UNIVERSITI PUTRA MALAYSIA

EFFICIENCY OF LIVESTOCK-OIL PALM INTEGRATION UNDER SMALL HOLDER SCHEME IN JOHOR, MALAYSIA

BASHIR HAMMAN GABDO

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By

BASHIR HAMMAN GABDO

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

April 2014

DEDICATION

To my great-great grand father, Late Modibbo Alkali Hammanjoda (1822-1908). Although we are generations apart, but you greatly inspired my life; desire for extensive knowledge acquisition. Your 40 years sacrificial sojourn to the Arab nations, parts of North and West Africa on foot in search of both Islamic and Western education that culminated into a degree (B.A) in Islamic Theology way back in 1880 from Al-Aqsar University, Cairo was indeed a remarkable feat. As the pioneer degree holder and an international Islamic scholar in Fombina Kingdom (Adamawa Province) and your royal exemplariness, makes your greatness too enormous to be forgotten.

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Doctor of Philosophy

EFFICIENCY OF LIVESTOCK-OIL PALM INTEGRATION UNDER SMALL HOLDER SCHEME IN JOHOR, MALAYSIA

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April 2014

Chairman: Ismail bin Abd Latif, PhD

Faculty: Agriculture

Malaysia has dominated global palm oil production for many decades. Even after Indonesia surpassed Malaysia in 2007 to become the current world leading producer, Malaysia's role in the global scene is still substantial and will continue to be for a long time to come. However, the Malaysia's oil palm policy of economy of scale has resulted to scarcity of land for agricultural use; upon which the poor performance of the ruminant animals is partly attributed to. This study analyzed production costs, returns and efficiency issues based on five estimators under goat-oil palm (GOI) and cattle-oil palm integrated (COI) systems. Data were collected from 255 livestock-oil palm smallholders across the 10 districts of Johor, Malaysia.

Descriptive statistics, gross margin model and net income model for estimating production costs and returns. The Data Envelopment Analysis (DEA), DEA-bootstrap, Free Disposal Hull (FDH), order-α and order-m for estimating efficiency of resource use. The box and whiskers plot was used to eliminate outliers in the data set in order to make the result more robust. The tobit and Ordinary Least Squares (OLS) regressions were used to analyze the determinants of Technical Efficiency (TE) under both goat-oil palm (GOI) and cattle-oil palm (COI). Depending on age of the palms, results on costs and returns show that the goat-oil palm (GOI) farms realized between 6.90mt/ha/yr and 22.84mt/ha/yr relative to the goat-oil palm (COI) between 13.17mt/ha/yr and 25.70mt/ha/yr of FFB. On the whole, while the goat-oil palm (GOI) farms realized between RM6562.94/ha/yr and RM17268.78/ha/yr, the cattle-oil palm (COI) farms obtained between RM11529.07/ha/yr and RM21034.17/ha/yr in net income. While the goat-oil palm (GOI) system predicted mean of 94% and 23% reduction in weeding cost and saved cost from total cost of production, the goat-oil palm (COI) system estimated 100% and 20% reduction in weeding cost and saved cost from total cost of production respectively, relative to none-integrated farms.

The Data Envelopment Analysis (DEA) results found mean TE of 0.997, 1.000 and mean Scale Efficiency (SE) 0.802, 1.000 for goat-oil palm (GOI) and cattle-oil palm (COI) systems respectively. Similarly, 1.000, 0.998, 0.990 and 1.000, 0.998, 0.972 were estimated as mean TE under FDH, order-α and order-m estimators under goat-oil palm (GOI) and cattle-oil palm (COI) systems respectively. Mean CE and AE were estimated 0.867, 0.869 and 0.865, 0.865 for goat-oil palm (GOI) and cattle-oil palm (COI) respectively. Analysis of input and output slacks detected higher slack in the cattle-oil palm (COI) relative to the goat-oil palm (GOI) system; just as the noise estimate for factors beyond farmers' control found lower bias (mean=0.047) components in the cattle-oil palm (COI) relative to the goat-oil palm (GOI) (mean=0.065). The bootstrap estimator reports that the plantations operate at sub-optimal phase of production under increasing returns to scale and estimated 0.888, 0.764-0.950 and 0.891, 0.776-0.937 as bias-corrected TE and confidence interval for goat-oil palm (GOI) and cattle-oil palm (COI) systems respectively. The t-test result found significant statistical difference between Fresh Fruit Bunches (FFB) yield and stocking rate under the two systems, also between the DEA and DEA-bootstrap estimators and between Federal Land Development Authority (FELDA) and independent farms.

Finally, the tobit and OLS results found farmers' age, years of integration, farmers' education, credit and farming association to have positive and significant impact consistently across both integration systems. Policy decision encouraging increased farm size and one that can mitigate the effect of detrimental exogenous factors (flood, diseases) among others will help increase their efficiency status.

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

KEBERKESANAN INTEGRASI TERNAKAN-KELAPA SAWIT DI BAWAH SKIM PEKEBUN KECIL DI JOHOR, MALAYSIA

Oleh

BASHIR HAMMAN GABDO

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Malaysia telah mendominasi pengeluaran minyak sawit global untuk beberapa dekad. Walaupun selepas Indonesia mengatasi Malaysia dari segi pengeluaran pada tahun 2007 untuk menjadi pengeluar terkemuka dunia sehingga kini, namun, peranan Malaysia dalam arena global adalah masih besar dan akan berterusan untuk masa yang mendatang. Walau bagaimanapun, polisi skala ekonomi kelapa sawit Malaysia telah menyebabkan kekurangan tanah untuk kegunaan pertanian yang sebahagiannya berpunca daripada prestasi buruk haiwan ruminan . Kajian ini menganalisis kos pengeluaran, pulangan, dan isu-isu keberkesanan berdasarkan lima estimator di bawah sistem bersepadu kambing-kelapa sawit (GOI) dan lembu- kelapa sawit (COI) . Data telah dikumpulkan daripada 255 pekebun kecil ternakan-kelapa sawit di seluruh 10 daerah Johor, Malaysia.

