel subsidy refer to petrol and diesel price. The average growth rate for paddy productivity since 1990 to 2012 was 1.5% vs. subsidy at 12.6%. SSL remains almost stagnant despite an increasing in subsidies. Fuel and fertilizer are chosen as direct and indirect energy in this research because of both energy are subsidized by government. Hence, the government policy will effect paddy production sector. What is the impact of paddy and fuel subsidies withdrawal on paddy expenditure and farmers' income.

The energy use in paddy production sector utilises energy analysis (EA) approach. System dynamics (SD) is a methodology that can be used to understand the behaviour of a complex system. This is because SD model are interested in general dynamics tendencies; whether the system as a whole is stable or unstable, oscillating, growing, declining or in equilibrium. The complex systems arise from its causal structure from the pattern of physical and information in the whole system. The idea of two-way causation or feedback use to understand system structure. This method is suitable in studying the issue as it addresses the circular relationship between variables over time, characterized by interdependence, mutual interaction, information feedback and circular causality (Sterman, 2004). The research questions of the study are;

1) What is the share of energy use by activity and sources in paddy production?
2) What is the impact of an increase in world crude oil price on paddy productivity and farmers expenditure?
3) What is the impact of fuel subsidy withdrawal on expenditure and income?
4) What is the impact of paddy subsidies withdrawal on expenditure and income?
5) What is the impact of paddy and fuel subsidies withdrawal on paddy expenditure and farmer's income?

1.6 Objectives of the Study

The general objective of this study is to examine the impact of paddy and energy subsidies withdrawal on paddy production in Malaysia. There are four main specific objectives in this study;

1) To formulate the share of energy use by activity and sources in the paddy sector;
2) To simulate a change in world crude oil price on the paddy productivity and expenditure;
3) To simulate the impact of paddy and fuel subsidies removal on the expenditure and farmers' income; and
4) To simulate the impact of various policy scenarios on the paddy sector.

1.7 Significance of the Study

There are three significant contributions of the study. The first significance is originality, where this study develops a new model that evolved from tested new variables combined with a review of the current study. This new model is believed to contribute towards better comprehension on the mutual influence among the variables. The second significant contribution of the study is novelty as the study makes an improvements from previous research. The improvements are in term of deeper understanding on the subject matter, detailed analysis, broader literature, diversified variables and combined theory.

Last but not least is the contribution towards knowledge. In order to contribute towards the expansion of knowledge, sense of novelty is required to bring new innovation and fresh ideas to the field of study. Existence of more studies and findings contribute to the development of new model, new validated results by revised variables, new simulation technique through advanced formulation and theory, better methodology and improved data analysis. Implementation of new intervention is also feasible through upgraded model and theory. When this study is published, data related to the construction of the model, mainly primary data, are used as a reference with the latest insights on the subject and helps to improve understanding and knowledge among researchers. However, the results of this study will invite new questions due to the different dimensions of the model. With this knowledge developed in the field of study, this study is deemed as worthwhile to conduct.

1.8 Chapter Organization

The research is organized into six chapters. The first chapter begins with an introduction to the agriculture and energy sectors in Malaysia. Agricultural policy is shelled to understand the structure of the paddy sector in Malaysia. This is followed by problem statement and objectives of the research. Chapter Two describes the paddy and energy sector in Malaysia related to the economic actors that influence the paddy production. The characteristics of supply and demand functions, government's role, instruments used and policy implementation for both paddy and energy sector are also discussed in this chapter.

The discussion in Chapter Three mainly focuses on the review of previous literature in the analysis of energy use in paddy sector, system dynamics methodology and its analysis in paddy crop and energy sector. Various government policies in term of production, price levels and subsidies that were adopted to better promote the development of paddy industry are also examined.

Chapter Four introduces two methods are used by researchers including EA and SD. The first method is the interpretation of energy use in terms of the coefficient value in analysing the short run relationship between the output and input. Later, the model is estimated for cointegration by using the SD to examine the long-run relationship and dynamic interactions among the variables of interest.

The findings are discussed in Chapter Five. Energy analysis is conducted to analyse the usage pattern and share of energy use according to respective activity and source in paddy production. The Theil inequality statistics are conducted for the key variables to quantify the magnitude and nature of the errors existing in the system dynamics model. Simulation results from different scenarios are later presented in this chapter. The tests on the model structure, behaviour and policy analysis are included in this research. The discussion and conclusion from the main finding for paddy and energy relationship in Malaysia from the period 1990 to 2030 are wrapped in Chapter Six. This is followed by a discussion on policy implication before concluding with limitations of the current study and suggestions for future research.

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APPENDICES A

DATA COLLECTION

Information	No.		Units
Farmer	1	**Total farmer in MADA**	By PPK (27 units PPK)
	2	**Farmer's background**	
		Region	Wilayah I,II,III,IV
		Farm size category	re/ he / ac
		Status of land	Owner, Tenant, Owner-Tenant
		Name	
		Adress	
		Age	years
		Education	No education, SRP, SPM, above SPM
		Profession	Full-time / part-time
		Experience	years
		Training status	Years
		No. of household	
	3	**Crop information**	
		Average yield	Ton/ha/season
		Price of paddy	RM/kg
		Place to selling paddy	BERNAS, Private milling
		Production cost	RM/ha, RM/re
		Variety of seed	MR219, MR232, MR220 CL1, CL2, MR211, others
		Soil type	Marine and estuarines clays, Riverine alluvium, Others
		Planting method	Direct seeding
Irrigation & Drainage	1	Irrigation block	
	2	Area irrigated	ac / ha / re
	3	Irrigation pump	
	4	Type pf pumps	Booster, recycled pum
	5	Water flow rate	Q
	6	Water sources	
	7	Irrigation phases	I, II, III
	8	Minimum pumping level	For recycled pump (cm)
Production cost	1	Activity (RM)	a) Post-harvest
			b) Land preparation
			c) Planting
			d) Applying input
			e) Harvesting
Applying input	1	Seed	Price (RM)
			Quantity/re/ha
	2	Chemical control	Price (RM)
			Quantity/re/ha
	3	Human	Wage (RM/re) (RM/day)
			Duration time (time/re/ha)
The use of machinery by activity	1	Land preparation	a) Machinery/Implement types
	2	Planting	b) Model
	3	Applying input	c) Capacity (hp)/(Watt)
	4	Harvesting	d) Weight of machine (kg)
			e) Implement width (m)
			f) Operation speed (km/ha)
			g) Duration of operation (hours/ha)
			h) Fuel consumption (RM/L) / (L/re/ha)
			i) Life-long (years / seasons)

Notes: 1 relong (re)=0.3475 ha, 1acres (ac)=2.4711ha, 1 horse power (hp)=746 Watt

APPENDICES B

QUESTIONNAIRE

ENERGY USE IN PADDY PRODUCTION IN THE MADA AREA, MALAYSIA

Faculty of Economics and Management, Universiti Putra Malaysia

The purpose of this study is to obtain information related to energy consumption foer each activity in the paddy production. Findings from the study will be a good guideline for researcher in making appropriate decisions concerning to the energy efficiency in paddy production sector in the MADA area. With this, the resources will be protected and efficiently managed. Consequently, the resources will be viable for the consumption of future researchers.

Hence, your willingness in contributing information to this questionnaire would be useful in achieving the purpose of the study. Your willingness in spending time for the questionnaire is highly appreciated. All the information obtained from the respondents will be utilized fully for the purpose of research only and kept confidential by the researcher.

Location :
Region :
Season :
Interviewer name. :

Prepared by,
SITI 'AISYAH BINTI BAHARUDIN
A student of Ph.D. of Economics

PART A: FARMER'S BACKGROUND

1. Farm size category (1 relong = 0.3475 hectares)

Relong	Hectares	NKEA's member
		Yes/No

2. Name of farmer

Age	Education	Profession	Experience (year)	Training status (season)	No. of household

3. Address of the household

PART B: CROP INFORMATION

1.Paddy

Information	Main season	Off-season
Yield (ton/re)		
Price of paddy (RM/kg)		
Selling paddy to (BERNAS /Private)		
Soil type		
Status of land (re)	Tenant :	
	Owner :	

2.Variety of seed

☐ MR 219 ☐ MR 220 CL1 ☐ MR 211

☐ MR 232 ☐ MR 220 CL2 ☐ Others (specify)________

PART C: ENERGY USE IN PRODUCTION PROCESS

1.Land preparation

Tillage	Capacity of machine (hp)	Weight of machine (kg)	Fuel (ℓ/re) / (RM/ℓ)	Operating speed (km/re)	Wage (RM/re)
1st Plowing					
2nd Plowing					
3rd Plowing					
Levelling					

2.Planting

Method	Machinery				Manual	
	Weight (kg)	Power (hp)	Fuel (ℓ/re) / (RM/ℓ)	Operating speed (km/re)	Operation time (hour/re)	Wage (RM/day)
Direct Seeding						

3.Crop Management

Inputs	Quantity & Price	Main season	Off-season
a) Seed	Amount (kg/re)		
	Price (RM/kg)		
b) Chemical control			
Pesticides (specify)	Amount (ℓ/re)		
	Price (RM/ℓ)		
Herbicide (specify)	Amount (ℓ/re)		
	Price (RM/ℓ)		
Fungicide (specify)	Amount (ℓ/re)		
	Price (RM/ℓ)		

Others (specify)	Amount (kg/re)		
	Price (RM/kg)		
Others (specify)	Amount (kg/re)		
	Price (RM/kg)		
c) Fertilizer Manure			
Urea	Amount (kg/re)		
	Price (RM/kg)		
Others (specify)	Amount (kg/re)		
	Price (RM/kg)		
Others (specify)	Amount (kg/re)		
	Price (RM/kg)		
d) Labor			
Activity (specify)	Operation time (hour/re)		
	Wage (RM/day)		
Activity (specify)	Operation time (hour/re)		
	Wage (RM/day)		

4.Irrigation

a) Irrigation

No. of irrigation	Operation time (hour)	Rate of electricity (RM/kWh)	Bill for irrigation (RM)

b) Pumps

No. of pumps	Weight (kg)	Power (hp)	Voltage (Volt)	Current (Amp)	Operating speed (km/re)	Rate of electricity (RM/kWh)	Bill paid for electricity (RM)	Area irrigated (ha)

5.Harvesting

Season	Machinery					Wage (RM/re)
	Weight (kg)	Power (hp)	Fuel (ℓ/re) / (RM/ℓ)	Operating speed (km/re)	Amount harvested (ton/re)	
Main						
Off						

