MALAYSIA’S COCOA BEANS DECLINE: A PROGNOSIS

Fatimah Mohamed Arshad  
Institute of Agricultural and Food Policy Studies,  
Universiti Putra Malaysia, 43400 UPM Serdang  
Selangor, Malaysia  
mafatinah@gmail.com

Abdulla Ibragimov  
Institute of Agricultural and Food Policy Studies,  
Universiti Putra Malaysia, 43400 UPM Serdang  
Selangor, Malaysia  
upmikdpm@gmail.com

ABSTRACT

The Malaysian cocoa beans has gone through a complete cycle of production from a stellar performance in the 1990s to almost extinct in 2014. The production reached 400,000 tonnes during its heydays to a mere 3,000 tonnes in 2013, indicating an “overshoot” and later “collapse” behavior. This behavior invites questions such as: (i) What caused the overshoot and decline in production? and (ii) Is this an irreversible trend? This study attempts to answer these questions. The push factors that led to the abandonment of cocoa area are pest and diseases problem, unstable price, low productivity and hence return. The pull factors include: better return from oil palm farming and other non-cocoa enterprises. The intervening factors are plenty such as limited institutional supports to farmers, farm constraints and structural setback in the cocoa industry. In view of the complexity of the problem, a system dynamics methodology is used to capture the feedback relationships between variables that were responsible in shaping the production trends. A simulation is carried out on the impact of productivity enhancement and innovation in farm supply chain on the trends of cocoa production in the future.

Key words: Cocoa Beans Production, Malaysia, System Dynamics

Introduction

Malaysia’s cocoa beans production has gone through a complete “life cycle” from an infant industry in the 1970s, maturing in the early 1980s, reaching its peak in the early 1990s and later declining rapidly to its 1970s level. No other commodity in Malaysia experiences this “boom and bust” behavior. While oil palm plantation is indicating an S-shaped production curve, rubber has passed its peak and slowly declining. These behaviors are in accordance to Meadows’s proposition that there is a limit to growth to an industry as the carrying capacity is not indefinite (1974). In the case of oil palm, land is a major constraint particularly in the Peninsular Malaysia as well as the competition for urbanization and other profitable ventures. Competition from neighboring countries in ASEAN and African regions poses a formidable challenge to local production too. A similar explanation can be used against the case of rubber. However, in the case of cocoa, the matrix differs somewhat as cocoa plantation is unique in terms of production characteristics and hence the variables affecting it. The cocoa industry in Brazil has undergone a similar fate which may provide some cues for the decline of cocoa beans production in Malaysia despite a brighter future of cocoa in the world market. This chapter aims at explaining the “boom and later bust or decline” behavior of the cocoa beans production in Malaysia from a system dynamics perspective in the hope of seeking some answers to reverse the trend.

The Decline

After a stellar performance in the 1990s, the decline of cocoa area and beans production was unstoppable (Figures 1 and 2). During the 1970s and 1980s, the industry has undergone spectacular transformations. With low production costs and good prices, cocoa production was a profitable venture. It has attracted the estate sector to invest in cocoa plantation taking with them “estate farm management technology” into cocoa beans production. At its height, the share of estate reached 201,615 ha or 49% of the total cocoa area compared to 212, 621 ha or 51% of the smallholders in 1989. During this period, the cocoa area and cocoa beans production reached its peak of over 414,236 ha and 247 thousand tonnes in 1989 and 1990, respectively. The average rate of production growth in the 1980 was the highest at 24.2% per annum indicating that the industry responding positively to the price signal.

Figure 1: Malaysia: Cocoa area (ha), 1980-2014
Figure 2: Malaysia: Production of cocoa beans (tonnes), 1980-2014

http://www.koko.gov.my

Figure 3: Annual percentage change in cocoa area, cocoa beans price and production

http://www.koko.gov.my
However, the price took a turn in 1986 when it began to decline from RM4,260 per tonne to RM3,790 in 1987 and RM2,314 in 1993. Despite the decline, the area and production continued to rise indicating a delay in response due to irreversibility in fixed resources particularly land. Prices continued to hover around RM3,000 per tonne during 1990-2000 (MCB, 2014). On average the cocoa beans price was in an upward trend in the 1990s with an average annual change of 6.5% (Figure 3).