Statistik deskriptif, model margin kasar dan model pendapatan bersih digunakan bagi menganggar kos pengeluaran dan pulangan. Analisis Envelopmen Data (DEA), *Bootstrap DEA*, Pelupusan Percuma Hul (FDH), order-α dan order-m adalah untuk menganggarkan keberkesanan penggunaan sumber. Plot-Kotak telah digunakan untuk menghapuskan unsur luaran dalam set data bagi memperoleh keputusan yang lebih mantap . Regresi Tobit dan *Ordinary Least Square* (OLS) telah digunakan untuk menganalisis determinan Keberkesanan Teknikal (TE) di bawah kedua-dua sistem,iaitu kambing-kelapa sawit (GOI) dan lembu-kelapa sawit (COI). Bergantung pada umur pokok kelapa sawit, hasil kos dan pulangan menunjukkan bahawa ladang kambing-kelapa sawit (GOI) memperoleh antara 6.90mt/ha/yr dan 22.84mt/ha/yr berbanding dengan ladang lembu-kelapa sawit (COI) ,iaitu antara 13.17mt/ha/yr dan 25.70mt/ha/yr BTS. Pada keseluruhannya, ketika ladang kambing-kelapa sawit (GOI) memperoleh antara RM6562.94/ha/yr dan RM17268.78/ha/yr, ladang lembu-kelapa sawit (COI) memperoleh pendapatan bersih, antara RM11529.07/ha/yr dan RM21034.17/ha/yr . Sementara sistem ladang kambing-kelapa sawit (GOI) meramalkan min sebanyak 94% dan pengurangan sebanyak 23% dalam kos merumput dan ini dapat menjimatkan kos daripada jumlah keseluruhan kos pengeluaran, sistem lembu-kelapa sawit (COI) pula menganggarkan 100% dan pengurangan sebanyak 20 % dalam kos merumput dan ini

dapat menjimatkan kos daripada jumlah keseluruhan kos pengeluaran masing-masing, berbanding dengan ladang bukan bersepadu.

Keputusan Analisis Envelopmen Data mendapati min bagi Keberkesanan Teknikal (TE), iaitu 0.997, 1.000 dan min Keberkesanan Skala (SE) iaitu masing-masing, 0.802, 1.000 bagi kambing-kelapa sawit (GOI) dan sistem lembu-kelapa sawit(COI). Begitu juga, 1.000, 0.998, 0.990 dan 1.000, 0.998, 0.972 dianggarkan sebagai min Keberkesanan Teknikal (TE) di bawah Pelupusan Percuma Hul (FDH), estimator order-α dan order-m , masing-masing di bawah sistem kambing-kelapa sawit (GOI) dan lembu-kelapa sawit (COI). Min untuk CE dan AE dianggarkan , masing-masing,0.867, 0.869 dan 0.865, 0.865 untuk kambing-kelapa sawit (GOI) dan lembu-kelapa sawit (COI) . Analisis terhadap slack input dan output, dikesan slacknya lebih tinggi dalam sistem lembu-kelapa sawit (COI) berbanding dengan sistem kambing-kelapa sawit (GOI); hanya sebagaimana bunyi yang dianggarkan bagi faktor di luar kawalan petani didapati komponen bias lebih rendah (min = 0.047) dalam lembu-kelapa sawit (COI) berbanding dengan kambing-kelapa pada fasa pengeluaran suboptimum di bawah peningkatan skala pulangan dan masing-masing, dianggarkan 0.888, 0.764-0,950 dan 0.891, 0.776-0.937 sebagai pembetulan bias bagi Keberkesanan Teknikal (TE) dan interval keyakinan bagi sistem kambing-kelapa sawit (GOI) dan lembu-kelapa sawit (COI) . Hasil ujian-t mendapati perbezaan statistik yang signifikan antara hasil Tandan Buah Segar (FFB) dan kadar stok di bawah kedua-dua sistem dan juga antara estimator DEA dan *Bootstrap* DEA,dan antara Lembaga Kemajuan Tanah Persekutuan (FELDA) dan peladang persendirian.

Kesimpulnnya, keputusan Tobit dan OLS mendapati bahawa umur petani, tempoh integrasi, pendidikan petani , kredit dan persatuan perladangan mempunyai impak yang positif dan signifikan secara konsisten pada kedua-dua sistem integrasi. Keputusan polisi menggalakkan peningkatan saiz ladang dan ini boleh mengurangkan kesan beberapa faktor eksogenus yang memudaratkan (banjir, penyakit,yang antara lainnya akan membantu peladang meningkatkatkan status keberkesanan mereka.

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

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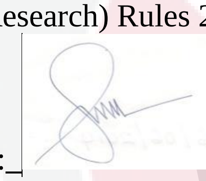
Signature:  ________________ Date: ____________

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AE	Allocative Efficiency
ATE	Average Technical Efficiency
CE	Cost Efficiency
COI	Cattle-Oil palm Integration
CPO	Crude Palm Oil
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DGP	Data Generating Process
DMU	Decision Making Unit
DOA	Department of Agriculture
DRS	Decreasing Return to Scale
DVS	Department of Veterinary Services
EE	Economic Efficiency
FDH	Free Disposal Hull
FEAR	Frontier Efficiency Analysis with R
FELCRA	Federal Land Consolidated and Rehabilitated Authority
FELDA	Federal Land Development Authority
FFB	Fresh Fruit Bunches
GDP	Gross Domestic Product
GM	Gross Margin
GOI	Goat-Oil palm Integration
IDF	Input Distance Function
IMP	Industrial Master Plan
IRTS	Increasing Return to Scale
MARDI	Malaysian Agricultural Research and Development Institute
MOA	Ministry of Agriculture
MBOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Council
MPOPC	Malaysian Palm Oil Promotion Council
MPSS	Most Productive Scale Size
MT	Million Metric Tons
MVP	Marginal Value Product
NAP	National Agricultural Policy
NEP	New Economic Policy
NI	Net Income
NIRTS	Non-increasing Return to Scale
ODEA	Output Data Envelopment Analysis
ODF	Output Distance Function
OLS	Ordinary Least Square
OPT	Oil Palm Trunk
OTE	Overall Technical Efficiency
PDF	Parametric Distance Function
PKC	Palm Kernel Cake

POF	Palm Oil Fronds
POME	Palm Oil Mill Effluent
PORIM	Palm Oil Research Institute of Malaysia
PORLA	Palm Oil Registration and Licensing Authority
PPO	Processed Palm Oil
PTE	Pure Technical Efficiency
RISDA	Rubber Industry Smallholders Development Authority
SE	Scale Efficiency
SPF	Stochastic Production Frontier
TC	Total Cost
TE	Technical Efficiency
TFC	Total Fixed Cost
TVC	Total Variable Cost
USDA	United States Department of Agriculture
VRS	Variable Return to Scale

CHAPTER 1

INTRODUCTION

1.1 Oil palm and Livestock Production Systems

Although the oil palm crop originated from West Africa, its production has long crossed the shores of Africa. Substantial evidence abound not only to attest the production of oil palm outside the horizons of Africa but also to testify the long shift in its global index of production to the Asian continent. Global account for oil palm as a crop will be incomplete without mentioning the role Malaysia played and still playing in transforming the crop to a more economically viable status. Hardly is there any country in the world that invested so much on oil palm both in its up-stream and down-stream activities like Malaysia and hardly also is there a nation in the world that reaped so much economic benefit from oil palm like Malaysia.

