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The causal structure of paddy deduction system in the MADA granary area: A system dynamics approach

Kerangka konseptual terhadap sistem pemutuan padi di kawasan MADA: Pendekatan sistem dinamik

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Keywords: causal structure, paddy deduction rate, system dynamics

Abstract

Paddy deduction system is an instrument to ensure a high quality throughput goes to the mills and hence high quality rice is produced. A paddy deduction scheduled was introduced as a reference for the industry participants particularly the farmers and the millers. However in reality, the determination of the actual rate goes beyond the schedule. The rate is the function of supply and demand of paddy and rice in MADA area. On the supply side, the paddy quality is determined by a multiple factors such as farm practices, the efficiency of the harvesting machine and climatic factors. Demand of rice by the mills on the other hand is influenced by the local rice market situation which to some extent moves in tandem with the international market scenarios. The actualised rate achieved depends on the dynamics of the negotiation between the farmers and millers. The former negotiates for lower deduction in contrast to the later. Both parties, the producers and millers are driven by their economic interest. The farmers normally negotiate for lower rate to maintain higher net price while it is the opposite in the case of the millers. At the farm level, factors that determined paddy quality include; farm practices, variety and postharvest practices. As for the millers, decision on deduction rate is the function of their profitability which in turn is determined by the supply and demand of rice and their margin. The millers margin is somewhat fixed by the difference between the Guaranteed Minimum Price (GMP) and retail price of rice. It is clear that the decision making process is complex involving two parties with opposite motives and interest with different variables affecting their decisions. In view of such complexity, this paper attempts to develop a conceptual framework on their decision making model for the determination of paddy deduction rate in the MADA granary area. A causal loop diagram (CLD) based on the system dynamics approach is developed to examine the causal factors that determine the desired deduction rate between the farmers and the millers.

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Introduction

Paddy deduction is an instrument to ensure a high quality throughput goes to the mills, thus, high quality rice is produced. This rate is translated into monetary value and later deducted from the gross farm price paid to the farmers. The higher the rate, the lower the net price received by farmers and hence their net return from sales. A deduction rate schedules as depicted in *Table 1* was introduced as a guideline for the millers to determine an effective deduction rate based on the quality of the paddy sent to the mills. Paddy deduction rate refers to a rate negotiated between farmers and millers for the purpose to deduct the wet paddy before rice processing begins.

The paddy deduction scheme started in 1979 in line with the introduction of Paddy Price Subsidy (PPS) Scheme. In practice, the paddy grading uses the deduction schedule as shown in *Table 1*. The deduction schedule presents deduction percentage for moisture content, damaged grain, immature grain and foreign matters or impurities. No deduction imposed if the moisture content in the wet paddy falls below 14% in order to prolong the storability of rice. Moisture deduction above 14.1% will be deducted according to the percentage of deduction as suggested in the schedule. Damaged grains refer to grains that have abnormal colours and become rotten, mouldy and germinated. The deduction for damaged grain is more severe than the deduction for the moisture content as farmers are responsible directly for grain quality. Moreover, the damaged grain cannot be processed or recovered by the millers. The whole rice is susceptible to discoloration if the damaged grains are not removed. The deduction rate for the immature grain is equally proportional to its weight. The immature grains are unripe paddy, which will become chalky and reduce to dust during the milling process. Foreign matters are also proportional to its weight which include stalks, dirt, dried mud, sand and, in some cases, grasshoppers.