APPENDICES C

DISTRIBUTION OF THE INTERVIEWED RESPONDENTS IN THE STUDY AREA

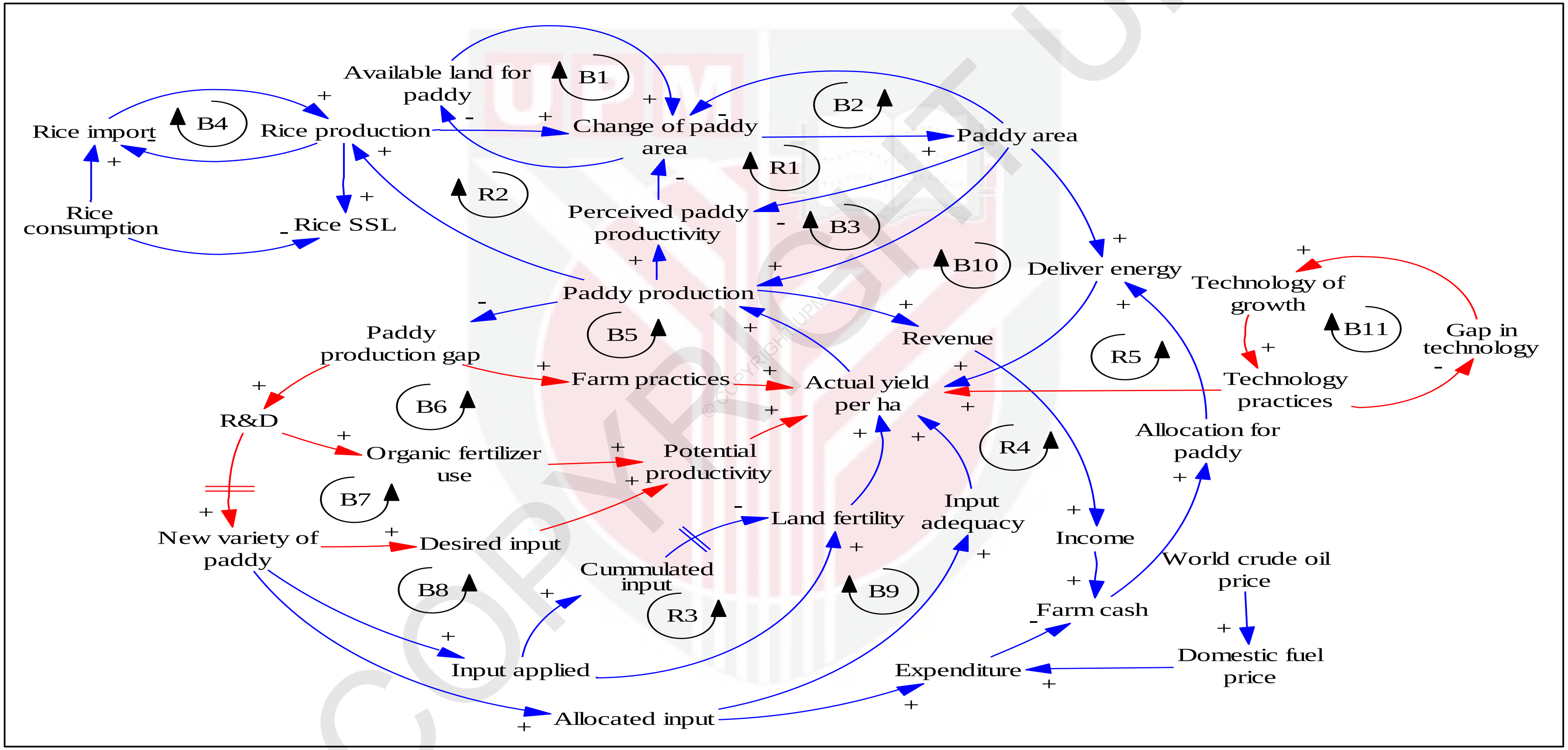
Province	Localiti	No. of farmers (N)	No of respondent (S)
Wilayah I	A-I – Arau (PPK Harapan Mewah)	1,612	2
	B-I – Kayang (PPK Muda Sepakat)	2,266	4
	C-I – Kangar (PPK Bahagia)	1,592	2
	D-I – Tambun Tulang (PPK Setia Jaya)	1,956	2
	E-I – Simpang Empat Perlis (PPK Jayadiri)	2,995	5
	TOTAL : 5	**10,421**	**15**
Wilayah II	A-II – Kodiang	2,232	2
	B-II – Sanglang	2,6632	2
	C-II – Kerpan	2,161	2
	D-II – Tunjang (PPK Sinar Bahagia)	2,437	1
	E-II – Kubang Sepat (PPK Usahajaya)	2,111	2
	F-II – Jerlun (PPK Semangat Baru)	2,017	2
	G-II – Jitra (PPK Empat Serangkai)	1,505	2
	H-II – Kepala Batas (PPK Tenaga Baru)	2,111	1
	I-II – Kuala Sungai (PPK Semangat Baru)	2,556	1
	TOTAL : 9	**19,762**	**15**
Wilayah III	A-III – Hutan kampong (PPK Muda Jaya Kinabalu)	2,404	2
	B-III – Alor Senibong (PPK Muda Gerak Maju)	2,121	2
	C-III – Tajar (PPK Aman)	2,754	2
	D-III – Titi Hj. Idris (PPK SilatulRahim)	2,490	2
	E-III – Kobah	1,560	2
	F-III – Pendang	1,928	5
	TOTAL : 6	**13,257**	**15**
Wilayah IV	A-IV – Batas Paip (PPK Seri Pantai)	2,012	2
	B-IV – Pangkalan Kundor (PPK Tun Adam Malik)	1,439	2
	C-IV – Simpang Empat Kangkong (PPK Suka Setia)	2,098	3
	D-IV – Permatang Buluh (PPK Usaha Padu)	1,989	2
	E-IV – Bukit Besar	2,599	2
	F-IV – Sungai Limau Dalam	2,264	2
	G-IV – Guar Chempedak (PPK Seri Jerai)	2,094	2
	TOTAL : 7	**14,495**	**15**
MADA	**27 PPK**	**55,130**	**60**

Source: Field survey 2012 season

Note: The representative farmers were chosen according to many considerations (criteria respondents) that could make possible successful achievement of the study objectives and enable smooth running of field surveys.

APPENDICES D

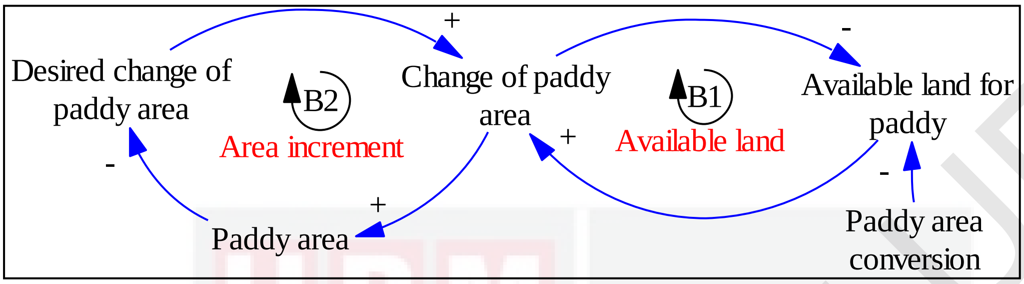
CAUSAL LOOP DIAGRAM (FULL-MODEL)



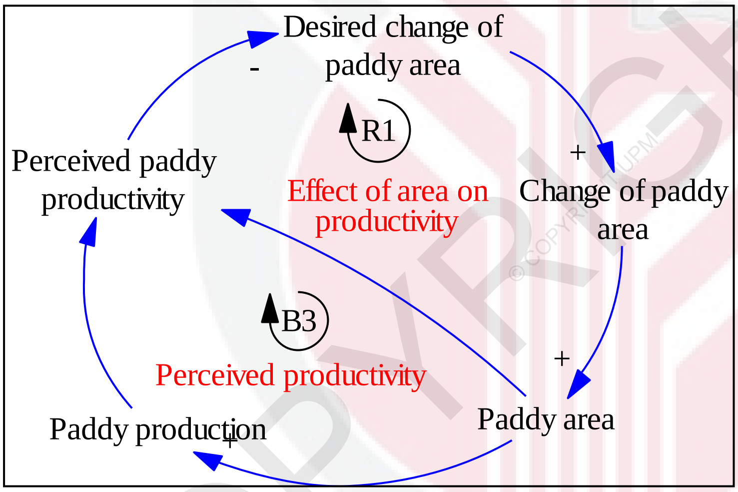
APPENDICES E

CAUSAL LOOP DIAGRAM (SUB-MODEL)

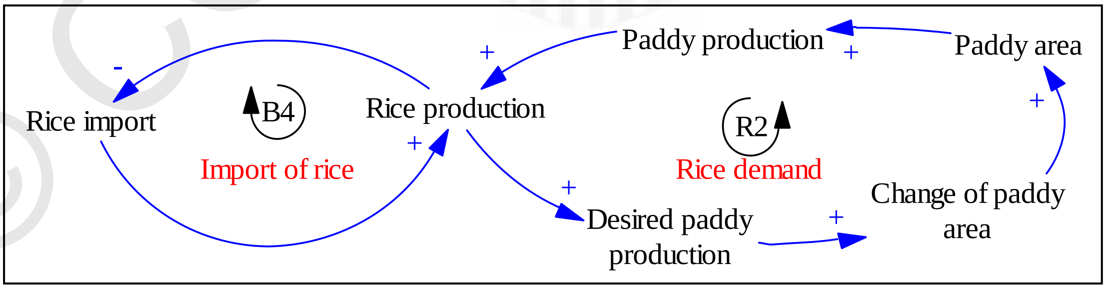
Sub-Model (Paddy Area)



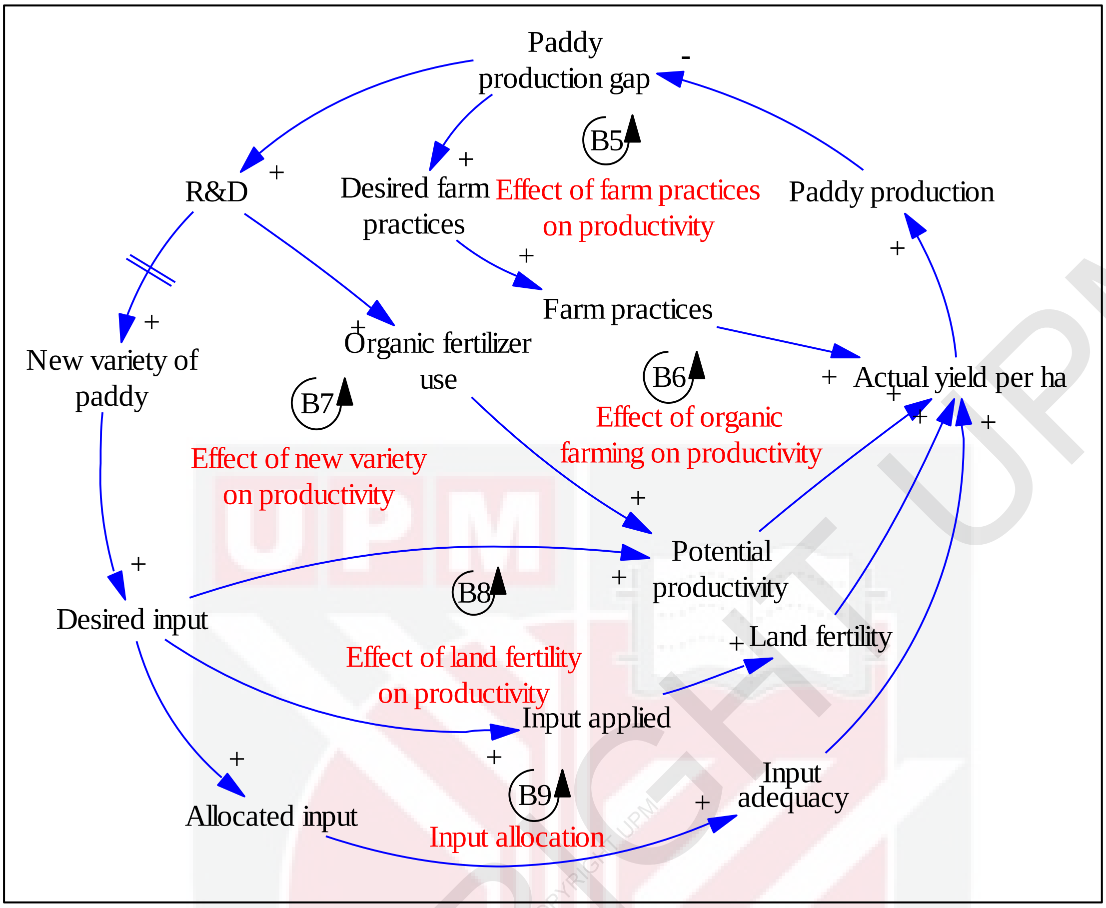
Sub-Model (Productivity)