Malaysia has dominated the global scene of the oil palm industry for more than four decades, out of which it became the highest world producer for over three decades. Malaysia surpassed Nigeria as the world leading producer nation in the 1970s up until Indonesia surpassed Malaysia as the highest producer nation in 2007. Rieger (2006) asserted the position of Nigeria in the 70's as the world's leading producer nation of oil palm that accounted for 43% of global production, Malaysia was accountable then for less than 10% of the world's output. As at 2007, when Malaysia was about to be surpassed by Indonesia, Malaysia accounted for 51% of world palm oil production and currently, Indonesia and Malaysia jointly produce 85% of world production, making them the first and second leading producer countries respectively in the world (Dompok, 2010). MPOB (2010) presented a production output of 15.8 million MT of crude palm oil, 4.1 million MT of palm kernel, 1.9 million MT of crude palm kernel and 2.15 million MT of palm kernel cakes produced in Malaysia in 2007. In 2008, 17.7 million MT of crude palm oil was produced in Malaysia on 4.5 million hectares (Mha) of land (Wikepedia, 2010), 4.57 million MT of palm kernel, 2.1 million MT of crude palm kernel and 2.35 million MT of palm kernel cakes were produced while in the following year, 17.56 million MT of crude palm oil, 4.5 million MT of palm kernel, 2.1 million MT of crude palm kernel and 2.3 million MT of palm kernel cakes were profiled (MPOB, 2010). MPOB (2013) asserted that the active oil palm plantations in Malaysia estimated at 5.1 million ha is projected to produce 18.9 million MT of crude palm oil in 2013. Other world renowned producers are Nigeria, Thailand, Colombia, Ecuador, Ghana, Congo, Cameroon, Ivory Coast, Brazil and Papua New Guinea. See table 1.1 below.

Table 1.1: Top 15 palm oil producing nations

Country	Production (million MT)
Indonesia	28,000,000
Malaysia	18,500,000
Thailand	1,700,000
Colombia	960,000
Nigeria	850,000
Papua New Guinea	530,000
Ecuador	505,000
Cote D'Ivoire	300,000
Brazil	275,000
Honduras	252,000
Costa Rica	225,000
Guatemala	197,000
Cameroon	190,000
Congo	185,000
Ghana	120,000

Source: USDA (2012)

In the export market, Malaysia is a global giant and a major player considering her volume of export. MPOC (2009) rated Malaysia as the current largest palm oil exporter in the world. MPOC (2013) indicated that Malaysia contributes not less than 44% of the global export market of oil palm. This rating is on the premise that Indonesia; the largest producer, consume locally a greater proportion of her palm oil and export smaller percentage while Malaysia exports little below 100 percent with an insignificant local consumption rate of her output. MPOB (2010) reported a volume of 15.4 million MT and 15.88 million MT of palm oil exported from Malaysia to 151 and 157 countries of the world in 2008 and 2009 respectively.

Through palm oil exportation to the world market, the oil palm industry plays a very significant role in the Malaysian economy. The Sabah Government (2010) attested that palm oil products alone has earned the Malaysian economy RM 5 billion in 1998, RM 26.15 billion in 2003 and RM 31.81 billion in 2006 (Wahid, Lim and Mohd Arif, 2007). Wikipedia (2010) estimated 13 million MT of palm oil valued at USD10 billion was exported by Malaysia to other countries of the world in 2007. Similarly, In 2008, a production index of 15.4 million MT of refined palm oil valued RM 47.9 billion and 21.76 million MT of total production of palm oil products valued RM 65.22 billion were exported.

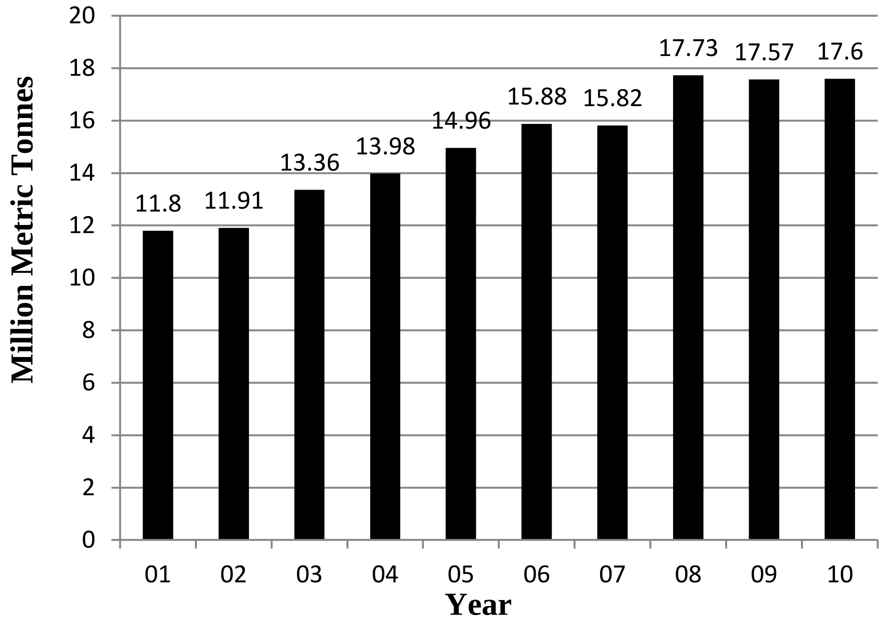

Figure 1.1: Malaysia's crude palm oil output between 2001 and 2010 (million MT)

Source: MPOB (2010)

In 2009, 15.88 million MT of refined palm oil valued RM36.95 billion and 22.47 million MT of total production of palm oil products valued RM49.66 billion were reported (MPOB, 2010) and a sum of RM 80.4 billion (USD26.8 billion) was generated as foreign exchange in 2011 and 18.8 million MT of palm oil was produced in 2012 (MPOB, 2013). Thus, palm oil alone contributes larger than one third of the agricultural Gross Domestic Product (GDP) of Malaysia (Wahid, Lim and Mohd Arif, 2007) and more than 30% of her total income from exports (Sabah Government, 2010). So far in history, the Malaysian oil palm industry never had it well as she did in 2011 in terms of volume of production and foreign exchange earnings resulting from favorable world market prices for the palm oil products.