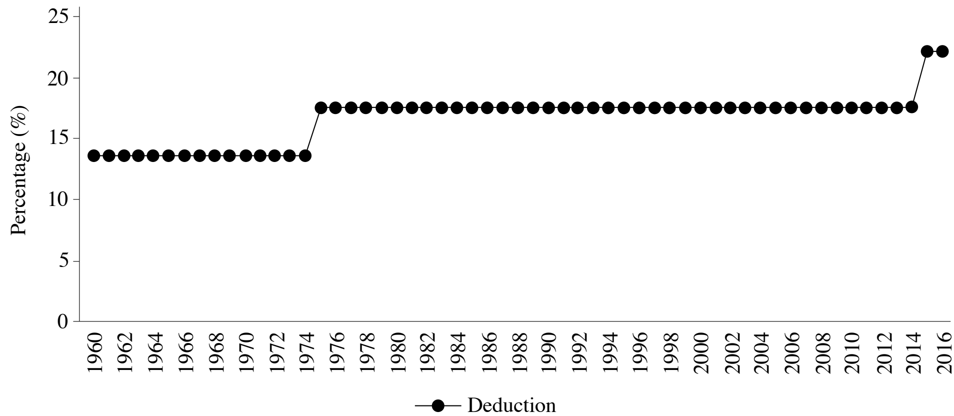
Figure 1 shows the paddy deduction rate between 1980 and 2013. In the 1960s, the farmers harvested and dried the paddy manually before selling the paddy to the rice mills. The deduction was found to be lower as the farmers took care of their produce. In 1980 along with the introduction of combine harvester, the deduction rate ranged between 17 and 18% as the government implemented flat-rate deduction in order to increase the farmer's income. The deduction rate was 20% and above in the mid 2014 following the introduction of fixed paddy price of RM1,200 per tonne.

Nevertheless, the determination and implementation of paddy deduction rate in the production sub sector is flawed due to the structural problem at the farm, impacted the farmers income, in that higher deduction rate lowers the farmers net income. The agreed deduction rate by both parties (producers) and buyers (millers, private and BERNAS) is subjected to the relative strength of the bargaining power between the two. While each party attempts to optimize their utility, the decision arrived may be skewed in favour of the buyers in view of their strength in terms of market share, better equipped with information and larger capacity to absorb risks. As at the 2015, there were 157 millers compared to 974 millers in 1974 and 295 millers in 1987 despite the increase in the production quantity. These data roughly indicate the growing concentration of the sector, in that millers have grown in size, scale and market share. Based on a focus group discussion made in MADA area on 2017, on average the paddy brought in by farmers was low in quality and the deduction rate charged to them was in the range of 20 to 45 per cent. Syahrin et al. (2016) also stated that the paddy deduction rate in MADA area is normally above 20% and not consistent although the paddy came from the same field. The low quality of paddy was attributed to several factors such as poor farm practices, weather, diseases and spillage during harvesting and transporting.