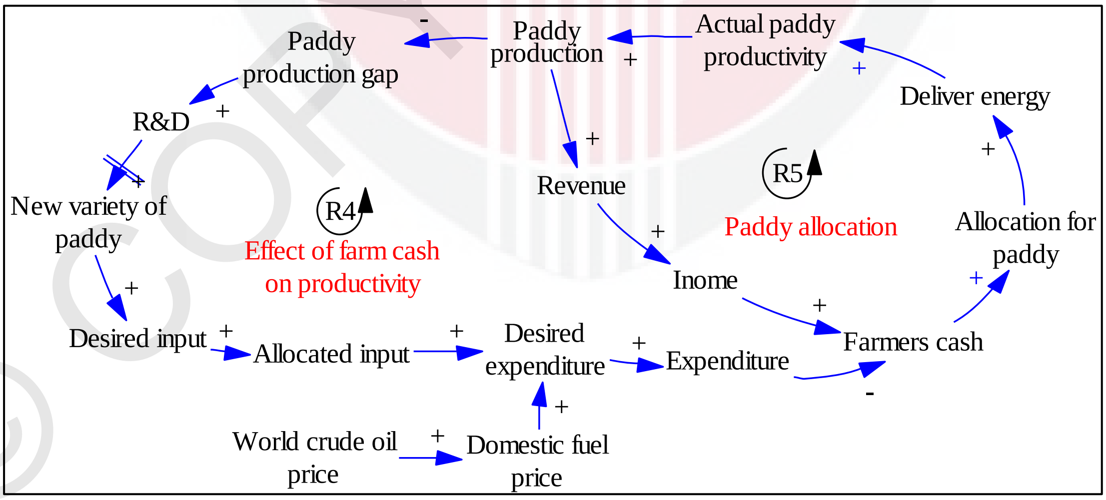
Sub-Model (Consumption)



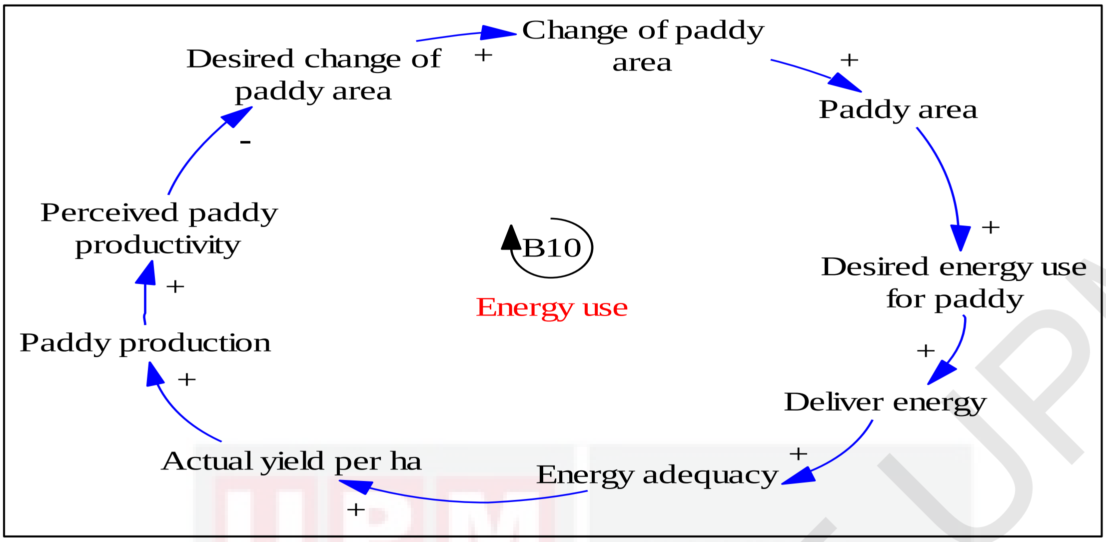
Sub-Model (Input)



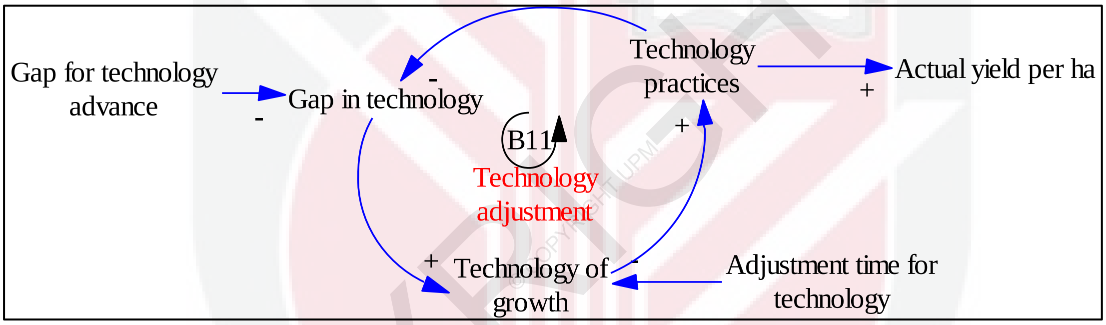
Sub-Model (Farm Cash)



Sub-Model (Energy Use)



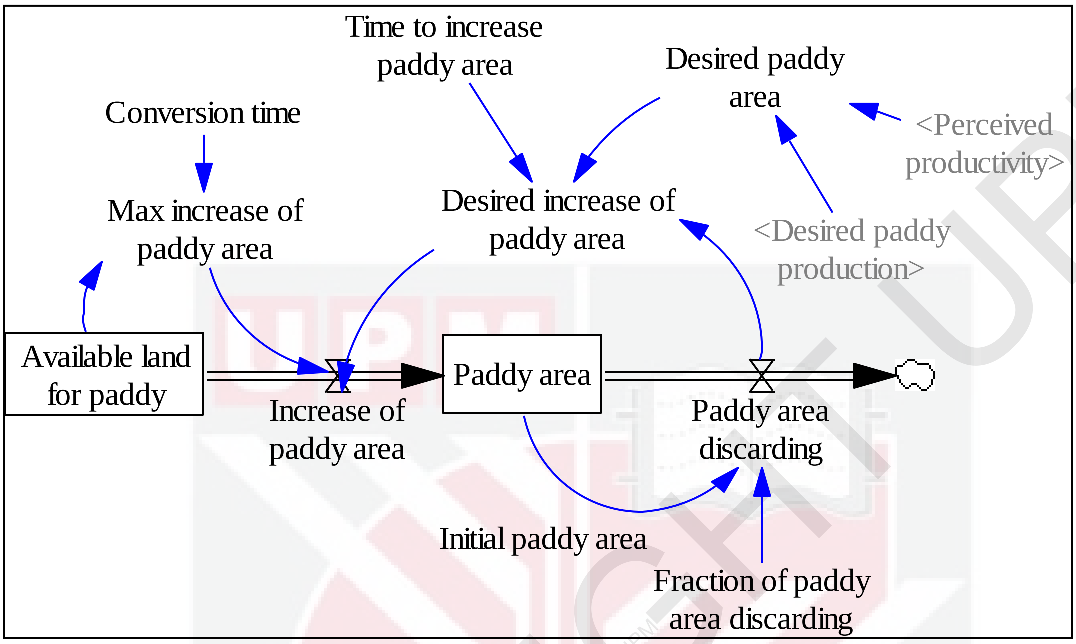
Sub-Model (Technology Practices)



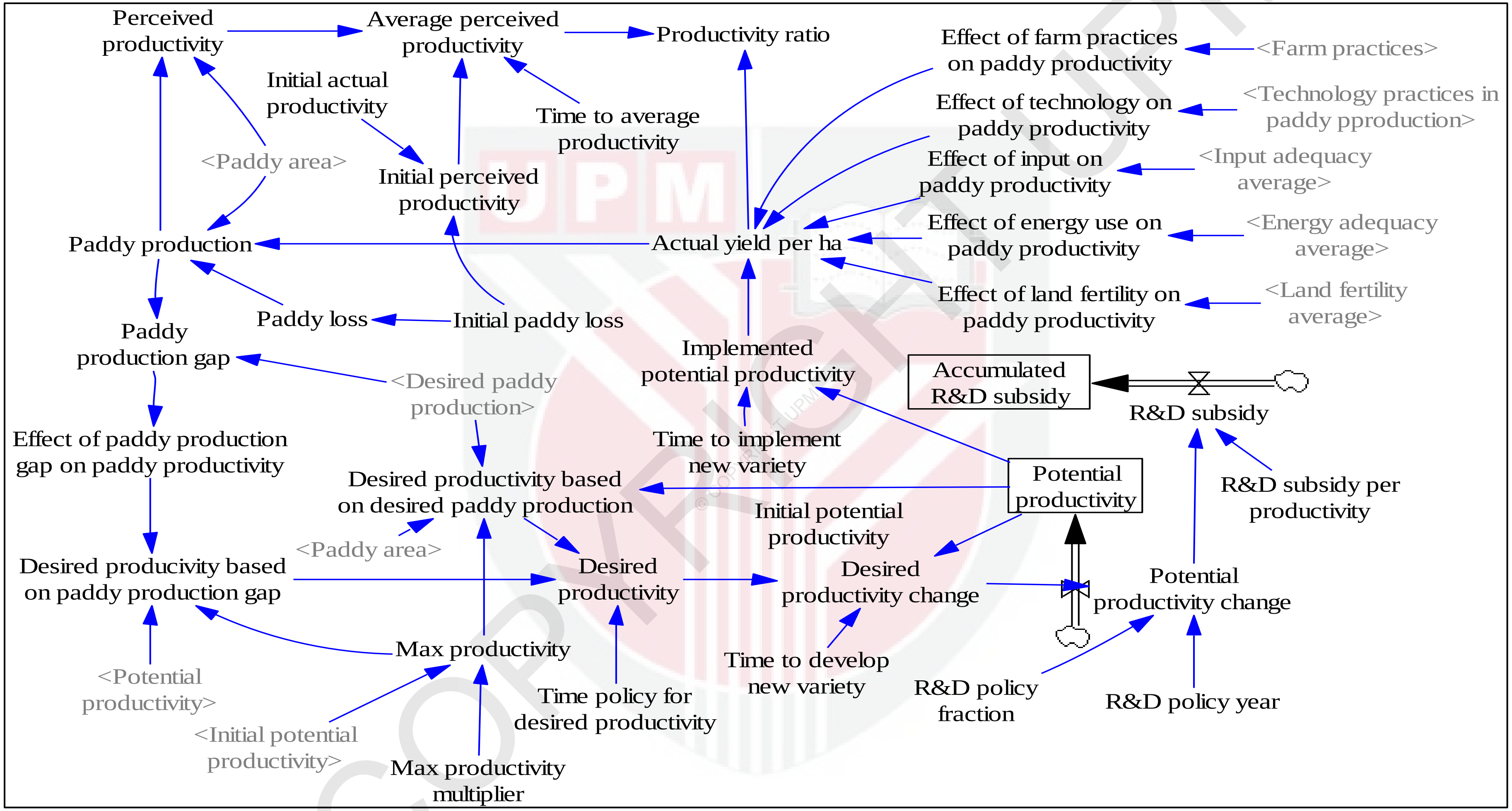
APPENDICES F

STOCK AND FLOW DIAGRAM (SUB-MODEL)