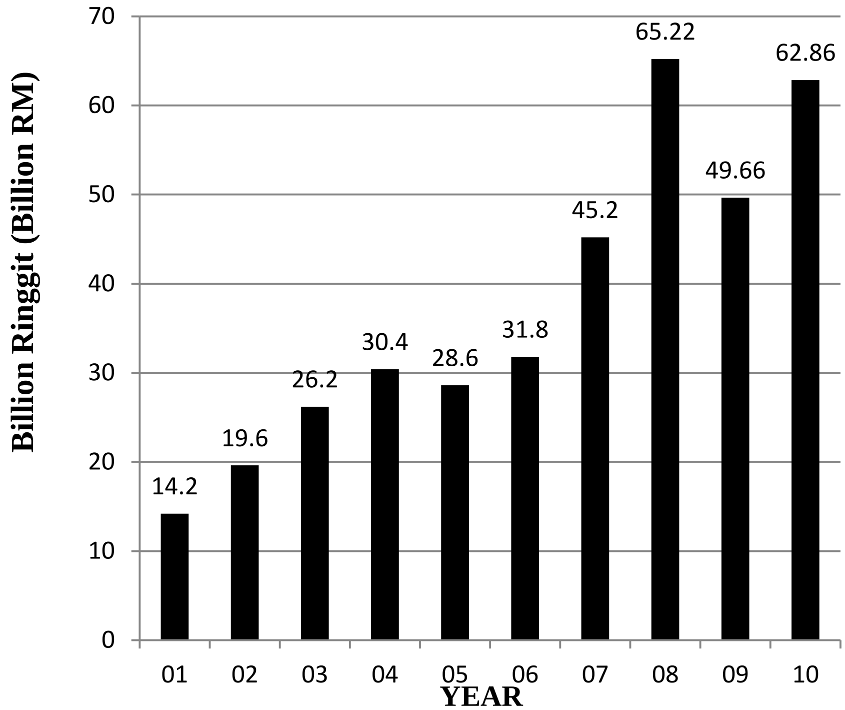

Figure 1.2: Malaysia's palm oil exports between 2001 and 2010 (million MT)
Source: MPOB (2010)

The utility of oil palm products and its byproducts are quite numerous. The fruit of oil palm can be separated into the pulp (fleshy part) and the seed (Kernel). The latter further produce the palm oil (edible oil) while the former produce the palm kernel oil (non-edible oil). Wikipedia (2010) noted that palm oil is the most widely produced oil in the tropics and constitutes 30% of world edible oil; used for cooking, as biofuel, as medicine, in cosmetics, confectionary and other food industries owing to its relatively cheap price, high oxidative stability, high natural antioxidant and high saturated fats content that enable it to withstand deep frying under excessive heat condition. Furthermore, while the palm kernel oil is used in local and established industries for soap making, the kernel meal and palm fronds are processed and used as livestock feeds. On the whole, the oil palm industry has created employment opportunities to several hundreds of thousands people in the country both in skilled or unskilled labor. Amatzin (2006) stated that the oil palm sub sector of the economy as reported by the Ministry of Plantations, Industries and Commodities in 2005 provided nearly 2 million jobs to workers in Malaysia.

The smallholder and the estate scheme are the two importantly existing categories of livestock-oil palm producers in Malaysia. The latter which is the focus of this research, portray oil palm cultivation on a piece of land less than 10 ha in size. The smallholder is further splitted into two sub schemes on the basis of aid to factors of production in to those with very minimal or no access to aid in factors of production which is the independent smallholder while the organized smallholder constitute the other sub scheme.

Livestock-oil palm integration as a system of economy of scope; ensures increased productivity of both the livestock and oil palm by using common resources such as land and other resources to complement one another. For instance, the animal dung helps in soil fertility; a substitute to inorganic fertilizer, which ensures sustainability due to its environmental friendliness. Similarly, the oil frond is a chief source of feeds to the livestock. Thus, the two play a role of cost reduction from either unit of integration. Although livestock-oil palm integration existed for long in the context of Malaysian agricultural system. But the integration system was not widely practiced; partly because there was no pressure on agricultural land. In the advent of land scarcity and high demand for beef due to rising population, the livestock-oil palm integration system remain one of the avenues for increase in both the livestock and the oil palm units. Furthermore, the system will also ensure land use maximization and the cost of both oil palm and livestock maintenance will be reduced since their byproducts serve as complementary resources.

Livestock-oil palm integration also stimulates domestic livestock production. In view of the huge government expenditure on beef importation in Malaysia, the livestock-oil palm integration will help reduce the bill for beef importation. Eventually, with wider patronage, Malaysia will in the future have potential to attract foreign exchange by exporting instead of the current import status of beef.

Livestock-oil palm integration in Malaysia is gaining more attention, which started thriving under the estate scheme with substantial involvement of the smallholders recently. The call for oil palm integration; especially that of livestock-oil palm at national level was made in 1999. The focus was to encourage farmers to participate in livestock-oil palm integration in other to boost the beef sub sector of the economy. A projection for consumer demand for beef in Malaysia between 2000, 2005 and 2010 asserted that self-sufficiency can only be achieved if all oil palm areas are integrated with cattle (MOA, 1992). Despite the clamor for oil palm integration in the country the concept has not receive a holistic action particularly within the independent smallholder sub scheme due to persistent neglect from government and non-governmental organizations in providing aid to factors of production and the self-challenges of capital faced by most smallholder farmers.

In the livestock-oil palm integration, grazing and supplemental feeding using palm kernel cake (PKC) is economically feasible. In Sabah, most livestock under livestock-oil palm integrated farms feed widely on palm oil fronds (POF). Fronds of 2.2m length from mature palms are fed to small ruminants and chopped to feed cattle. However, small ruminants feed on only the leaves and the softer parts of the fronds, but chopping enables total intake of the fronds by the higher ruminants. Each mature frond produces about 2.5kg of chopped feed. Adequate care should be taken when cutting fronds to engage only the matured ones to avoid displacing the sagging position of the fresh fruit bunches (FFB). As a rule of thumb, every matured palm is entitled to two harvests of two oil palm fronds per month (Devendra, 2009).

The oil palm environment offers a great opportunity for livestock-oil palm integration especially with livestock. Some of these opportunities and suitability that influence decision to integrate oil palm and livestock are summarized below. Devendra (2009) itemized seven conducive production attributes for livestock integration to enhance total factor productivity:

1. Availability of forage dry matter: Between 2.16-2.99 mt/ha for 3 and 5 years old palms, which gradually reduce to 435-628kg/ha for 10-29 year old palms.
2. Availability of 60-70 forage species in young palms which gradually reduce up to 66% in older palms.
3. Forage categories: 56-64% grasses, 18-23% dicotyledons, 3-19% legumes and 2-15% ferns for 3-10 years old palms, and 50% grasses, 13% dicotlydons, 2% legumes and 35% ferns for older palms.
4. Palatabilty: About 72-93% of the forages are palatable and of great value to the ruminants.
5. Availability of ample space for movement and exercise of the animals.
6. Carrying capacity: 25-30 indigenous goats/ha in 3-4 years old palms with average daily gain of about 40-60g/day for two year cycle to 3-5 goats/ha with over 7 year old palms.
7. Other categories of feeds from the palm tree are: the oil palm trunk (OPT), palm oil fronds (POF), palm kernel cake (PKC) and palm oil mill effluent (POME).