Cocoa prices are well known for its volatility. Beginning of 2002, the price continued to climb an increasing curve albeit with some degree of volatility before reaching its peak at RM8,535 in 2014. Despite the price increase, area and production of cocoa beans were not responding as they should.

The estate cocoa area has declined significantly from the height of 201,615 ha in 1989 to a mere 827 ha in 2014 (a decline of 99%) while the smallholder area declined from 212,621 ha to 15,243 ha (a reduction of 92%). The estate showed a rapid decline throughout the period. For instance the annual rate of cocoa area abandonment among the estates was 21% in 2000-2014 compared to 8% among the smallholders. This opposing behaviour manifested by the cocoa area and production is against the theoretical proposition that supply responses positively to an increase in price. As shown in Figures 7.1-7.3, despite an increase of cocoa price of about 8.2% annually in 2000-14, cocoa area and production of cocoa beans have declined 10% and 17.6% annually respectively.

Besides rapid decline in area and production, within the sector, the smallholder has become the predominant sub-sector. The share of smallholders in the area has increased from 37% (46,284 ha) in 1980, 51% (200,100 ha) in 1990 and 95% (15,243) by 2014. In 2014, the share of the estate was only 5% with 827 ha. In short, the smallholder became the major producer in the cocoa beans production albeit at a very much lower volume and area.

The increase in the area and production of cocoa beans is easy to explain as purported in the agricultural supply response theory. However, this theory is inapplicable with declining behavior. This implies that there exists other factors then price that resulted in the cocoa area abandonment or conversion. Based on the experiences in Brazil, the decline in the cocoa area was attributed to un treatable pest and disease problem and the pull of better return of non-cocoa ventures. A similar phenomenon is observed in Malaysia.

A unique feature of cocoa plant is that it is an agro-forestry crop. It requires a shade tree to grow healthily. This means that it could be either planted under shade tree or in the forest particularly thinned forests. In the early stage of plantation, a large area of forest was cleared up to make way for cocoa plantings. In a bid to improve productivity, it is reported that many farmers have attempted to remove shade. This practice proven right in the short term. However, in the long term it damages ecosystems by reducing the biodiversity and destruction of the natural habitat of the insects in the area. The disruption of the ecosystem as well as poor farming practices have resulted in an increase of insect attack as well as numerous pest and diseases (Clough et al., 2009). As discussed by Lee (2013) the infestation of Cocoa Pod Borer (CPD) was wide spread and very damaging to the cocoa beans production. This incident occurred due to the failure of early detection and poor control of the disease. A good farm monitoring and extension systems would have been able to identify early symptoms and take precautionary measures. This infestation was further worsened by low productivity (about 0.5 tonnes/ha) despite the claim that the maximum yield achievable at the MCB’s experimental laboratory which is 6 tonnes per ha. Again, this gap can be narrowed through an effective extension services. All these factors made cocoa farming no longer a profitable option which partly explain the massive area abandonment and conversion. These “push” factors were complemented by “pull” factors particularly better return from oil palm farming and other non-cocoa activities. It is estimated that the income from oil palm is about RM4,794/ha in 2012 (MPOB, 2014) which is twice achieved by cocoa farming. The workings of these push and pull factors are largely explained the exit of cocoa producers from the industry and hence the overall decay of the industry.

Figure 4: Malaysia: Production and grindings of cocoa beans (tonnes), 1980-2014

![Graph showing production and grindings of cocoa beans (tonnes), 1980-2014](http://www.koko.gov.my)
Addressing The Cocoa Decline

Malaysia chose not to let the decline continue. In fact it intends to revive the cocoa beans production as well as enhancing the grinding sector. Besides continuing strategies formulated in the National Agricultural Policy III (1998-2010), the new National Commodity Policy (2011-2020) sets explicit targets as the goals for the industry (Table 1).