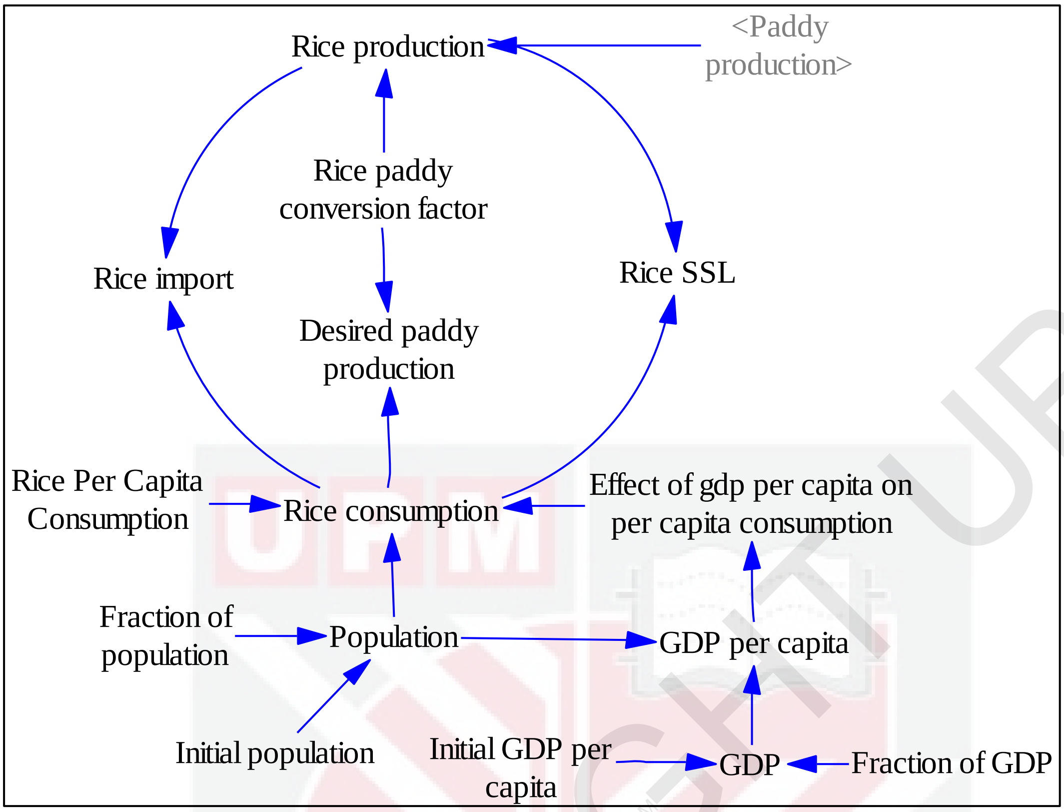
Sub-Model (Paddy Area)



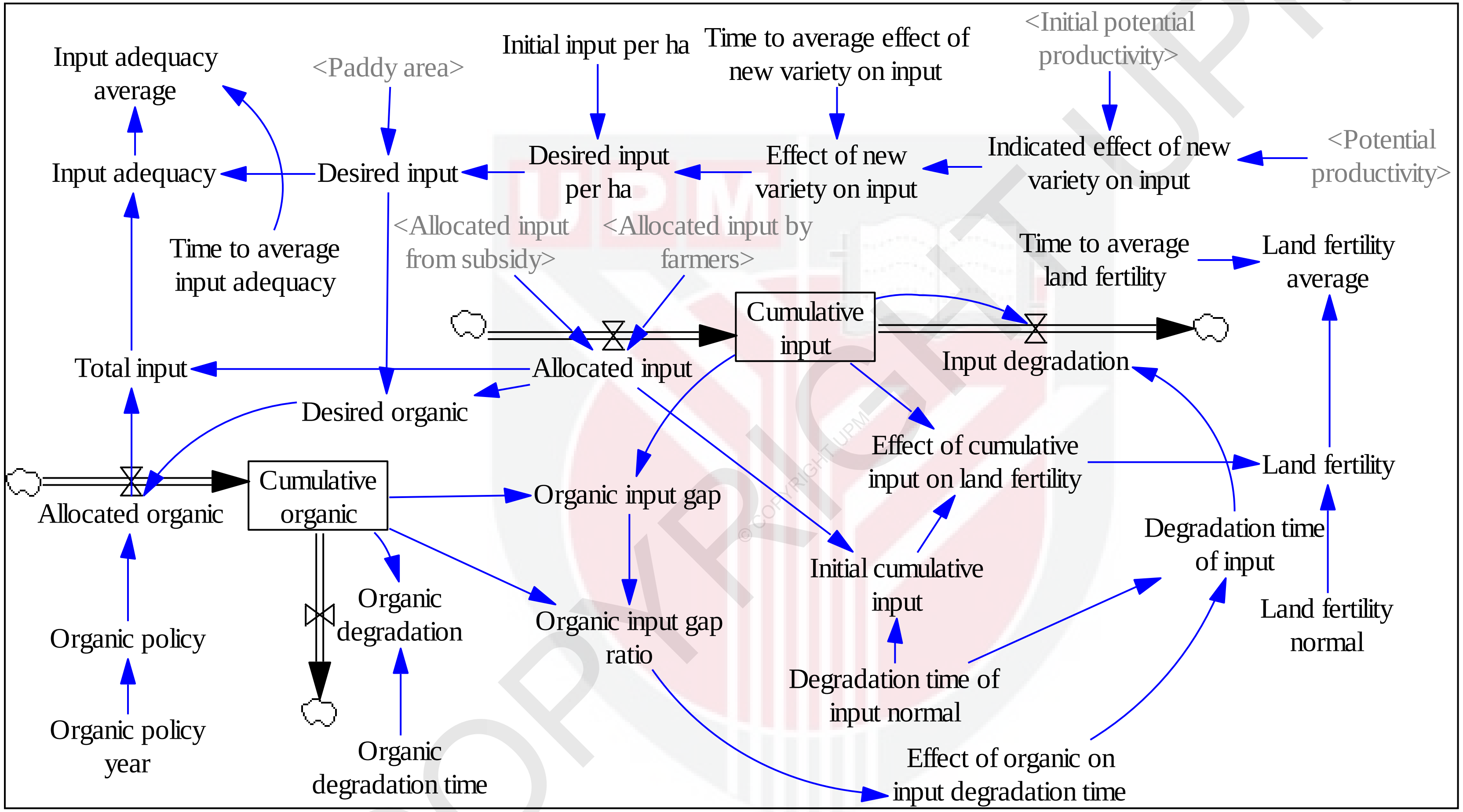
Sub-Model (Productivity)



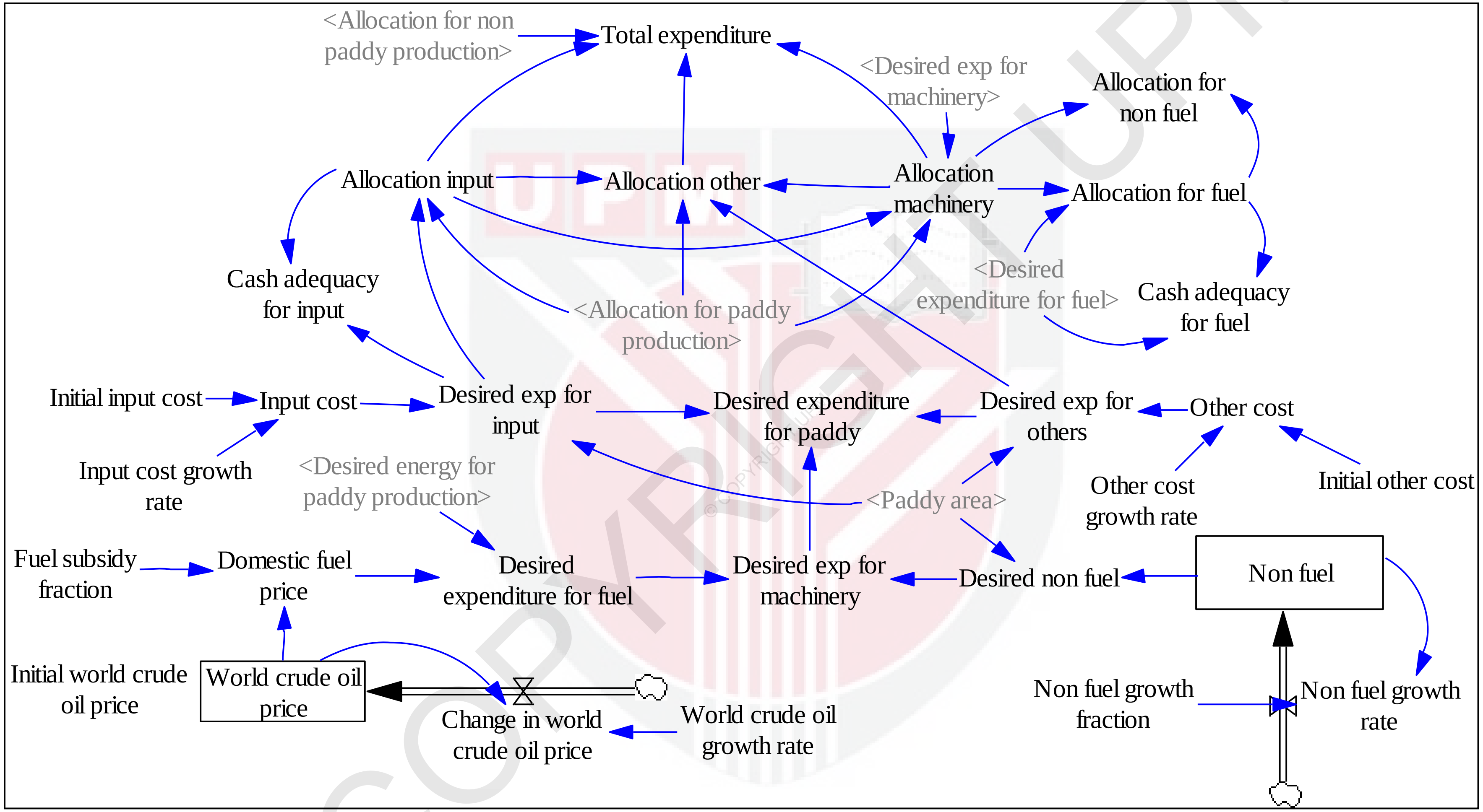
Sub-Model (Consumption)