Like the Malaysian oil palm industry, the livestock industry also plays a vital role to the economy. However, they differ in terms of level of contributions to the economy, while the oil palm industry contributes immensely to the overall economy; the livestock sector is not encouraging in its performance, particularly with the non-ruminant animals. DVS (2002) stated that between 1980 and 2001, the livestock industry as a whole experienced an average growth rate of only 5.8% annually; translated to only 2% contribution to the GDP. The livestock industry is divided into ruminant and non-ruminant sub-sectors. While cattle, buffalo, goat and sheep are the major ruminants reared in Malaysia, the non-ruminant sub-sector is largely dominated by poultry and swine production. There is a wide distinction between the ruminant and non-ruminant categories in Malaysia. Serin *et al* (2008) remarked that the ruminant and non-ruminant animals in Malaysia differ relative to their systems of management, value of output produced, nature of marketing and opportunities and challenges facing them. Furthermore, of the two, the non-ruminant sub-sector is more developed and contributes more to the economy than the ruminant sub-sector. The ruminant sub-sector is still largely dominated by cow-calf smallholder operations which accounts for 80% of the domestic beef production and so far no history of attainment of self-sufficiency. However, the non-ruminant (poultry and swine) sub-sector advanced from smallholder farming to a mechanized and modern status and had attained self-sufficiency level since the early part of 1980. Although the swine production suffered serious setback in 1999 following the viral attack, but the establishment of modern pig farming area (PFA) is indeed a step towards reviving the swine production.

Despite the surge in population and increase in income growth as stimulants for beef demand in Malaysia, the supply side of the ruminant sub-sector seems to be less responsive to the rising demand. While the ruminant animals (beef) are still being imported from India and Australia, the non-ruminant (poultry and swine) are being exported to Singapore. On the part of the government, several efforts to encourage the growth and development of the beef sub-sector were made but due to policy failures most of these efforts did not bring impressive results. A breeding program was established in 1960's aimed at distributing pregnant heifers or high quality bulls to selected farmers. Upon delivery, the calf was returned to the government as a replacement for the heifer received and government in turn bred the calf to pregnancy and distribute further to other farmers in the waiting list. Although this scheme was formally terminated in the 7th Malaysian plan owing to policy liberalization from highly subsidized to competitive policy, but is still being practiced in some states.

Again, the government established 13 cattle farms located in different localities in 1970's with the mandate of breeding, producing, training and conducting research and development. This effort was also discontinued in the 1990's as some of the farms were closed down and others closed tactically in the name of relocated them to better sites (Serin *et al.*, 2008). Cattle feedlot scheme was also initiated in 1985/1986 to enhance productivity by fattening the calves for duration between 6 and 12 months to be ready for slaughter. This scheme appeared to be very promising, however, lack of steady supply of feeder cattle from local source, rising price of commercial feeds and initial capital to start project constituted a bottleneck to many farmers. Similarly, in 2002, another pilot project named Cow rearing Sector Entrepreneur Transformation Scheme was launched in Kedah. A total of 300 farmers were selected and assigned with 10 cows each rear and repay its cost to the government after 7 years of operation. The sum of RM 4.5 million was expended for this project. It is interesting to note that until today, the Malaysian government never relents in her effort of transforming the livestock sub-sector, particularly, the ruminant unit to a competitive and self-sufficient level to satisfy local demand and tap more the benefit of the export market.

Vermeulen and Goad (2006) anchored their definition of smallholder oil palm production based on the definition applied by the round table on sustainable palm oil to mean a family venture producing oil palm from a land below 50 hectares. But in the context of this study consideration was given to oil palm farms with less than 10 ha of size. In 2000, a total of 87,717 farmers were found in the category of independent smallholder oil palm in Malaysia and 39,711 of that, representing 45.26% were found in the state of Johor (MPOBb, 2001). Furthermore, the study revealed a total of 320,835.66ha planted area under independent oil palm smallholder in Malaysia and 39.10% of that were located in Johor State. The study also disclosed that between 1999 and 2000, the area planted by independent oil palm smallholders had increased and by 2000 it accounted for 8.59% of total oil palm planted area in the country (MPOBa, 2001a). See tables 1.1, 1.2 and 1.3

Table 1.2: Distribution of oil palm planted areas according to category of producers from 1999 to 2000 (hectares)

	1999		2000	
	Ha	%	Ha	%
FELDA	674948	17.64	598190	16.01
FELCRA	132354	3.46	154357	4.13
RISDA	41561	1.09	37011	0.99
State Schemes	235565	6.16	242002	6.48
Total Organized Smallholders	1084428	28.34	1031560	27.61
Independent Smallholders	286513	7.49	320818	8.59
Total Smallholders	1370941	35.83	1352378	36.20
Total	3826310	100.00	3736316	100.00

Source: MPOBa (2001)

Table 1.3: Distribution of Independent oil palm smallholders in Malaysia according to state in year 2000 (hectares)

State	Frequency	%	Ha	%
Johor	39711	45.26	125459.83	39.10
Perak	15921	18.15	53089.78	16.55
Selangor	15324	17.47	33407.47	10.41
Pahang	3277	3.74	16683.21	5.20
Negeri Sembilan	2015	2.30	11057.77	3.13
Kedah	1485	1.69	10045.77	3.13
P. Pinang	1119	1.28	6869.02	2.14
Melaka	626	0.71	4212.29	1.31
Terengganu	582	0.66	4042.34	1.26
Kelatan	103	0.12	1128.96	0.35
Sabah	5994	6.83	48031.85	14.97
Sarawak	1560	1.78	6807.21	2.12
Total	87717	100.00	320835.66	100.00

MPOBb (2001)

Table 1.4: Distribution of independent oil palm smallholders producers in Johor according to district in in year 2000 (hectares)

District	Frequency	%	Ha	%
BatuPahat	12669	31.90	32563.99	25.96
Muar	8420	21.20	23727.63	18.91
Kluang	8304	20.91	30764.67	24.52
Pontian	6186	15.58	18844.94	15.02
Johor Bahru	1766	4.45	8099.52	6.46
Segamat	1115	2.81	4906.31	3.91
Kota Tinggi	704	1.77	4413.29	3.52
Mersing	547	1.38	2139.48	1.71
Total	39711	100.00	125459.83	100.00

MPOBc (2001)

Ismail *et al.* (2003) categorized oil palm smallholders into organized and independent and further characterized the independent smallholder as having scattered farm plots and lack organization; due to low capital base of the farmers, lack support from government and non-governmental organizations. The consequences of the aforementioned characteristics associated with the independent smallholder results into lack of information and up to date data on its economic performance. The independent smallholders are distinguished from the organized smallholders by their ability to access technical support, input supply and market opening from the Federal Land Development Authority (FELDA), Federal Land Consolidated and Rehabilitation Authority (FELCRA), Rubber Industry Smallholders Development Authority (RISDA) and similar other government and non-governmental agencies. The independent smallholder source individual capital and establish plantations themselves with little and less effective intervention from government through extension services provided then by the Department of Agriculture (DOA) and now by PusatTunjuk Ajar dan Nasihat (TUNAS) of the palm oil board (Ismail *et al*., 2003) while the organized smallholder farmers access all the above mentioned services.