Table 1: Targets for the Malaysia’s cocoa industry

<table>
<thead>
<tr>
<th>Item</th>
<th>Base year: 2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>20,070</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>Smallholder</td>
<td>18,770</td>
<td>27,500</td>
<td>37,500</td>
</tr>
<tr>
<td>Estate</td>
<td>1,300</td>
<td>2,500</td>
<td>2,500</td>
</tr>
<tr>
<td>Production (’000 tonnes)</td>
<td>16</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td>Productivity (kg/ha)</td>
<td>1.2</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Export earnings (RM bln.)</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>


The area for cocoa is expected to increase from 20,070 ha in 2010 to 40,000 ha in 2020 suggesting an increase of close to 100% or 10% per year. Close to 94% of the area are expected to come from the smallholder and the rest is from the estate. With the assumption that productivity will increase from 1.2 tonnes/ha in 2010 to 1.5 tonnes/ha in 2020, production of cocoa beans will almost quadruple from 16,000 tonnes in 2010 to 60,000 tonnes in 2020. With the improvement in the cocoa beans production, export earning is estimated to increase to RM6 bn by 2020.

The revival stance is driven by the following justifications: (i) the fundamentals are promising in that the International Cocoa Organization (ICCO, 2015) forecasted that demand for chocolate may outstrip supply in the years to come; (ii) established infrastructures and institutional supports particularly R&D; and (iii) downstream sector (grindings) is quite well-established to absorb cocoa beans. Despite the promising future, the targets seem a little far-fetched.

The targets can be considered ambitious as the achievements of the industry in 2014 are far below the 2015 expectation. If one assumes that the 2014’s figures are indicative of 2015, then the targets are beyond what has been achieved thus far. Firstly, with the exception of export earning, none of the variables: area, production and productivity showed an increasing trend. In the case of cocoa area, instead of increasing, the trend after 2010 showed a declining one, that is the area declined from 20,083 ha in 2010 to 16,070 ha in 2014 which is 24% below the 2015 target of 30,000 ha. Similarly, the productivity achieved in 2014 is estimated at 0.2 tonnes/ha or 86% below the targeted 1.2 tonnes/ha in 2015. Although the export earnings were on the rise, the level achieved in 2014 is 28% below the 2015’s target.

Malaysia has five more years to fulfill these targets. At the rate it is going, the targets may be farfetched. In view of that, what matters are the effectiveness of the strategies implemented to ensure that the cocoa farming is attractive and all market supports are in place to entice the current farmers to either rehabilitate or plant new cocoa trees. The strategies stipulated in the National Commodity Policy include: to increase productivity and competitiveness of cocoa beans and cocoa-based products, to improve public awareness on cocoa farming, to enhance R&D and commercialization, to improve the linkages between upstream and downstream sectors, to encourage SME participation in cocoa processing and manufacturing of cocoa-based products, to improve competitiveness and market share of the country’s cocoa-based products, to strengthen institutional and extension supports and to improve human capital. Some of the strategies taken to achieve these objectives include Cocoa Seedling Nursery Development Programme, Cocoa Planting Rehabilitation Programme-Rolling Plan, Domestic Market Support Programme (KSPD), and New Cocoa Plantation Development Project.