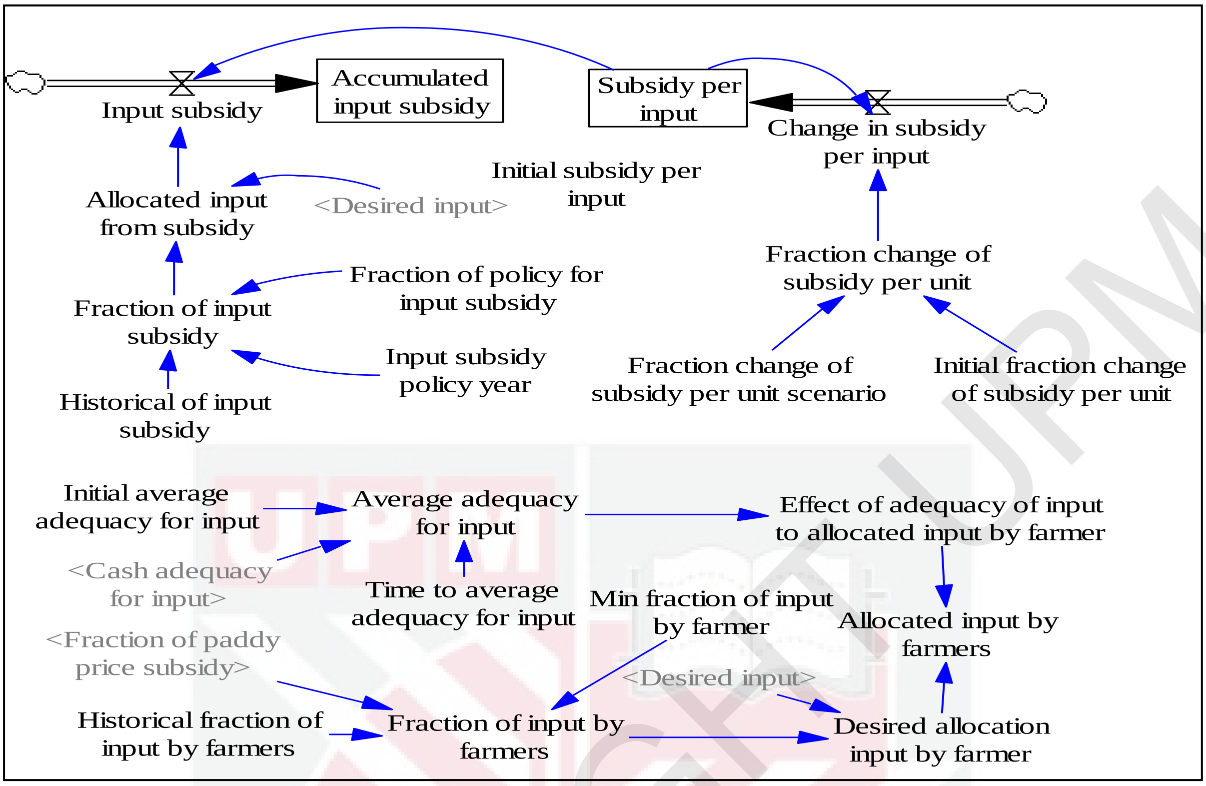
Sub-Model (Input)



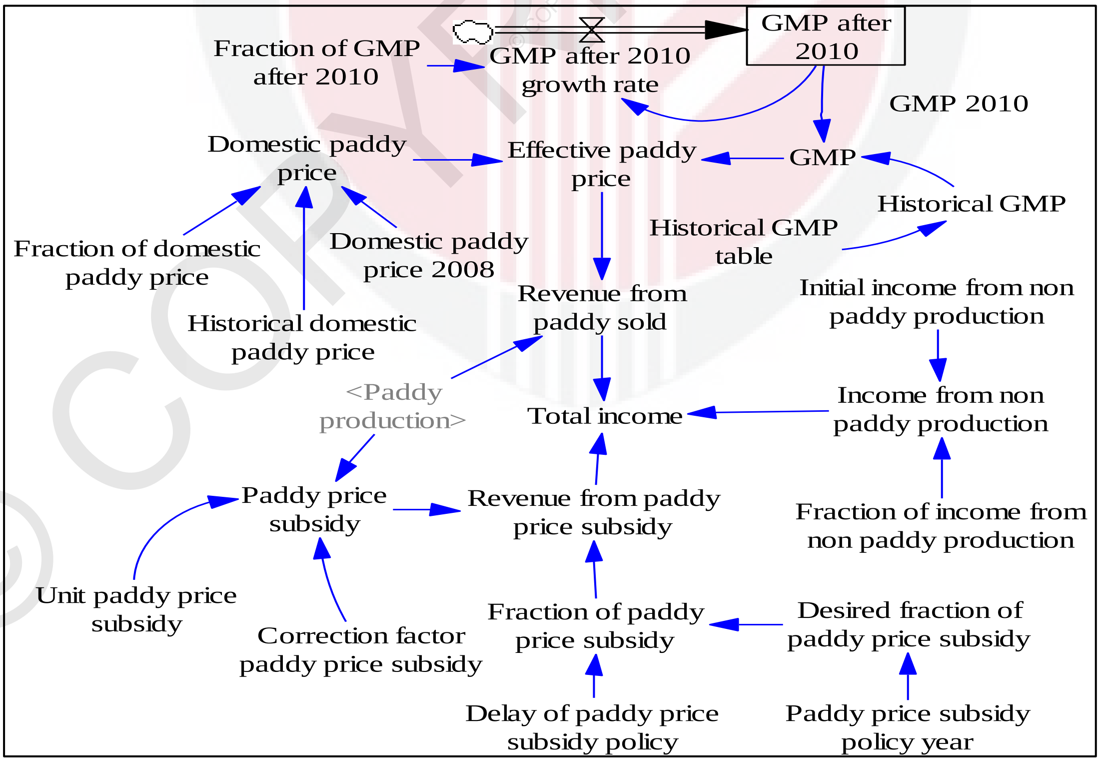
Sub-Model (Expenditure)



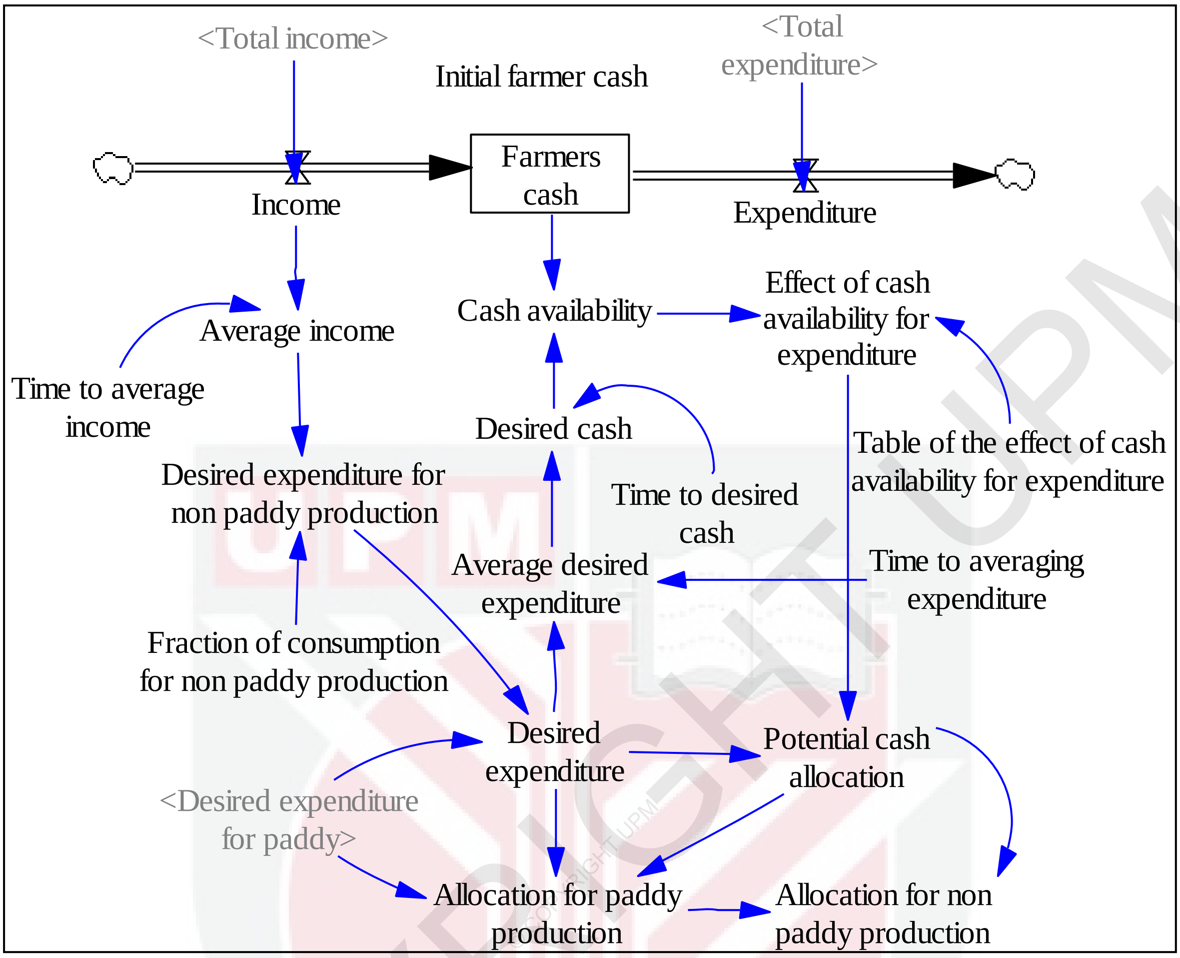
Sub-Model (Allocated Input)



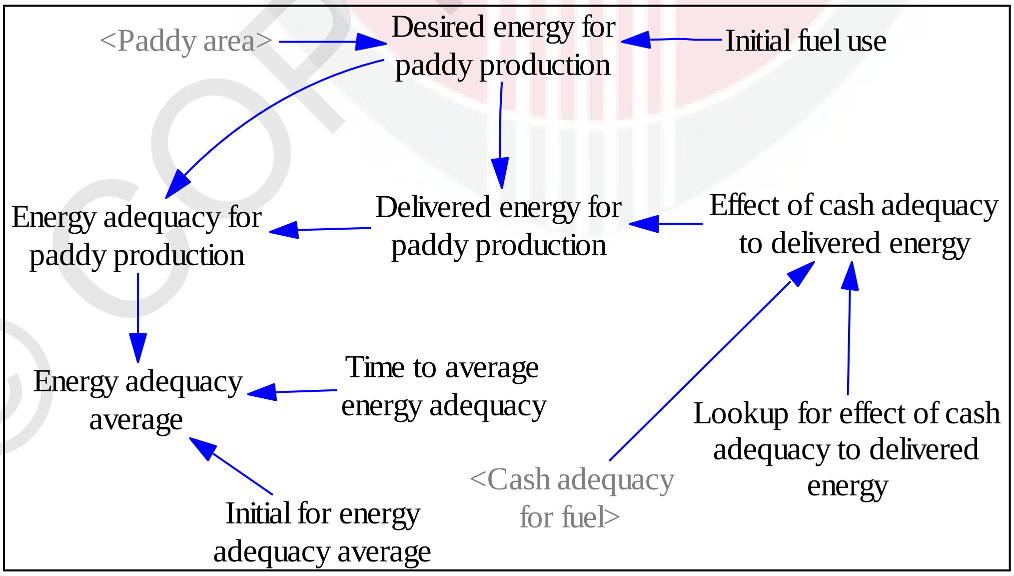
Sub-Model (Income)