1.2 Brief on Federal Land Development Authority (FELDA) and independent oil palm farms

The Federal Land Development Authority (FELDA) in Malaysia was established in 1956 following the enforcement of the Land Development Act under Prime Minister Tunku Abdul Rahman. The first Federal Land Development Authority (FELDA) settlement in Malaysia was in Kelantan which resettled 400 farmers. Federal Land Development Authority (FELDA) is an agency of the Malaysian government initially saddled with the responsibility of resettlement of rural poor farmers into newly developed sites and to handle the organization of smallholder farms who grow cash crops. Since 1990's, the Federal Land Development Authority (FELDA) ceased to establish new settlement, rather it focuses on wide range of economic and business development activities. The launching of FELDA Global Ventures Holdings in 2012 on the global stock exchange was the second largest listing in the world in the year 2012 with over USD$3 billion generated.

The Federal Land Development Authority (FELDA) farms were allocated to the rural poor with priority to those who did not have farm lands. Each farmer was provided with either 10 acres (4.0ha) or 12 acres (4.9ha) or 14 acres (5.7ha) of cultivable land to grow either oil palm or rubber. The Federal Land Development Authority (FELDA) has over the years provided such communities with all basic infrastructure for good living; such as electricity, piped water, schools, market points, sporting areas, worship points, medical centers and other infrastructural support.

Federal Land Development Authority (FELDA) started as a cooperative venture, where all settlers own equal share of the proceeds generated. But this management system was contested against the fact that settlers who did not participate actively enjoyed equal benefits with those on active participation. A 3-phase scheme was then set up in view of the cooperative management issue. In the 1st phase, the cooperative became a mechanism for the farmers to learn applied farming skills. The 2nd and 3rd phases dealt with the provision of plots to the farmers and provision of land title to the farms plots allocated respectively. The Federal Land Development Authority (FELDA) settlement scheme were financed by government loans to the Federal Land Development Authority (FELDA) farmers to service cost of acquiring, developing and allocating the land. The repayment period for the loan was via installment deductions on monthly basis from the farmers' income over a period of 15 years.

Are the Federal Land Development Authority (FELDA) farms fixed? Do they have means to increase farm size (ha)? Yes, the Federal Land Development Authority (FELDA) have fixed farm size; depending on the location (either 4.0ha or 4.9ha or 5.7ha). Since government policy from Federal Land Development Authority (FELDA) changed from land resettlement to economic and business oriented activities, then obviously farmers under the scheme has no means of increasing farm size. Except if they can venture into an independent means to source their land.

The independent farmers of oil palm are those farmers who source their land for oil palm production on their own. They also partake in the management of the land to grow oil palm, source inputs with little or no government subsidy and with general lack of government attention. Unlike the Federal Land Development Authority (FELDA) farms, the independent farms are mostly scattered and they have more challenges than the Federal Land Development Authority (FELDA) farms.

1.3 Issues and Challenges

The Malaysian oil palm policy has over the years been on economy of scale; expanding estates and plantations and minimal emphasis has been made in the area of economy of scope; enterprise combination between oil palm and livestock or other crop production for productivity. Today, about 5 million hectares of land are cultivated with oil palm and these exclude Malaysian plantations established outside Malaysia, particularly in the neighboring countries such as Indonesia; thus, an indication that Malaysia is faced with shortage of agricultural land. On average, a hectare of oil palm plantation grow only 148 palm trees; imaging the spaces in between the palms an indication of land under-utilization and given that there is issue of general agricultural land scarcity at hand. Devendra (2009) remarked that the oil palm farms has economic potentials for integration with livestock since there is ample space for the animals, pasture availability and general potentiality for symbiotic relationship between the oil palm and the livestock. Considering the depletion in Malaysian agricultural land, it may be said that the economy of scale policy in the Malaysian oil palm is about to be exhausted, perhaps, strategies such as integration with livestock and further genetic modifications are avenues that guarantees FFB increase and livestock growth that can help Malaysia remain competitive in the future.

Of the Malaysian total plantation labor force, the oil palm sector constitutes the highest with about 577,900 workers, 61% of them as foreigners (Adnan, 2010). The present policy of Malaysia on foreign labor owing to acclaimed social and security problems is responsible for the acute shortage of labor and rise in the oil palm production necessitated by increase in the cost of recruitment of foreign labor, medical cost and security bond. The implication of this policy if allow to go unchecked will further rise the cost of producing FFB and palm oil in the country. Dearth of manpower in the oil palm plantations is indeed a problem to cost of production, however, its effect can to a large extent be mitigated when livestock are introduced in the plantations; that could help tap the benefits of economy of scope and aid break the jinx of high cost of production.

Although the non-ruminant sub sector has developed to a level of self-sufficiency in poultry and pig production to the extent of exporting abroad, the ruminant sub sector has been very poor in terms of local production with no self-sufficiency status ever achieved in any of the major ruminants (cattle, buffalo, goat and sheep). Serin *et al* (2008) asserted that the livestock industry as a whole managed to contribute only an average of 2% to the GDP between 1992 and 2001. Following the in-sufficiency level in the beef-sector and given the surge in local demand for the beef consumption arising from increasing population and rise in household income, the Malaysian economy depends heavily on imports of beef and dairy products to satisfy the growing local demand and often results to billions of dollars annually in terms of balance of trade to the economy. Studies have also found the Malaysian beef industry as inefficient and lack comparative advantage; these were largely attributed to high cost of animal production in terms of lack of available feeds, land scarcity and capital constraints. Thus, livestock integration with oil palm can help stimulate domestic livestock production and given the mutual benefits of availability of feeds to the animals, compost manure and benefits of grazing to the palm trees, land use intensity is assuredly increased.

In 2008 the Malaysian government had approved the mandatory blending of up to 5% palm biodiesel with diesel (B5), which was to be implemented in phases for domestic fuel market beginning with the government, industrial and transport sectors of the economy with full implementation in the year 2010. Dompok (2009) stated that the B5 production will expose the oil palm industry by lowering the palm oil stocks and will create an annual demand increase of 500,000 tons of palm oil. To contend this surge in demand, strategies for increase in fresh fruit bunches (FFB) production need to be identified.

Since 2007 when the world’s leading producer nation for the oil palm shifted to Indonesia from Malaysia, several oil palm nations across the world including Malaysia, China and India are moving to Indonesia to establish oil palm projects owing to land scarcity and cheap labor. This trend is gradually shifting world focus, world investment and world price domination for oil palm from Malaysia to Indonesia; indeed this trend is economically unhealthy for Malaysia. Again, integration may perhaps change the equation owing to the increase in FFB resulting from it and reduction in cost of labor.