1 Calculated from www.koko.gov.my
Under the Cocoa Seedling Nursery Development Programme, MCB has created a total of 41 nurseries in 2013 to produce seedlings which were then distributed to the interested producers. As at 2013, a total of 477,537 trees were supplied (MCB, 2014). MCB has spent RM28mn for the Cocoa Planting Rehabilitation Programme-Rolling Plan. This programme encourages farmers to rehabilitate their cocoa trees through various means such as side grafting which proved to be popular and effective compared to new planting. The Domestic Market Support Programme aims at providing marketing channels for producers to sell their beans. The low production of beans has resulted in a vacuum market at the farm level as middlemen found that it was no longer profitable to trade in cocoa beans. In view of this, MCB provides the “middlemen” functions of buying and selling farm level beans until the market is sizeable enough to be run by the private sector. To encourage new plantation of cocoa, the New Cocoa Plantation Development Project was introduced. A total of RM16 mn budget was allocated to provide a subsidy worth RM8,000/ha to new cocoa plantation for a total of 2,000 farmers.

It is clear that the decline of the cocoa beans production was due to multi-faceted factors that interact with each other in a complex manner. In the early stage of development, the supply of cocoa appeared to be responsive to price but during its decline, price was no longer the determinant despite its increasing trend. The advent of insect infestation, the failure of the system to detect and address the problem particularly through extension services, structural problems at the farm and the “pull” of external factors have intermingled in reinforcing the decline. The challenge for Malaysia now is how to undo the decay after a decade of steep and unchallenged decline. This chapter attempts to empirically establish the roles of three major factors that contributed to the decay which are: the insect infestation, lack of extension services and the pull of external factors have intermingled in reinforcing the decline. The structural factors in the cocoa system that shape the behavior manifested by the industry. It also attempts to simulate the impact of intensifying extension services and R&D effort and withdrawal of subsidies on the industry. The simulation results should provide some cues as the effective measures to revive the industry in the future.

Methodology

Several studies have reported on boom and bust incidence among agricultural commodities like shrimp aquaculture industry (Arquitt et al. 2005; Bala and Hossin 2010; Prusty et al. 2011). From a system perspective, the boom and the decline tragedy occurred when the industry exceeded and consumed its environmental carrying capacity. Clough et al. (2009) has conceptualized the circular relationship between growth/decay and environmental carrying capacity of the cocoa crop (Figure 5). In the initial stage of development, forest thinning is carried out to make way for cocoa crop. This leads a “growth” phase of the cocoa plantation with area and production are trending upward. The plantation will soon reach a “boom” period where area and production reach their maximum. However, according to Clough et al., shade removal invites insect infestations and diseases as their natural habitat is destroyed by the new cocoa crops. This brings the cocoa plantation to the next phase called “stagnation” where productivity is challenged by frequent pest and disease problems and aging trees. Reduction in productivity and hence income will leave little capital for further investment on the farm. Decay occurs in this phase as seen in Brazil and Malaysia. The industry may opt to open up new area or shift to a more lucrative crop such oil palm in Malaysia. The circle continues. Franzen and Mulder (2007) concluded the importance of a balanced mix of ecological, economic and social considerations for sustainable cocoa production.

Figure 5: Cocoa boom and bust model
The above deliberations indicate the complex matrix of variables that determines the behavior and performance of the cocoa beans sector. The resultant behavior is a function of an interplay of economic, environmental and institutional factors that are feeding each other in a non-linear and circular relationship, interrupted at times by delays in decision making and physical flow. Under such an environment, a system dynamics methodology is very apt to capture those complex relationships.

This study utilizes a system dynamics methodology developed by Forrester (1961). System dynamics (SD) is a computer-aided approach to policy analysis and design. It is applicable to dynamic problems arising in complex social, managerial, economic, or ecological systems. Literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, delay and circular causality. The proposed model is intended to provide two deliverables: short term insights of the boom and bust and long term insights of sustainable development. It involves two major processes: model building and testing. Model building refers to the following activities: problem articulation, identifying dynamic hypothesis, causal loop diagram to depict the feedback relationship between variables in the system structure and stock and flow diagram to empirically estimate the relationships. The model testing involves model validation and policy simulation (Martinez-Moyano and Richardson, 2013).