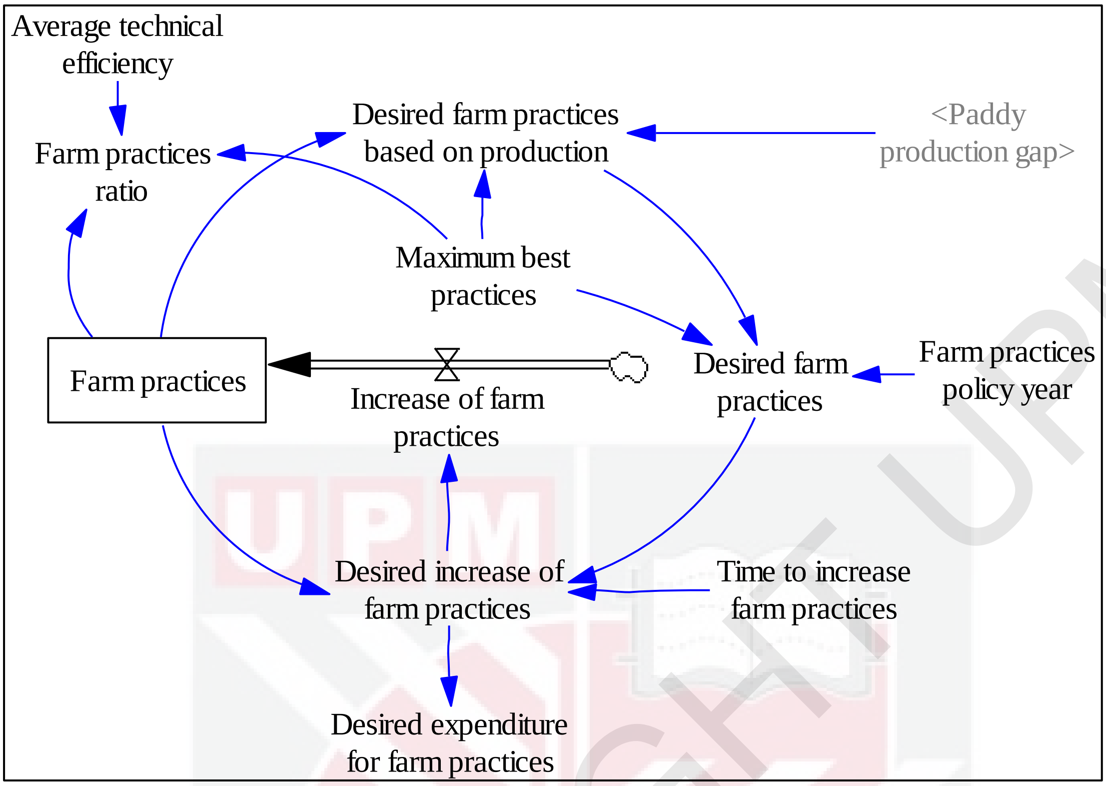
Sub-Model (Farm Cash)



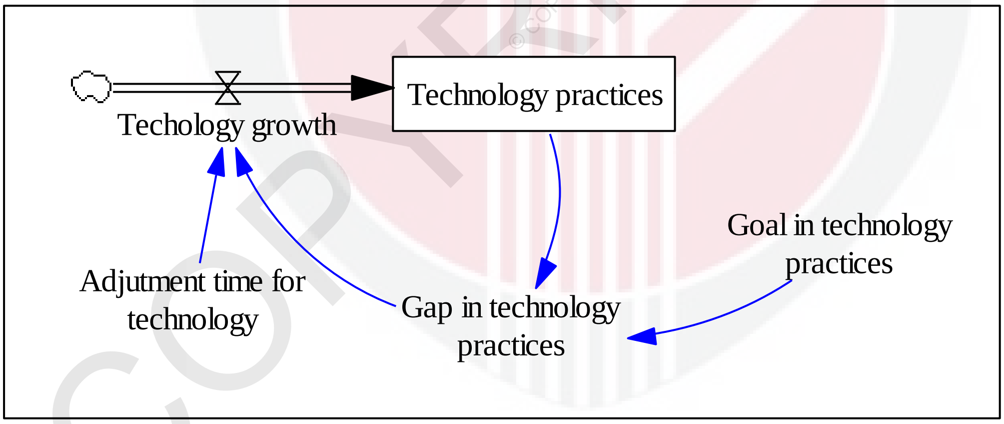
Sub-model (Energy Use)



Sub-model (Farm Practices)



Sub-model (Technology Practices)



APPENDICES G

VARIABLES AND EQUATIONS

Sub-model (Paddy Area)

Available land for paddy= INTEG (-Increase of paddy area,88000)
Units: ha

Conversion time=8
Units: Year

Desired increase of paddy area=MAX(0, Desired paddy area/Time to increase paddy area+Paddy area discarding)
Units: ha/Year

Desired paddy area=Desired paddy production/Perceived productivity
Units: ha

Desired paddy production=Rice consumption*Rice paddy conversion factor
Units: t

Fraction of paddy area discarding=0.0075
Units: Dmnl/Year

Increase of paddy area=MIN(Desired increase of paddy area, Max increase of paddy area)
Units: ha/Year

Initial paddy area=680647
Units: ha

Max increase of paddy area=Available land for paddy/Conversion time
Units: ha/Year

Paddy area= INTEG (Increase of paddy area-Paddy area discarding,Initial paddy area)
Units: ha

Paddy area discarding=Fraction of paddy area discarding*Paddy area
Units: ha/Year

Perceived productivity=Paddy production/Paddy area
Units: t/ha
Time to increase paddy area=1
Units: Year

****

Sub-model (Productivity)

"Accumulated R&D subsidy"= INTEG ("R&D subsidy",0)
Units: RM/(ha*Year)

Actual productivity=Implemented potential productivity*Effect of input on paddy productivity*Effect of land fertility on paddy productivity*Effect of energy use on paddy productivity*Effect of technology on paddy productivity* Effect of farm practices on paddy productivity
Units: t/ha

Average perceived productivity=SMOOTHI(Perceived productivity, Time to average productivity, Initial perceived productivity)
Units: t/ha

Desired paddy production=Rice consumption*Rice paddy conversion factor
Units: t

Desired producivity based on paddy production gap=MIN(Max productivity, Potential productivity*Effect of paddy production gap on paddy productivity)
Units: t/ha

Desired productivity=IF THEN ELSE(Time<Time policy for desired productivity, Desired producivity based on paddy production gap, Desired productivity based on desired paddy production)
Units: t/ha

Desired productivity based on desired paddy production=MIN(MAX(Desired paddy production/Paddy area, Potential productivity), Max productivity)
Units: t/ha

Desired productivity change=(Desired productivity-Potential productivity)/Time to develop new variety
Units: t/(ha*Year)

Effect of energy use on paddy productivity= WITH LOOKUP (Energy adequacy average,([(0,0.6)(1,1)],(0,0.6),(0.0550459,0.631579),(0.189602,0.668421),(0.299694,0.707018),(0.385321,0.736842),(0.470948,0.849123),(0.64526,0.875439),(0.761468,0.9),(0.889908,0.926316),(0.993884,0.996491)))
Units: Dmnl

Effect of farm practices on paddy productivity= WITH LOOKUP (Farm practices, ([(1.4,0)(1.7,1)],(1.00214,0.0394737),(1.04495,0.188596),(1.12202,0.285088),(1.21621,0.39912),(1.28685,0.47807),(1.37248,0.144737),(1.4367,0.188596),(1.51804,0.447368),(1.59511,0.653509),(1.67859,1.01754)))
Units: Dmnl

Effect of input on paddy productivity= WITH LOOKUP (Input adequacy average, ([(0,0.8)-(1,1)],(0,0.89),(0.1,0.9),(0.2,0.9),(0.3,0.91),(0.4,0.91),(0.5,0.91),(0.6,0.92),(0.7,0.92),(0.8,0.93),(0.9,0.93),(1,1)))
Units: Dmnl

Effect of land fertility on paddy productivity= WITH LOOKUP (Land fertility average,([(0,0.4)-(1,1)],(0,0.5),(0.1,0.51),(0.2,0.54),(0.3,0.59),(0.4,0.66),(0.5,0.74),(0.6,0.83),(0.7,0.9),(0.8,0.95),(0.9,0.98),(1,1)))
Units: Dmnl
Effect of paddy production gap on paddy productivity= WITH LOOKUP (Paddy production gap,([(0,1)-(1,2)],(0,1),(0.1,1),(0.2,1.03),(0.3,1.08),(0.4,1.16),(0.5,1.25),(0.6,1.37),(0.7,1.51),(0.8,1.65),(0.9,1.8),(1,2)))
Units: Dmnl

Effect of technology on paddy productivity= WITH LOOKUP (Technology practices in paddy pproduction,([(0.2,0.8)-(0.8,2)],(0.21,0.99),(0.24,0.991),(0.29,0.992),(0.34,0.993),(0.38,0.994),(0.44,0.995),(0.5,0.996),(0.56,0.997),(0.63,0.998),(0.67156,1),(0.711927,1.00526),(0.763303,0.989474),(0.8,1.3)))
Units: Dmnl

Energy adequacy average=SMOOTHI(Energy adequacy for paddy production, Time to average energy adequacy, Initial for energy adequacy average)
Units: Dmnl

Farm practices= INTEG (Increase of farm practices,1)
Units: Dmnl

Implemented potential productivity=SMOOTHI(Potential productivity, Time to implement new variety, Potential productivity)
Units: t/ha

Initial actual productivity=2.8
Units: t/ha

Initial paddy loss=0.0072
Units: Dmnl

Initial perceived productivity=(1-Initial paddy loss)*Initial actual productivity
Units: t/ha

Initial potential productivity=3.5
Units: t/ha

Input adequacy average=SMOOTHI(Input adequacy, Time to average input adequacy, Input adequacy)
Units: Dmnl

Land fertility average=SMOOTHI(Land fertility, Time to average land fertility, Land fertility)
Units: Dmnl

Max productivity=Initial potential productivity*Max productivity multiplier
Units: t/ha

Max productivity multiplier=5
Units: Dmnl

Paddy area= INTEG (Increase of paddy area-Paddy area discarding,Initial paddy area)
Units: ha

Paddy loss=Initial paddy loss
Units: Dmnl

Paddy production=(Paddy area*Actual productivity)*(1-Paddy loss)
Units: t

Paddy production gap=(Desired paddy production-Paddy production)/Desired paddy production
Units: Dmnl

Perceived productivity=Paddy production/Paddy area
Units: t/ha

Potential productivity= INTEG (Potential productivity change,Initial potential productivity)
Units: t/ha

Potential productivity change=IF THEN ELSE(Time<"R&D policy year", Desired productivity change, "R&D policy fraction"*Desired productivity change)
Units: t/(ha*Year)
Productivity ratio=Average perceived productivity/Actual productivity
Units: Dmnl

"R&D policy fraction"=1
Units: Dmnl

"R&D policy year"=2016
Units: Year

"R&D subsidy per productivity"=(4.6*1e+006)/0.2
Units: RM/t/Year

"R&D subsidy"=Potential productivity change*"R&D subsidy per productivity"
Units: RM/(ha*Year*Year)