From the foregoing, it is conspicuous that land, labor and supply crises are of major concern in the Malaysian oil palm industry, a study of integration systems with a view to intensify economy of scope, to estimate current costs of production, expected revenues, estimate current resource use efficiency in production and identify oil palm integration system that yields the highest dividend is very timely. Evidences abound to attest that this integration research may help address the challenges of land under-utilization, encourage production diversification, identify avenues of productivity at lower cost, demonstrate increased productivity of both oil palm and livestock towards increasing farmers' income.

1.4 Policy environment for livestock and oil palm production system

As a national policy, oil palm was given a mandate in the industrial master plan (IMP1) which was flagged in 1986. The plan emphasized on the value added, promotion of the oleo-chemical industry, promotion of downstream activities and palm oil refining for increased efficiency and competitiveness at world stage (Malaysia, 1986). Except for the development of the oleo-chemical industry, most of these mandates were achieved even before target period (Malaysia, 1990). At the launching of the IMP1, government announced the gradual reduction in tariffs on CPO exports and bleaching earth (input used in PPO processing) having ascertained that bleaching earth and PPO have attained economic viability and world-class standard in quality, in addition to complaints received from palm oil farmers and processors clamoring for the tariff rebate. The IMP1 provided for a tax abatement of corporate income amounting to 50% of export sales enjoyed by oil palm refineries. In addition, the oil palm refineries benefited from double-deduction tax on export sales. Thus, these two provisions made many export-oriented outlets completely tax-free. The IMP also provided for the continuation of the export credit refinancing policy of the government under the coordination of Bank Negara. Under the IMP, the supporting role of PORIM in providing marketing functions for the industry also expanded to incorporate training, research and development in oleo-chemicals, specialty fats and processed palm kernel oil. Thus, a tax allowance (covering expenses incurred on personnel, machineries, building, equipment, materials and research and development contracts) over a 10 years period was granted.

The IMP2 was launched in 1996 and one of the cardinal emphases was for Malaysian firms to import CPO from abroad to increase her processing capacity as the domestic CPO supply for processing was below capacity hence, CPO imports as an avenue for enhancing productivity gains was emphasized. Following the decline in labor supply and land reserve in Peninsular Malaysia, the IMP2 urged for the extension of oil palm operations to East Malaysia. Thus, it provided incentives for labor-intensive and agro-processing firms in East Malaysia at a time when such incentives were drastically reduced in similar firms located in Peninsular Malaysia. This extension led to the opening of export-oriented processing, export processing zones, assembly plants and development of new infrastructures and flourishing of downstream activities.

Under the IMP2, mass tissue culture, cloning, biotechnology/genetic engineering, mechanization and crude processing aspects of value chain were vigorously stimulated. Specialization and division of labor in production and processing was obvious as complementary firms developed to provide packaging, machinery, equipment and related services demanded by the industry. One of the advances brought by the IMP2 was the localization of machinery and equipment which were hitherto imported. This helped many firms establish processing plants and equipment fabricated locally in Malaysia thereby helped saved substantially foreign exchange for the economy. In the IMP2, the role of MPOPC was emphasized as an organ for the promotion of palm oil products to attract international trade. Though, autonomous and private in nature, the MPOPC was owned by government, but it was designed to introduce the culture of private corporate management practices in government institutions.

Lall (1996) defined industrial policies as the acquisition of technological potential or capabilities as a key to technological advancement. In accordance with Lall (1996) and Bruno (2008) acquisition of technological capacities to attain technological progress can be achieved through incentives, skills, market building function and institutional support. These industrial policy has helped transformed the Malaysian oil palm sector and hence a thorough study about their operations are captured in the subsequent paragraphs.

1. Incentives: Here, the focus is on three different incentives laws governing investment that were changed over time: the Pioneer Ordinance 1958 (amended by the Pioneer Industrial Act 1965), Investment Act 1968 (Revised in 1978) and Investment Promotion Act 1986. The first attempt at investment promotion in Malaysia came via the pioneer ordinance of 1958. It provided a tax holiday to companies with pioneer status up to a minimum of 2 years and maximum of 5 years depending on the company's volume of investment. The policy was argued to be an import substitution policy since at that time Malaysian domestic market was small hence investment attraction was limited generally and in particular for the oil palm sector. The investment act of 1968 was an export oriented policy designed with the following incentives:

(i) Investment abatement allowance: provided for a 40% deduction in tax of corporate income tax for a minimum period of 2 years and a maximum period of 8 years (Gopal, 2001).

(ii) Pioneer status: This status was being achieved if investment was ascertained to be potentially good for further development or if perceived to be in the interest of the public. However, in the case of palm oil both apply (Fong and Lim, 1984). Thus, all the 9 palm oil refineries that obtained the pioneer status between 1969 and 1974 enjoyed 7 years tax holiday.

(iii) Investment tax credit: Provided for tax exemptions via investment.

(iv) Export allowance: Allowed for tax deduction of 5% of export sales in the same year.

(v) Accelerated depreciation allowance: Granted to those companies exporting at least 20% of the value of their production and incur cost due to improvement and modernization plants. The accelerated depreciation allowance given was up to 20%.

(vi) Deduction expenses incurred on promotion of exports overseas: these were deductions of expenses to companies trying to promote Malaysian products abroad.

The development of the palm oil mills and refineries could be attributed to some of the incentive policies. For instance, government started promoting the higher value Processed Palm Oil (PPO) in the late 1960s, contrary to reports from world economic experts such as World Bank that Malaysia had no comparative advantage on PPO production but should continue to focus on CPO only. However, the Malaysian government was determined and wanted to promote the refineries through PPO production which is a forward linkage effort. In 1976 an export tax was introduced on CPO in order to promote PPO production and exports. That policy made CPO more expensive at the international scene via reduction of the CPO exports and an increasing export substitution effect on the PPO. Again, the policy helped to increase supply of CPO to domestic refineries and hence an increase in the export of the higher valued PPO. On the whole, Gopal (2001) summarized that between 1969 and 1978, only one firm got 100% tax exemption, 22 had 50%, one firm had 30% and 19 others got 25% investment tax credit. From 1968 a major productivity rise and increased export of CPO became glaring. These may partly be associated with the impact of the investment act of 1968.

2. Skills: One of the giant steps taken by government in an attempt to train and supply skilled manpower to the agricultural sector (particularly the palm oil sub sector) was the establishment of schools with expertise in palm oil technology. The establishment of Universiti Pertanian Malaysia (UPM) in 1973 which is today known as Universiti Putra Malaysia (UPM) was indeed commendable. The aim was to train graduates in the field of agri-business, agricultural and agro-industrial engineering. Although the educational policy led to rise in literacy at various levels but the trained manpower has to be competed for between the palm oil industry and the manufacturing sector but the downstream activities and forward linkages in the oil palm sector also fuelled the

manufacturing sector, thus, the educational policy became a force to reckon with in development of the oil palm industry.