The model is largely based on secondary data from published reports and studies. To derive decision behavior of the producer, a triangulation and participatory approach has been used to identify and fully understand the challenge of cocoa production systems in Malaysia. Focus group discussions were conducted with the stakeholders and documents related to the industry were collected and the information collected are analyzed to develop and discuss the dynamic hypotheses to explain the rise and fall of the cocoa beans production. Historical data in particular is important to understand the dynamics of the underlying change in the system. Based on the understanding of the dynamics of the problem, the study defines the boundary of the system so as to encapsulate the significant structural elements that shaped the increasing curve in the beginning and its rapid decline in the later stage. Data collected is also used to calibrate the model as part of model validation process.

**Problem Articulation**

This methodology requires one to define the problem at hand as it dictates the boundaries of the study. The study recognizes that the major problem faced by the cocoa industry is the rapid decline of cocoa beans production after a stellar performance in the 1980s. The behavior of the production curve which shot up and later decayed is parallel to the “boom and bust” archetype in system dynamics methodology. Based on the above deliberations, this behavior is attributed to a number of interdependent factors which are: environmental disruption that resulted in insect infestation and diseases, inadequate extension support to detect and monitor pest and diseases as well as to promote good practices, hence improving productivity and the pull factors from higher return crop such as oil palm and non-cocoa ventures. The country has laid out impressive R&D infrastructures and achieved reasonable success in high yielding varieties and high value added, but their dissemination to the ground is still minimal. The extension bridge has not been effective towards this end. To revive the cocoa beans production the government has implemented a number incentives particularly subsidies and programmes to achieve certain targets as stipulated in the country’s National Commodity Policy. Despite the targets, subsidies and programme, the trends of cocoa area, production and productivity continue to decline.

**Dynamic Hypothesis**

A dynamic hypothesis is a conceptual model typically consisting of a causal loop diagram, stock-flow diagram, or their combination. The dynamic hypothesis seeks to define the critical feedback loops that drive the system’s behavior. When quantified in a simulation model, the endogenous feedback structure of a conceptual model should be capable of reproducing the reference behavioral mode based on the assertion that “structure causes behavior.” Thus, in this study the system structure in the form of causal loop diagram and stock-flow diagram is hypothesized to generate the observed dynamic behaviour.

The study proposes that the interdependent relationship of environmental, economic and institutional support (particularly extension services and subsidies) play significant role in affecting the behavior of the cocoa beans production. Alternative policies that address these weaknesses such as intensification of extension to improve productivity, better R&D to improve practices and productivity may hold the key for improvement in future area expansion and production.

**Causal Loop Diagram**

There are three balancing and two reinforcing loops (B1, B2, B3, R1 and R2) in the cocoa system dynamics model (Figure 6). The balancing loop B1 represents the non-insect operating cost and B2 represents the yield decay by insects from area growth and weed thinning. Balancing loop B1 includes non-insect cost, profit, profit/area, weed thinning and pruning and weeding cost whereas B2 includes yield, production, revenue, profit, profit/area, weed thinning and pruning and insect infestation. Balancing loop B3 represents the anti-insect cost and it comprises five variables: insect cost, profit, profit/area, weed thinning and pruning and insect infestation. Reinforcing loop R1 represents the area growth or decay driven by profitability and it includes planted area, production, revenue, profit, profit/area and net area addition. Reinforcing loop R2 represents the yield growth by forest thinning and it includes yield, production, revenue, profit, profit/area, net area addition and planted area. The relationships between the variables follow the principles of an economic theory.
Reinforcing loop R1: Generates growth (or decay) in planted area depending on more or less profits. Reinforcing loop R2: Generates growth in yield through weed thinning and pruning. Balancing loop B1: Compensating feedbacks to limit profits from supply side, due to normal operating costs. Balancing loop B2: To reduce yields due to more insect infestations (from both area growth and yield growth (by weed thinning and pruning). Balancing loop B3: To accelerate emerging costs to fight insects.