Technology practices in paddy pproduction= INTEG (Techology growth,0.2)
Units: Dmnl

Time policy for desired productivity=2016
Units: Year

Time to average productivity=1
Units: Year

Time to develop new variety=5
Units: Year

Time to implement new variety=5
Units: Year

Sub-model (Consumption)

Desired paddy production=Rice consumption*Rice paddy conversion factor
Units: t

Effect of gdp per capita on per capita consumption= WITH LOOKUP (GDP per capita,([(4000,60)-(9000,90)],(4000,83.7),(4500,84.8),(5000,85.6),(5500,85.8),(6000,85.7),(6500,85),(7000,84),(7500,82.4),(8000,80.5),(8500,78),(9000,75.2)))
Units: Dmnl

Fraction of GDP=0.045
Units: Dmnl

Fraction of population=0.021
Units: Dmnl

GDP=Initial GDP per capita*EXP(Fraction of GDP*(Time-START TIME))
Units: RM/person

GDP per capita=GDP/Population
Units: RM*Year/(person*person)

Initial GDP per capita=4382
Units: RM/person

Initial population=1.81024e+007
Units: person/Year

Paddy production=(Paddy area*Actual productivity)*(1-Paddy loss)
Units: t

Population= Initial population*EXP(Fraction of population*(Time-START TIME))
Units: person/Year
Rice consumption=(Population*Effect of gdp per capita on per capita consumption)/1000
Units: t

Rice import=Rice consumption-Rice production
Units: t

Rice paddy conversion factor=1.5
Units: Dmnl

Rice Per Capita Consumption= WITH LOOKUP (Time,([(1990,60),(2030,100)],
(1990,87),(1991,90.3),(1992,93.6),(1993,90.9),(1994,87.2),(1995,86.9),(1996,95.2),
(1997,92.9),(1998,86.2),(1999,84.8),(2000,85),(2001,78.3),(2002,78.5),(2003,72.4),
(2004,77.1),(2005,79.2),(2006,76.8),(2007,77.5),(2008,77.9),(2009,79.6),(2010,79.6),
(2011,79.3),(2012,79.1),(2013,78.8),(2014,74.4826),(2015,73.7942),(2016,73.1058),
(2017,72.4174),(2018,71.729),(2019,71.0406),(2020,70.3523),(2021,69.6639),
(2022,68.9755),(2023,68.2871),(2024,67.5987),(2025,66.9103),(2026,66.2219),
(2027,65.5335),(2028,64.8451),(2029,64.1567),(2030,63.4683)))
Units: kg/peron

Rice production=Paddy production/Rice paddy conversion factor
Units: t

Rice SSL=(Rice production/Rice consumption)*100
Units: Dmnl

START TIME=1990
Units: Year

****

Sub-model (Input)

Allocated input=Allocated input from subsidy+Allocated input by farmers
Units: t/Year

Allocated input by farmers=Desired allocation input by farmer*Effect of adequacy of input to allocated input by farmer
Units: t/Year

Allocated input from subsidy=Fraction of input subsidy*Desired input
Units: t/Year

Allocated organic=Desired organic*Organic policy
Units: t/Year

Cumulative input= INTEG (Allocated input-Input degradation,Initial cumulative input)
Units: t

Cumulative organic= INTEG (Allocated organic-Organic degradation,1e-007)
Units: t

Degradation time of input=Degradation time of input normal*Effect of organic on input degradation time
Units: Year

Degradation time of input normal=50
Units: Year

Desired input=Desired input per ha*Paddy area
Units: t/Year

Desired input per ha=Initial input per ha*Effect of new variety on input
Units: t/(ha*Year)

Desired organic=Desired input-Allocated input
Units: t/Year

Effect of cumulative input on land fertility= WITH LOOKUP (Cumulative input/Initial cumulative input,([(0.8,0.4)-(2,1)],(1,1),(1.1,1),(1.2,0.98),(1.3,0.95),
(1.4,0.89),(1.5,0.8),(1.6,0.68),(1.7,0.58),(1.8,0.53),(1.9,0.51),(2,0.5)))
Units: Dmnl

Effect of new variety on input=SMOOTHI(Indicated effect of new variety on input, Time to average effect of new variety on input, Indicated effect of new variety on input)
Units: Dmnl

Effect of organic on input degradation time= WITH LOOKUP (Organic input gap ratio,([(0,0)-(1,1)],(0,1),(0.1,1),(0.2,0.97),(0.3,0.9),(0.4,0.72),(0.5,0.43),(0.6,0.27),
(0.7,0.19),(0.8,0.14),(0.9,0.11),(1,0.1)))
Units: Dmnl

Indicated effect of new variety on input= WITH LOOKUP (Potential productivity/Initial potential productivity,([(1,0)-(4,1.5)],(1,1),(1.5,1),(2,1),
(2.5,1.2),(3,1.2),(3.5,1.5),(4,1.5)))
Units: Dmnl

Initial cumulative input=Degradation time of input normal*Allocated input
Units: t

Initial input per ha=0.78
Units: t/(ha*Year)

Initial potential productivity=3.5
Units: t/ha

Input adequacy=Total input/Desired input
Units: Dmnl
Input adequacy average=SMOOTHI(Input adequacy, Time to average input adequacy, Input adequacy)
Units: Dmnl

Input degradation=Cumulative input/Degradation time of input
Units: t/Year
Land fertility=Land fertility normal*Effect of cumulative input on land fertility
Units: Dmnl

Land fertility average=SMOOTHI(Land fertility, Time to average land fertility, Land fertility)
Units: Dmnl

Land fertility normal=1
Units: Dmnl

Organic degradation=Cumulative organic/Organic degradation time
Units: t/Year

Organic degradation time=25
Units: Year

Organic input gap=Cumulative organic-Cumulative input
Units: t

Organic input gap ratio=Organic input gap/Cumulative organic
Units: Dmnl

Organic policy=IF THEN ELSE(Time<Organic policy year, 0, 1)
Units: Dmnl

Organic policy year=2016
Units: Year

Paddy area= INTEG (Increase of paddy area-Paddy area discarding,Initial paddy area)
Units: ha
Potential productivity= INTEG (Potential productivity change,Initial potential productivity)
Units: t/ha

Time to average effect of new variety on input=5
Units: Year

Time to average input adequacy=5
Units: Year

Time to average land fertility=10
Units: Year
Total input=Allocated input+Allocated organic
Units: t/Year

****

Sub-model (Allocation Input)

Accumulated input subsidy= INTEG (Input subsidy,0)
Units: t*t

Allocated input by farmers=Desired allocation input by farmer*Effect of adequacy of input to allocated input by farmer
Units: t/Year

Allocated input from subsidy=Fraction of input subsidy*Desired input
Units: t/Year

Average adequacy for input=SMOOTHI(Cash adequacy for input, Time to average adequacy for input, Initial average adequacy for input)
Units: Dmnl

Cash adequacy for input=Allocation input/Desired exp for input
Units: 1

Change in subsidy per input=Subsidy per input*Fraction change of subsidy per unit
Units: t/Year

Desired allocation input by farmer=Desired input*Fraction of input by farmers
Units: t/Year

Desired input=Desired input per ha*Paddy area
Units: t/Year

Effect of adequacy of input to allocated input by farmer= WITH LOOKUP (Average adequacy for input,([(0,0)-(1,1)],(0,0),(1,1)))
Units: Dmnl

Fraction change of subsidy per unit=IF THEN ELSE(Time<=2010, Initial fraction change of subsidy per unit, Fraction change of subsidy per unit scenario)
Units: 1/Year

Fraction change of subsidy per unit scenario=0.03
Units: 1/Year

Fraction of input by farmers=Min fraction of input by farmer+(Historical fraction of input by farmers-Min fraction of input by farmer)*Fraction of paddy price subsidy
Units: Dmnl

Fraction of input subsidy=IF THEN ELSE(Time<Input subsidy policy year, Historical of input subsidy, Fraction of policy for input subsidy)
Units: Dmnl

Fraction of paddy price subsidy=SMOOTHI(Desired fraction of paddy price subsidy, Delay of paddy price subsidy policy, 1)
Units: Dmnl

Fraction of policy for input subsidy= WITH LOOKUP (Time,([(2010,0)-(2020,0.5)],(2010,0.41),(2012,0.29),(2014,0.29),(2016,0.09),(2018,0),(2020,0)))
Units: Dmnl

Historical fraction of input by farmers=0.39
Units: Dmnl

Historical of input subsidy= WITH LOOKUP (Time,([(0,0)-(2100,2001)],(1990,0.19),(1991,0.2),(1992,0.22),(1993,0.22),(1994,0.22),(1995,0.22),(1996,0.23),(1997,0.23),(1998,0.38),(1999,0.4),(2000,0.37),(2001,0.38),(2002,0.39),(2003,0.42),(2004,0.39),(2005,0.43),(2006,0.4),(2007,0.41),(2008,0.41),(2009,0.43),(2010,0.43),(2011,0.45),(2012,0.45))
Units: Dmnl

Initial average adequacy for input=1
Units: Dmnl

Initial fraction change of subsidy per unit= WITH LOOKUP (Time,([(1990,0)-(2010,0.08)],(1990,0.03),(1992,0.03),(1994,0.03),(1996,0.03),(1998,0.03),(2000,0.08),(2002,0.08),(2004,0.08),(2006,0.08),(2008,0.08),(2010,0.08)))
Units: 1/Year

Initial subsidy per input=456.07
Units: t

Input subsidy=Subsidy per input*Allocated input from subsidy
Units: t*t/Year

Input subsidy policy year=2016
Units: Year

Min fraction of input by farmer=0.33
Units: Dmnl

Subsidy per input= INTEG (Change in subsidy per input,Initial subsidy per input)
Units: t

Time to average adequacy for input=2
Units: Year

****

Sub-model (Income)

Correction factor paddy price subsidy=0.76
Units: Dmnl

Delay of paddy price subsidy policy=1
Units: Year

Desired fraction of paddy price subsidy=1-STEP(1, Paddy price subsidy policy year)
Units: Dmnl

Domestic paddy price=IF THEN ELSE(Time<2009, Historical domestic paddy price, (Domestic paddy price 2008*EXP(Fraction of domestic paddy price*(Time-2008))))
Units: RM/t

Domestic paddy price 2008=787.3
Units: RM/t

Effective paddy price=IF THEN ELSE(Domestic paddy price<GMP, Domestic paddy price)
Units: RM/t

Fraction of domestic paddy price=0.04387
Units: Dmnl

Fraction of GMP after 2010=0.02
Units: 1/Year

Fraction of income from non paddy production=0.1
Units: Dmnl

Fraction of paddy price subsidy=SMOOTHI(Desired fraction of paddy price subsidy, Delay of paddy price subsidy policy, 1)
Units: Dmnl

GMP=IF THEN ELSE(Time<=2010, Historical GMP, GMP after 2010)
Units: RM/t

GMP 2010=750
Units: RM/t

GMP after 2010= INTEG (GMP after 2010 growth rate,GMP 2010)
Units: RM/t

GMP after 2010 growth rate=IF THEN ELSE(Time<2010, 0, GMP after 2010*Fraction of GMP after 2010)
Units: RM/t/Year