Table 1. Deduction schedule

Moisture content		Damaged grain	
Moisture content (%)	Deduction (%)	Damaged crain (%)	Deduction (kg)
14% and below	0	1.0 – 1.9	1.0 – 2.8
14.1 – 15.0	0.1 – 1.2	2.0 – 2.9	3.0 – 4.8
15.1 – 16.0	1.3 – 2.3	2.0 – 2.9	5.0 – 6.8
16.1 – 17.0	2.4 – 3.5	3.0 – 3.9	7.0 – 8.7
17.1 – 18.0	3.6 – 4.7	4.0 – 4.9	9.0 – 10.7
18.1 – 19.0	4.8 – 5.8	5.0 – 5.9	11.0 – 12.7
19.1 – 20.0	5.9 – 7.0	6.0 – 6.9	13.0 – 14.7
20.1 – 21.0	7.1 – 8.1	7.0 – 7.9	15.0 – 16.7
21.1 – 22.0	8.3 – 9.3	8.0 – 8.9	17.0 – 18.7
22.1 – 23.0	9.4 – 10.5	9.0 – 9.9	19.0 – 20.7
23.1 – 24.0	10.6 – 11.6	10.0 – 10.9	21.0 – 22.7
24.1 – 25.0	11.7 – 12.8	11.0 – 11.9	23.0 – 24.7
25.1 – 26.0	12.9 – 14.0	12.0 – 12.9	25.0 – 26.7
26.1 – 27.0	14.1 – 15.1	13.0 – 13.9	27.0 – 28.7
27.1 – 28.0	15.2 – 16.3	14.0 – 14.9	29.0 – 30.7
28.1 – 29.0	16.4 – 17.4	15.0 – 15.9	31.0 – 32.7
29.1 – 30.0	17.6 – 18.6	16.0 – 16.9	33.0 – 34.7
30.1 – 31.0	18.7 – 19.8	18.0 – 18.9	35.0 – 36.7
31.1 – 32.0	19.9 – 20.9	19.0 – 19.3	37.0 – 37.5
32.1 – 33.0	21.0 – 22.1		
Immature grain		**Foreign matters/Impurities**	
Content (%)	Deduction (%)	Content (%)	Deduction (%)
3.0	0	0.1	0.1
3.1 – 4.0	0.1 – 1.0	0.2	0.2
4.1 – 5.0	1.1 – 2.0	0.3	0.3
5.1 – 6.0	2.1 – 3.0	0.4	0.4
6.1 – 7.0	3.1 – 4.0	0.5	0.5
7.1 – 8.0	4.1 – 5.0	0.6	0.6
8.1 – 9.0	5.1 – 6.0	0.7	0.7
9.1 – 10.0	6.1 – 7.0	0.8	0.8
10.1 – 11.0	7.1 – 8.0	0.9	0.9
11.1 – 12.0	8.1 – 9.0	1.0	1.0
12.1 – 13.0	9.1 – 10.0	1.1	1.1
13.1 – 14.0	10.1 – 11.0	1.2	1.2
14.1 – 15.0	11.1 – 12.0	1.3	1.3
15.1 – 16.0	12.1 – 13.0	1.4	1.4
16.1 – 17.0	13.1 – 14.0	1.5	1.5
17.1 – 18.0	14.1 – 15.0	1.6	1.6
18.1 – 19.0	15.1 – 16.0	1.7	1.7
19.1 – 20.0	16.1 – 17.0	1.8	1.8
20.1 – 21.0	17.1 – 18.0	1.9	1.9
21.1 – 22.0	18.1 – 19.0	2.0	2.0

Source: MOA (2014)



Sources: Fatimah (1982) and Paddy Production Report (1980 – 2014)

Figure 1. Paddy deduction rate (%), 1960 – 2016

Bad quality paddy means low quality rice and lower hence profits to the millers. The recent increase in the price of paddy from RM750/tonnes to RM1,200 per tonnes while the retail price of rice remain unchanged, has left millers with lower margin to work on. Hence in order to sustain their profit, high profitability that the millers resorted to unwarranted high deduction rate to take care of their throughput cost.

The above delineation represents a complex problem that arises in the decision making process between the farmers and the millers in regards with the desired deduction rate which mutually satisfies both parties. The recent deduction method based on actual quality of paddy indicates that the average deduction is relatively high at 20% despite mechanisation. This reduces the farmers' nett income by one-fifth, squeezes miller's profit and consumers are not assured of high quality rice. Hence, arriving at a reasonable desired deduction rate that mutually satisfies both the farmers and millers is essentially important as a quality control instrument.

The decision making process in determining an effective deduction rate in Malaysia has thus far not been investigated. This situation necessitates an investigation on the determination of paddy deduction that mutually satisfies both the farmers and the millers. This paper thus attempts to develop a conceptual framework by using a causal loop diagram based on the system dynamics approach to examine the causal factors that determine the desired deduction rate between the farmers and the millers.