Implications: Rapid growth phase (BOOM) is dominated by the 2 reinforcing loops (R1 and R2) driven by profitability to continue increasing both area and yield. In the long-run (the collapse phase), however, the dominance is shifted to Loops B2 and B3 which create undesirable double effects (from insects) that not only reduce yields but also accelerate the combating costs; hence causing profits down and down, resulting in area abandonment and yield decay, then production system collapse. What is further needed: To clarify why and how weed thinning and pruning can increase yield while inducing insect infestation, as well as how costly to fight insects.

Figure 6: Causal loop diagram of cocoa production system in Malaysia

Stock–Flow Model

Dynamic systems consist of interconnected feedback loops that are used to simulate dynamic behavior of the systems. There are two fundamental types of variable elements within each loop which are the building blocks of a system dynamics model. These building blocks are stock and flow. The stock is a state variable and it represents the state or condition of the system at any time t. The flow shows how the stock changes with time. The flow diagram shows how stocks and flows are interconnected to produce the feedback loops and how the feedback loops interlink to create the system. Figure 7 shows the stock-flow diagram of the boom and bust of cocoa production systems in Malaysia. The relationships represented in the flow diagram are expressed in terms of integral and algebraic equations and these equations are solved numerically to simulate the dynamic behavior (Forrester, 1968; Bala, 1999).

Basically, there are three major modules: (i) cocoa production system, (ii) cocoa beans inventory, price and grindings and (iii) areas under estates and smallholders. The “cocoa production system” has five sub-modules. The “farm profitability” module indicates the relationship between cocoa price and its impact of farm cost and profitability and hence area and production. The “cocoa area” module elaborates the effect of cocoa price, insect infestation and oil palm price on cocoa area. The “insect infestation” module explains the effect of insect infestation on cocoa yield. The “subsidy” modules explain the amount of subsidies provided and the “extension” module indicates the relationship between extension and yield.
The second module depicts the relationship between cocoa beans inventory, price and grindings. The last module indicates the stock-flow diagram of the smallholder and estate areas.

The mathematical equations that describe stock $stock(t)$ and flow structures are represented by integral equations:

$$stock(t) = stock(t - 1) + inflow \times \Delta t - outflow \times \Delta t$$

(1)

The $stock(t)$ is a state variable at any time t and it is represented by a rectangle. The flow shows how the stock changes with time and it is represented by valve symbol. The flow with arrow towards the stock indicates inflow and the flow with arrow outwards indicates outflow. The lines with arrow are influence lines and the direction indicates the direction of information flow. The variable/factor at the starting point indicates the variable/factor affecting the variable/factor at the terminating point and this in essence shows how one variable/factor influences other variable/factor with direction of information flow. In Figure 7 cocoa plantation areas is a stock variable and cocoa plantation rate is inflow into the stock – cocoa plantation area. Fundamental equations that correspond to major state variables shown in Figure 7 are as follows:

Cocoa plantation area is increased by cocoa plantation rate based on profitability of cocoa plantation and also cocoa plantation area is abandoned based on yield and profit. This is expressed as:

$$cocoa\ \text{plantation\ area}(t) = cocoa\ \text{plantation\ area}(t - 1) + cocoa\ \text{plantation\ rate} \times \Delta t - \text{abandon rate of cocoa} \times \Delta t$$

(2)

Figure 7: Stock-flow diagram of cocoa farm profitability, area, insect infestation and subsidy in Malaysia
Cocoa plantation rate depends on present level of cocoa plantation area, desired cocoa area and the time delay to reduce the gap between desired cocoa area and level of cocoa plantation area and it is expressed as:

\[
\text{cocoa plantation rate} = \text{MAX}(0, \frac{(\text{desired cocoa area} - \text{cocoa plantation area})}{\text{area adjustment time}})
\]  

(3)

Desired area is computed from the level of cocoa plantation area and profitability effect as:

\[
\text{desired cocoa area} = \text{cocoa plantation area} \times \text{profitability effect}
\]  