Historical domestic paddy price= WITH LOOKUP (Time,([(1990,0)-(2008,800)],
(1990,392.77),(1991,410),(1992,405),(1993,400),(1994,400),(1995,477),(1996,492),
(1997,523),(1998,615),(1999,553),(2000,538),(2001,661),(2002,692),(2003,722),
(2004,600),(2005,620),(2006,670),(2007,768.9),(2008,787.3)))
Units: RM/t

Historical GMP=Historical GMP table(Time)
Units: RM/t

Historical GMP table([(1990,400)-(2012,800)],(1990,496),(1991,496),(1992,496),(1993,496),(1994,496),(1995,496),(1996,496),(1997,496),(1998,550),(1999,550),(2000,550),(2001,550),(2002,550),(2003,550),(2004,550),(2005,550),(2006,650),(2007,650),(2008,650),(2009,750),(2010,750),(2011,750),(2012,750))
Units: RM/t

Income from non paddy production= Initial income from non paddy production*EXP(Fraction of income from non paddy production*(Time-START TIME))
Units: RM/Year

Initial income from non paddy production=867
Units: RM

Paddy price subsidy=Unit paddy price subsidy*Paddy production*Correction factor paddy price subsidy
Units: RM/Year

Paddy price subsidy policy year=2016
Units: Year

Paddy production=(Paddy area*Actual productivity)*(1-Paddy loss)
Units: t

Revenue from paddy price subsidy=Paddy price subsidy*Fraction of paddy price subsidy
Units: RM/Year

Revenue from paddy sold=Effective paddy price*Paddy production
Units: RM/Year

START TIME=1990
Units: Year

Total income=Income from non paddy production+Revenue from paddy price subsidy+Revenue from paddy sold
Units: RM/Year

Unit paddy price subsidy=248.1
Units: RM/t/Year

****

Sub-model (Expenditure)

Allocation for fuel=MIN(Desired expenditure for fuel, Allocation machinery)
Units: RM/Year

Allocation for non fuel=Allocation machinery-Allocation for fuel
Units: RM/Year

Allocation for non paddy production=Potential cash allocation-Allocation for paddy production
Units: RM/Year

Allocation for paddy production=(Desired expenditure for paddy/Desired expenditure)*Potential cash allocation
Units: RM/Year

Allocation input=MIN(Desired exp for input, Allocation for paddy production)
Units: RM/Year

Allocation machinery=MIN(Desired exp for machinery, Allocation for paddy production-Allocation input)
Units: RM/Year

Allocation other=MIN(Desired exp for others, Allocation for paddy production-(Allocation input+Allocation machinery))
Units: RM/Year

Cash adequacy for fuel=Allocation for fuel/Desired expenditure for fuel
Units: 1

Cash adequacy for input=Allocation input/Desired exp for input
Units: 1

Change in world crude oil price=World crude oil price*World crude oil growth rate
Units: RM/(Year*liter)

Desired energy for paddy production=Paddy area*Initial fuel use
Units: liter/Year

Desired exp for input=Paddy area*Input cost
Units: RM/Year

Desired exp for machinery=Desired non fuel+Desired expenditure for fuel
Units: RM/Year

Desired exp for others=Other cost*Paddy area
Units: RM/Year

Desired expenditure for fuel=Desired energy for paddy production*Domestic fuel price
Units: RM/Year

Desired expenditure for paddy=Desired exp for input+Desired exp for others+Desired exp for machinery
Units: RM/Year

Desired non fuel=Non fuel*Paddy area
Units: RM/Year

Domestic fuel price=World crude oil price*(1-Fuel subsidy fraction)
Units: RM/liter

Fuel subsidy fraction=IF THEN ELSE(Time<=2016, 0.3, 0)
Units: Dmnl

Initial input cost=429.95
Units: RM/ha/Year

Initial other cost=9+927.27
Units: RM/ha/Year

Initial world crude oil price=0.46
Units: RM/liter

Input cost=Initial input cost*EXP(Input cost growth rate*(Time-START TIME))
Units: RM/ha/Year

Input cost growth rate=0.032
Units: Dmnl

Non fuel= INTEG (Non fuel growth rate,1874.46)
Units: RM/ha/Year

Non fuel growth fraction=0.032
Units: Dmnl/Year

Non fuel growth rate=Non fuel*Non fuel growth fraction
Units: RM/(Year*Year*ha)

Other cost=Initial other cost*EXP(Other cost growth rate*(Time-START TIME))
Units: RM/ha/Year

Other cost growth rate=0.032
Units: Dmnl

Paddy area= INTEG (Increase of paddy area-Paddy area discarding,Initial paddy area)
Units: ha

Total expenditure=Allocation input+Allocation machinery+Allocation other+Allocation for non paddy production
Units: RM/Year

World crude oil growth rate=0.06
Units: 1/Year

World crude oil price= INTEG (Change in world crude oil price,Initial world crude oil price)
Units: RM/liter

****

Sub-model (Farm Cash)

Allocation for non paddy production=Potential cash allocation-Allocation for paddy production
Units: RM/Year

Allocation for paddy production=
(Desired expenditure for paddy/Desired expenditure)*Potential cash allocation
Units: RM/Year

Average desired expenditure=SMOOTH(Desired expenditure, Time to averaging expenditure)
Units: RM/Year

Average income=SMOOTH(Income, Time to average income)
Units: RM/Year

Cash availability=Farmers cash/Desired cash
Units: 1

Desired cash=Average desired expenditure*Time to desired cash
Units: RM

Desired expenditure=Desired expenditure for non paddy production+Desired expenditure for paddy
Units: RM/Year

Desired expenditure for non paddy production=Average income*Fraction of consumption for non paddy production
Units: RM/Year

Desired expenditure for paddy=Desired exp for input+Desired exp for others+Desired exp for machinery
Units: RM/Year

Effect of cash availability for expenditure=Table of the effect of cash availability for expenditure(Cash availability)
Units: Dmnl

Expenditure=Total expenditure
Units: RM/Year

Farmers cash= INTEG (Income-Expenditure,Initial farmer cash)
Units: RM

Fraction of consumption for non paddy production=0.3
Units: Dmnl

Income=Total income
Units: RM/Year

Initial farmer cash=3e+008
Units: RM

Potential cash allocation=Desired expenditure*Effect of cash availability for expenditure
Units: RM/Year
Table of the effect of cash availability for expenditure([(0,0)-(1,1)],(0,0),(0.1,0.01),(0.2,0.04),(0.3,0.11),(0.4,0.23),(0.5,0.52),(0.6,0.79),(0.7,0.91),(0.8,0.97),(0.9,0.99),(1,1))
Units: Dmnl

Time to average income=2
Units: Year

Time to averaging expenditure=0.5
Units: Year

Time to desired cash=0.25
Units: Year

Total expenditure=Allocation input+Allocation machinery+Allocation other+Allocation for non paddy production
Units: RM/Year

Total income=Income from non paddy production+Revenue from paddy price subsidy+Revenue from paddy sold
Units: RM/Year

****

Sub-model (Energy Use)

Cash adequacy for fuel=Allocation for fuel/Desired expenditure for fuel
Units: 1

Delivered energy for paddy production=Desired energy for paddy production*Effect of cash adequacy to delivered energy
Units: liter/Year

Desired energy for paddy production=Paddy area*Initial fuel use
Units: liter/Year

Effect of cash adequacy to delivered energy=Lookup for effect of cash adequacy to delivered energy(Cash adequacy for fuel)
Units: Dmnl

Energy adequacy average=SMOOTHI(Energy adequacy for paddy production, Time to average energy adequacy, Initial for energy adequacy average)
Units: Dmnl

Energy adequacy for paddy production=Delivered energy for paddy production/Desired energy for paddy production
Units: Dmnl

Initial for energy adequacy average=0.6
Units: Dmnl

Initial fuel use=120*2
Units: liter/ha/Year

Lookup for effect of cash adequacy to delivered energy([(0,0)-(1,1)],(0,0),(1,1))
Units: Dmnl
Paddy area= INTEG (Increase of paddy area-Paddy area discarding,Initial paddy area)
Units: ha

Time to average energy adequacy=10
Units: Year

****

Sub-model (Farm Practices)

Average technical efficiency=0.5
Units: Dmnl

Desired expenditure for farm practices=Desired increase of farm practices
Units: 1/Year

Desired farm practices= IF THEN ELSE(Time<Farm practices policy year,Desired farm practices based on production,Maximum best practices)
Units: Dmnl

Desired farm practices based on production=MIN(Farm practices*(1+Paddy production gap), Maximum best practices)
Units: Dmnl

Desired increase of farm practices=MAX(0,(Desired farm practices-Farm practices)/Time to increase farm practices)
Units: Dmnl/Year

Farm practices= INTEG (Increase of farm practices,30)
Units: Dmnl

Farm practices policy year=2016
Units: Year

Farm practices ratio=(Maximum best practices/Farm practices)^Average technical efficiency
Units: 1

Increase of farm practices=Desired increase of farm practices
Units: Dmnl/Year

Maximum best practices=100
Units: Dmnl

Paddy production gap=(Desired paddy production-Paddy production)/Desired paddy production
Units: Dmnl

Switch off desired farm practices=0
Units: Dmnl

Time to increase farm practices=8
Units: Year

****

Sub-model (Technology Practices)

Adjutment time for technology adjustment=10
Units: Year

Gap in technology practices=Goal in technology practices-Technology practices
Units: 1

Goal in technology practices=0.8
Units: Dmnl

Techology growth=Gap in technology practices/Adjutment time for technology adjustment
Units: Dmnl/Year

Technology practices= INTEG (Techology growth,0.2)
Units: Dmnl

BIODATA OF STUDENT

PERSONAL INFO

Name : Siti 'Aisyah Binti Baharudin
Address : 127, Lebuh Semangat 2, Taman Rapat Indah, 31350, Ipoh, Perak
IC No. : 850801-07-5338
Date of birth : 01 August 1985
Age : 30
Gender : Female
Marital status : Married
Religion : Islam
Race : Malay
Nationality : Malaysian
Email : humairah_13085@yahoo.com
Profession : Lecturer

ACADEMIC QUALIFICATION

Degree of Doctor of Philosophy (PhD) : Dec 2010 – 2015 (Expected year)
Course : Economics
Faculty : Economics and Management
Institusi/Universiti : Universiti Putra malaysia (UPM), Selangor, Malaysia
Thesis : A system dynamics analysis of the impact of the paddy and energy subsidies withdrawal on the paddy sector

Degree of Master of Economics (M.ec) : 2009-2010
Course : Economics
Faculty : Economics and Administration
Institusi/Universiti : Universiti Malaya (UM), Kuala Lumpur, Malaysia
Research Project : The effects of rice policy on food self – sufficiency in Malaysia

Degree of Bachelor of Social Science (Economics) : 2005-2008
Course : Economics
Faculty : Social Science
University : Universiti Sains Malaysia (USM), Pulau Pinang, Malaysia
Research Project : Agriculture in Malaysia and enterprises of pomelo in Tambun, Perak.

Sijil Tinggi Pelajaran Malaysia (STPM) : 2003-2004
Course : Science Social (Economics)

Sijil Pelajaran Malaysia (SPM) : 2002
Course : Science

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Siti 'Aisyah Baharudin and Fatimah Mohamed Arshad (2014). Energy Use in Paddy Production: NKEA's Estate in MADA Areas. *Economic and Technology Management Review*. Vol 9a. pp:51-60. ISSN 1823-8149.

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