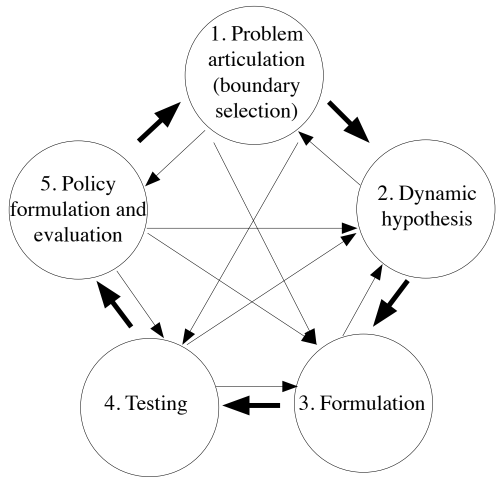
Methodology

The process of decision making is becoming complex due to the interaction of multiple dimensions. Normally, the complex system cannot be understood completely due to its segregated analysis from the constituent parts (Boulding 1956). In a dynamics field system, an observed phenomenon or the undesired phenomenon in the complex system normally uses a simulation technique. A complex system is any system that contains many interrelated variables and elements which are interconnected to each other and compared to the simple systems (Hashimah et al. 2015). A complex phenomenon normally uses a simulation technique to model the behaviors of the complex system (Chaim and Streit 2008). Other methodologies based on equations or analytical approaches are not practical or even possible to be applied (Hashimah et al. 2015). Therefore, this study applied system dynamics (SD) approach, which is one of the simulation techniques to model the whole system based on the set boundaries and limitations (Chahal and Eldabi 2008). Besides, the approach helps us to understand the systemic behavior over the time.

System dynamics (SD) modelling and simulation are tools that provide the feedback relationship or insight between elements in the market system and allow the analysis of various scenarios of intervention for an effective decision making. The methodology is often characterized by interdependence, mutual interaction, information feedback and circular causality (Sterman 2004). This approach focuses on the feedback process. The premise of the study is that the dynamic behaviour is formed by a consequence of system structures and eventually becomes meaningful and powerful. The method tends to look within a system for the source of the problems in its behaviour (Richardson and Pugh 1981).

SD is a decision-making process that involves the dynamics phenomena (Tasrif 2013) resulting from interaction of the structures and decision-making structures. The physical structure is formed by the accumulation (stock) and flow network of people, goods, energy and materials. The decision-making structure is formed through the accumulation (stock) and information flow network used by actors (human) in the system that describes the rules of their decision-making processes.

There are five stages involved in a system dynamics modeling process; (1) problem articulation; (2) formulation of dynamic hypothesis; (3) formulation of a simulation model; (4) model testing; and (5) policy design and evaluation, as illustrated in *Figure 2* (Sterman 2004). The modeling process is an iterative process. It is repeated until both structure and behaviour of the simulated model similar with the real structure and behaviour. However, this study only focuses on identifying the causal loop diagram (CLD) in the context of paddy deduction rate determination.



Source: Sterman (2004)

Figure 2. Process of modeling in system dynamics

Causal loop diagram

Causal loop diagram (CLD) is one of the mapping tools in SD, which consists of various variables connected by arrows denoting the hypotheses and mental models of the modeler represent the feedback structure of the systems (Sterman 2004). The variables with plus (+) and minus (–) signs are assigned in the arrows to indicate the direction of influence (Hashimah et al. 2015). The plus sign means changes in the cause results in changes in the effect in the same direction. In contrast, the minus sign means otherwise i.e. the effect of changes in the cause will occur in the opposite direction (Maani and Cavana 2000). All selected variables can be a condition, action or decision, which may influence or be influenced by other variables (Hashimah et al. 2015).The positive and negative terms are based on how it changes the system, and not related to the good or bad (Maani and Cavana 2000). The positive feedback represents the growth pattern while the negative feedback represents goal-seeking. The combination of these feedbacks will produce various behaviors that represent the real system. The polarity shows the loop is reinforced (R) or balanced (B).

The balancing loops function to adjust the loops to a desired goal whereas the reinforcing loops to enhance or lessen some kind of phenomenon within the system. The link polarities describe the structure of the system and what would happen if there were changes and would not describe what actually happens. Therefore, the polarity is important in each of the relationship because it describes the structure of the system. At least, one of the relationship chains must be a closed loop to ensure the dynamic relationship exists in the CLD.