(4)
Abandon rate of cocoa area depends on the level of cocoa plantation area, yield effect and effect of profit and it is expressed as:

\[
\text{abandon rate of cocoa area} = \text{cocoa plantation area} \times \text{yield effect} \times \text{effect of profit}
\] (5)

Cocoa yield is increased by development of new hybrid varieties of cocoa through research and development and also it depends on ecological effect resulting from insect infestation due to limiting the shading index and intensity of shading index. This is described as:

\[
\text{cocoa yield} = \text{yield normal} \times \text{ecological effect} \times \text{intensification effect}
\] (6)

Yield normal is increased by development of new high yielding/hybrid varieties through research and development.

Shading index reduction increases the yield in the short – run but large scale reduction of shading index invites insect infestation which results in ecological degradation in the long-run. Shading index is reduced by thinning the trees for higher yields in case of cocoa plantation under forest trees and also shading index can adjusted by changing the plant to plant distance of the coconut tree in case of cocoa plantation under coconut plantation and the shading removal intensification is expressed as:

\[
\text{shading tree removal intensification}\,(t) = \text{shading tree removal intensification}\,\,(t-1) + \text{thinning intensification} \times \Delta t
\] (7)

Shading tree and cocoa plants invite the insects and the severity of insect damage depends on the intensity of insect attack and the insect attack intensification is expressed as:

\[
\text{insect attack intensification}\,(t) = \text{insect attack intensification}\,\,(t-1) + \text{insect attack growth rate} \times \Delta t
\] (8)

Cocoa production in Figure 7 depends on cocoa yield (tons/ha) as well as on area under cocoa plantation and it is computed as:

\[
\text{cocoa production} = \text{cocoa yield} \times \text{cocoa area}
\] (9)

The coverage of the subsidy and extension through farmer field schools are expanded with a broad policy of high biodiversity and acceptable yields for sustainable development. These are described as:

\[
\text{subsidy covered}\,\,(t) = \text{subsidy covered}\,\,(t-1) + \text{subsidy growth rate} \times \Delta t
\] (10)

and

\[
\text{extension covered}\,\,(t) = \text{extension covered}\,\,(t-1) + \text{extension growth rate} \times \Delta t
\] (11)

Model Validation

Initial values and the parameters were estimated from the primary and secondary data collected from different research reports, statistical year books of Malaysia and field visits. Tests were also conducted to build up confidence in the model. Tests for building confidence in system dynamics models essentially consist of validation, sensitivity analysis and policy analysis (Bala, 1999). The two important notions of the building confidence in the system dynamics models are testing and validation of the system dynamics models. Testing means the comparison of a model to empirical reality for the accepting or rejecting the model and validation means the process of establishing confidence in the soundness and usefulness of the model. In the behavior validity tests emphasis should be on the behavioral patterns rather than on point prediction (Barlas, 1996).

Researchers (Grant et al., 1997; Vanclay and Skovsgaard, 1997) have advocated the terminology 'model evaluation' instead of 'model validation'. This term emphasizes relative utility of a model. A model that is useful for one purpose may be misleading for other purposes.

To build up confidence in the predictions of the model, various ways of validating a model such as model structures, comparing the model predictions with historic data, checking whether the model generates plausible behavior and checking the quality of the parameter values were considered.

Figure 10 shows the comparisons of simulated behaviors of plantation area of cocoa with the historical data. The historical data of cocoa plantation area in Malaysia shows boom and bust. Simulated behaviors are numerically sensitive to parameters and
shapes of the table functions. However, the basic patterns of the historical and simulated behaviors agree adequately and model predictions represent reality.

Figure 8: Simulated and historical patterns of boom and bust of total cocoa plantation area in Malaysia (1980-2012)

![Figure 8](image)

Policy Analysis

These validated models are used to simulate the impact of a number of policy scenarios as summarized in Table 2. Baseline scenario is also known as Business as Usual where the initial productivity is set at 0.5 tonnes/ha, the extension agent ratio to producers is equal 1:150 and the subsidy is maintained at the current level of RM8,000 for new comers. The simulation period is until 2025. Scenario 1 refers to a combination of yield at 0.5 tonnes/ha, the extension agent ratio to producers is equal 1:100 and the subsidy is maintained as in baseline scenario. Scenario 2 involves an improvement of the extension agent ratio to producers which is 1:50. Scenario 3 is Scenario 2 with an addition of R&D allocation is increased by 10%.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Productivity</th>
<th>Extension</th>
<th>R&amp;D allocation</th>
<th>Subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>0.5</td>
<td>1:150</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>S1</td>
<td>0.5</td>
<td>1:100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>S2</td>
<td>0.5</td>
<td>1:50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>S3</td>
<td>0.5</td>
<td>1:50</td>
<td>110</td>
<td>100 (Withdrawal after 5 years)</td>
</tr>
</tbody>
</table>

R&D is increased by 10%
The comparisons of the results are shown in Table 3 and Figures 7.11-7.13. The findings suggest the followings. First, under all scenarios, the DKN targets are not achievable. Second, among the four scenarios, Scenario 2 gives the best results in terms of area (30,433 ha), production (41,463 ha), yield (1.4 tonnes/ha) and export value of RM 7.3 bn. Third, the withdrawal of subsidy has to be compensated with an increase in R&D to increase the productivity.
Figure 10: Simulated smallholders and estates (ha)

Figure 11: Simulated export value (RM)
Conclusion

The boom and bust behaviour of cocoa industry is the result of interaction between nature and economic factors. Cocoa trees are unique in characteristics in that it depends on the right amount of sun shade and thrives under a rich biodiversity environment which was not fully understood by many producers during the take off period in the 1980s. Heavy clearings of the forest has disturbed the natural habitat of the insects and hence their encroachment into the cocoa area for food. With limited caring and maintenance, infestation is rampant which reduces yield and hence income. The lower price of cocoa in the early 1990s has resulted in farmers abandoning their cocoa area and shifted their effort and resources to a more profitable crop like oil palm. These factors explain for the big decline in the cocoa beans production.

To revive the cocoa beans production after the big drop, will be a low recovery process. This is largely due to lack of resources to care for the cocoa trees, institutional factors particularly lack of extension support and a stronger pull from better return activities. The producers particularly the estates sector have lost confidence in cocoa farming in that to rebuild their conviction in the short term is a challenging task. The policy simulation exercise indicates that under all scenarios, the DKN targets are not achievable. This is attributed to the low level of productivity in the base year (5 tonnes/ha in 2010). With this level, it is impossible to achieve the target even with heavy subsidy and good ratio of extension agents to producers. Clearly, the targets are too high while the parameters to achieve them are low. However, the study indicates that the continuation of subsidies, R&D allocation and intensification of extension program may improve production of cocoa beans although the level achieved is still below the NCP’s target. If the ratio of extension agent to producers is improved to 1:50 and the current R&D allocation and subsidies are continued, production of cocoa beans can be increased to about 23,886 tonnes by 2020, a short of 30% of the 60,000 tonnes of the NCP’s target. The productivity that will be achieved is estimated at 1.4 tonnes/ha which is short of 6% of the target. Similarly, the smallholder area is expected to increase to 23,886 ha or 63% of the 2020 target. The export earning is expected to increase beyond the target due to better price prospect in lieu of constrained supply world-wide.

In short, the decline of the cocoa beans production is reversible by providing incentives as well as minimising the productivity gap. The expected achievement may be below the target levels, but future of area, production and productivity are estimated to be on the increasing trend. Probably the country may have to revise their targets to the levels that are realistic and workable. The study have focused on three major instruments: extension, incentive and R&D. However, in reality there are a lot more institutional supports are needed to complement these major instruments. These include: improvement in supply chains, logistics, innovations, product development, marketing, promotion and SME development. Future studies will have to take these factors into account.

References