A closed chain of relationships is called a loop (Garcia 2006). The behaviour of a system or behavior over the time, can produce several behaviours, such as exponential growth, goal seeking, s-shaped growth, oscillation and growth with overshoot and collapse (Sterman 2004). As a summary, CLD is created from the mapping of cause-and-effect relationships between variables in the system. CLD is an excellent tool on characterising the causes of dynamics, important feedbacks and holistic view of a system (Sterman 2004). However, CLD is difficult to reveal the quantitative effects and to identify which loops dominate the model parameter (Hashimah et al. 2015). Subsequently, the stock and flow diagram are used later in the next stage.

Results and discussions

Figure 3 shows the overall causal loop diagram while *Table 2* lists sequence of balancing and reinforcing loops of the model. In this model, there are two balancing loops and four reinforcing loops. The subsequent paragraphs discuss each loop.

Balancing loop 1 (B1): Miller's investment

The first balancing loop (B1) describes the miller's investment. Based on the figure, higher paddy purchases made by the rice millers will increase the miller's production costs. The increase in their production costs will shrink their gross margin. The shrinking gross margin further reduces their capital investment. Reduction in the capital investment eventually lowers their production capacity.

Balancing loop 2 (B2): Miller's profit

The second balancing loop (B2) explains the miller's profit behaviour. Based on the figure, as more paddy are purchased by the millers, they will incur higher production costs which, in turn, decreases their gross margin. The decrease in the gross margin eventually lowers their capacity utilisation.

Reinforcing loop 1 (R1): Change in deduction through farm practices

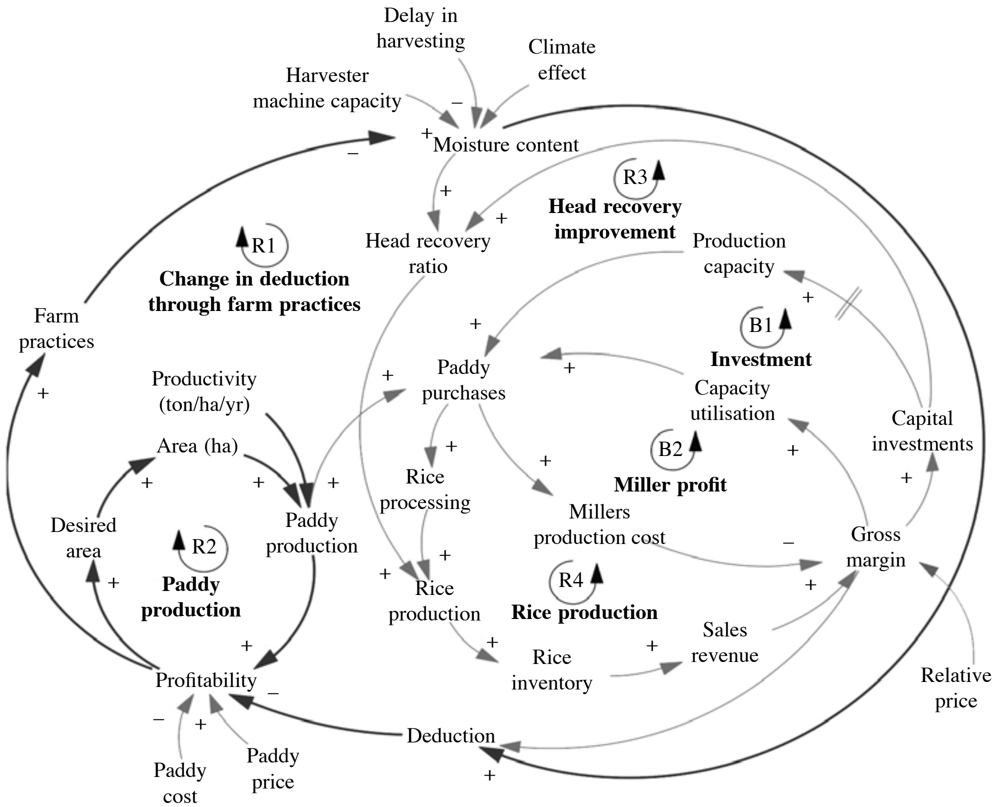
The first reinforcing loop (R1) describes the change in deduction through farm practices. The farm practices will improve as the farmers maximise their farm practices. The improved farm practices will result in the lower moisture content, hence, lower deduction rate imposed on the farmers. Lower deduction rate subsequently increases the farmer's profitability. Such increase motivates the farmers to further improve their farm practices. Apart from farm practices, increasing the harvester machine capacity also lowers the moisture content. However, delaying the harvesting activity tends to increase the moisture content.

Reinforcing loop 2 (R2): Paddy production

The second reinforcing loop (R2) describes the paddy production. The increase in the desired area will increase the total area. The increase in the total area incentivises the farmers to increase their paddy production, which is further enhanced by improved productivity. Higher paddy production will increase the farmer's profitability. Rationally, higher profitability incentivises the farmers to increase their paddy hectarage.

Reinforcing loop 3 (R3): Head recovery improvement

The R3 describes the head recovery improvement. Increasing the head recovery ratio will increase the rice production and rice inventory. Subsequently, increase in



Note: positive (+) sign – same direction; negative (–) sign – opposite direction; equal (=) sign – delay

Figure 3. Causal loop diagram of the paddy deduction model system in MADA area

Table 2. Sequence of balancing and reinforcing loops

Loops	Causal link
Balancing loop	
B1	paddy purchases→millers production cost→gross margin→capital investments→production capacity
B2	paddy purchases→millers production cost→gross margin→capacity utilisation
Reinforcing loop	
R1	moisture content→deduction→profitability→farm practices
R2	paddy production→profitability→desired area→area
R3	head recovery ratio→rice production→rice inventory→sales revenue→gross margin→capacity investment→head recovery ratio
R4	paddy purchases→rice processing→rice production→rice inventory→sales revenue→gross margin→capacity utilisation

the production and inventory will improve their sales revenue, gross margin and capital investment. Overall, the head recovery improvement 'reinforces' all key variables.

Reinforcing loop 4 (R4): Rice production

The reinforcing loop (R4) describes the rice production by the millers. Increasing the paddy purchases will encourage the millers to process more rice. Increase in the rice processing will improve the miller's rice production and the rice inventory. Improvement in the rice inventory subsequently boosts the miller's sales revenue, gross margin and the capacity utilisation.

Discussions

The objective of this study is to develop a conceptual framework to examine the determinants of paddy deduction rate derived by the farmers and millers in the system by using a CLD based on the system dynamics approach. All the structural elements that influence the dynamics of decision making towards achieving desired deduction rate have been shown in the CLD. The CLD helps the farmers and the millers identify the structural factors that cause the high deduction rate and understand the dynamics of paddy deduction rate determination. The desired deduction rate can be achieved if the farmers improve their farm practices as suggested by the Rice Check. Mohamed et al. (2016) revealed that 80% of the farmers indicated unsustainable paddy farming practices. Rosnani et al. (2015) also revealed that there was a huge gap between the best and the worst technological practices in Malaysia. Majority of the farmers in Malaysia indicated average technology index while 60% farmers in Vietnam reported the best technology index. They also indicated that the farmers need to be more self-motivated and committed in implementing the best practices in rice production technology (Rosnani et al. 2015).

For the millers, they need to expand their profit margin due to higher operating cost. Mohd. Ghazali et al. (1988) revealed that price control has suppressed the growth of the private milling sector. The ST price is currently controlled by the government in order to ensure stable rice price supplies to the low income consumers. All of these potentially affect the profit margin of the millers. Therefore, the small profit margin received, the millers tend to impose a higher deduction rate to gain their profit margin.

Conclusion and recommendations

A favourable deduction rate is crucial to ensure a fair distribution of profit between the farmers and the millers. The deduction rate is a function of demand and supply in the paddy and rice production sector. However, the current deduction system in the paddy and rice production subsector in Malaysia is challenged by an unfair determination of paddy deduction rate imposed on the farmers by the millers. High deduction rate is imposed on the farmers due to high moisture content in the wet paddy sent to the mill, thereby lowering their income. The millers, on the other hand, have to absorb high operating cost in processing the wet paddy in the presence of price control and stiff competition for paddy supply, thereby shrinking their profit margins. In view of the above complex problem, a conceptual framework of favourable paddy deduction rate determination has been developed by using CLD based on a system dynamics approach. All structural elements have been illustrated and discussed thoroughly in the CLDs. Two balancing and four reinforcing loops were identified which explain the dynamic behaviour of the decision making process in determining a desired deduction rate which mutually agreed both the farmers and the millers. The findings suggest that the farmers will be able to increase their income by improving their farm practices as suggested by the Rice Check. Maximising number of suggested farm practices lowers the moisture content, thus, lower deduction rate is imposed on them. Besides, price control has been found to suppress the growth of the rice millers in the sector apart from increasing operating cost in the rice processing. This situation implies a clear motivation for the millers to impose higher deduction rate on the farmers hence sustain their businesses. It is suggested that this study can be further quantified by considering the stock-and-flow diagram in the future. Later, the expanded model will be tested, evaluated and further used for policy evaluation.

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Abstrak
Sistem pemutuan padi adalah satu instrumen bagi memastikan padi berkualiti tinggi. Jadual pemutuan padi telah diperkenalkan sebagai rujukan kepada para pemain industri terutamanya kepada petani dan pengilang. Walau bagaimanapun, pada realitinya, kadar sebenar pemutuan adalah melebihi seperti yang telah ditetapkan. Kadar pemutuan padi adalah fungsi kepada bekalan dan permintaan padi dan beras di kawasan MADA. Di pihak pembekal pula, kualiti padi ditentukan oleh pelbagai faktor seperti amalan ladang, kecekapan mesin penuaian dan faktor iklim. Permintaan beras oleh kilang dipengaruhi oleh keadaan pasaran beras tempatan yang sedikit sebanyak bergerak seiring dengan senario pasaran antarabangsa. Kadar sebenar pemutuan yang dicapai bergantung pada dinamik rundingan antara petani dan pengilang. Petani berunding untuk potongan lebih rendah berbanding dengan pengilang. Kedua-dua pihak, petani dan pengilang didorong oleh minat ekonomi mereka. Petani memerlukan pemutuan yang lebih rendah untuk mendapatkan pendapatan yang lebih tinggi. Sebaliknya, pengilang padi mengenakan kadar potongan yang lebih tinggi untuk mengekalkan margin keuntungan mereka dengan adanya kawalan harga dan persaingan sengit untuk bekalan padi. Di peringkat ladang, faktor yang menentukan kualiti padi termasuklah amalan ladang, varieti dan amalan selepas tuai. Bagi pengilang, keputusan mengenai kadar pemutuan adalah fungsi keuntungan mereka yang seterusnya ditentukan oleh bekalan, permintaan beras dan margin mereka. Margin keuntungan bagi pengilang ditetapkan oleh perbezaan antara Harga Minimum Terjamin (GMP) dan harga runcit beras. Ini jelas menunjukkan proses membuat keputusan adalah kompleks yang melibatkan dua pihak dengan motif yang bertentangan, minat serta pemboleh ubah berbeza yang mempengaruhi keputusan mereka. Perincian di atas menunjukkan masalah yang dinamik dan rumit, melibatkan prinsip-prinsip panduan petani dan pengilang padi di dalam proses membuat keputusan. Kertas kerja ini bertujuan untuk membangunkan kerangka konseptual mengenai model pembuatan keputusan untuk menentukan kadar potongan padi di kawasan MADA. Kerangka konseptual (CLD) berdasarkan pendekatan sistem dinamik dibangunkan untuk mengkaji faktor perhubungan yang menentukan kadar pemutuan yang diingini antara petani dan pengilang padi.