3. Market Building Function: The oil palm sector had enjoyed a very high institutional support, first, infrastructural facilities provided during the rubber era was advantageously switched over for oil palm replanting since the two crops have similar management practices and subsequently more infrastructural support were provided to cater for the expansion in oil palm production. Secondly, farmers were granted access to credit facilities timely and adequately. Finally, the Federal Land Development Authority (FELDA) helped to provide the capital and labour needs of the farmers. The scheme also helped to provide an average welfare for the farmers through the provision of land for settlement.

4. Institutions: The establishment of technical and market supporting institutions such as Palm Oil Registration and Licensing Authority (PORLA) and Palm oil Research Institute of Malaysia (PORIM) has had a tremendous impact on the development of the Malaysian oil palm industry. PORLA was established in 1976 as a standard organization to ensure quality assurance for palm oil exports. The PORLA is saddled with two levels of inspection; firstly, quality assurance at processing point and secondly quality assurance at the point of export. The activities of the PORLA was further strengthen, for instance since 1984, licenses became mandatory for individuals engaged in the purchase, sales, transportation, storage, importation, exportation, survey or testing of palm oil products in the country. Similarly, PORIM was established in 1978 as a research body with mandate of developing new technologies to increase productivity, efficiency and usage (downstream activities or forward linkages). This body had contributed research findings immensely in the areas of biological, chemical, technological, techno-economic and technical advisory services and therefore made Malaysia the leading technological giant in palm oil production in the world.

   In 1998, PORLA, PORIM and Palm Oil Research and Development Board (MORDB) were merged to form the Malaysian Palm Oil Board (MPOB). In 1990, the MPOPC was established as an organ for the promotion of palm oil products to the rest of the world and information dissemination on scientific and technical issues related to the palm oil. These were achieved via exhibition, conferences and publications. This body has played a significant role in creating trade opportunities for the country via its international advertisement network.

   Effect of industrial policy: The effect of industrial policy will be examined under three different levels of production: the primary level production (plantations that produce FFBs), secondary level (mills that process FFBs into CPO and PKC) and tertiary level (refineries that process CPO into PPO). For economic viability FFBs should reach the mills within 24 hours after harvest (Bruno, 2008). The industrial policy has brought about positive transformation in all the three levels of production; it encouraged increased productivity and efficiency at the primary level and increased investment, usage /forward linkages and higher valued value added products at the secondary and tertiary levels.

1.5 Statement of Problem

As a sustainable system, livestock-oil palm integration is efficient when the two units of integration complements the growth of each other to produce more output at lower costs of production, lower prices to consumers and still remain environmentally friendly. In view of the rising demand for beef in Malaysia and rising demand for oil palm in the world market, more livestock and palm oil production is imperative; integration is a readily available avenue to achieving that.

Currently, sole ruminant production in Malaysia is not competitive; Serin *et al* (2008) attested that the Malaysian livestock (ruminant) production is operating inefficiently and without any comparative advantage (Zainalabidin *et al.*, 1992). The sources of inefficiency from the sole ruminant production in Malaysia mostly come from high cost of commercial feeds and difficulty in land ownership among others. The local beef industry failed to meet the growing demand due to the perception of high domestic resource cost (Ministry of Agriculture, 1992). Mohd Fauzi and Ibrahim (1993) attributed the stagnation of the Malaysian domestic beef industry to inadequate capital by proprietors as 90% of the operators are traditional small farmers with scattered and poorly organized farms. This is further aggravated by the problem of land; a major cost component hindering beef production. These costs can be reduced to a bearable level if enterprises are combined together; such as cattle production under oil palm which will increase intensity of land use or land use maximization, reduction in cost of oil palm maintenance and above all ensuring higher returns for both the joint oil palm and livestock enterprises (Latif & Mamat, 2002).

Furthermore, cattle-oil palm integration was identified by Malaysian government as one of the avenues for foreign exchange saving in the economy; in 1997 alone, the Malaysian economy incurred RM418.4 Million in foreign exchange through importation of beef and live cattle. This low demand and shortage of grazing land and lack of available feeds year round made the livestock-oil palm integration a good option for farmers. Thus, livestock-oil palm integration is apparently eminent in view of the rising demand for meat consumption in Malaysia and since it guarantees quantity and quality of feeds sufficient enough for the animals kept, particularly if reasonable stocking rate is maintained.

Thus, inefficiency in the livestock sector affects a large number of firms, livestock farmers and the government as well. If this integration principle is ignored, livestock farmers may continue to operate at loss, government will continue to spend huge amounts on beef importation and consumers will continue to suffer high prices of beef, which is often more severe during festive seasons. Furthermore, ignoring the inefficiencies in the livestock and oil palm systems may lead to huge loss in foreign exchange earnings via excess revenue and increase in government spending on beef importation from the rest of the world. In view of the loss in foreign exchange through beef importation, it is imperative to improve the efficiency of livestock-oil palm integration in order for the industry to actively participate in global market.

Most of the research in livestock-oil palm integration focused on financial analyses. In summary, such studies have found that livestock-oil palm integration leads to reduction in cost of production of varying degrees and increase in fresh fruit bunches (FFB) yield and revenue. On average a hectare of sole cultivated palm oil farm requires an average of RM3000 of resource utilization (Nordin et al., 2004) and the same amount is on the average required to maintain a hectare of palm oil farm and the animals thriving under it in livestock-oil palm integration set-up. Currently, the livestock-oil palm integration system is known to enhance fresh fruit bunches (FFB) yield by 30% per hectare per year. This study did not focus on sole oil palm production; there are available information on economics of sole oil pam production in Malaysia published by Malaysian Palm Oil Board (MPOB) and other publishing outfits.

Unlike the sole oil production or sole livestock production with available information, research on efficiency in livestock-oil palm integration is however, scarce and currently, there are no available benchmarks to indicate the level of efficiency in the system. In view of the scarcity of empirical studies and information on efficiency in livestock-oil palm integration and the lack of available benchmark for efficiency, this study focused extensively on its efficiency in order to close the knowledge gap. In determining the efficiency in the livestock-oil palm integration, five estimators or methods of measurement were used to understand the analytical sensitivity of the estimators to the data set and measure robust efficiency in livestock-oil palm integration based on bias-correction methodologies.

1.6 Objectives

The general objective of this study was to determine the efficiency of smallholder livestock-oil palm integration production system in Johor, Malaysia. The specific objectives were:

1. To analyse the socio-economic attributes and production constraints in the smallholder livestock-oil palm integration,
2. To measure the costs and returns in goat-oil palm and cattle-oil palm integration systems,
3. To determine the technical efficiency in goat-oil palm and cattle-oil palm integration systems and disaggregate the TE scores into various components,
4. To determine the cost and allocative efficiencies in production and

5. To identify the determinants of technical efficiency based on farmer's characteristics or farm specific factors.

1.7 Significance of the Study

The findings of this research exert multidimensional significance in the study area; from the smallholder oil palm farmers, household and industrial consumers of oil palm products, government, and potential entrants into the oil palm venture and to educational institutions and research organizations with oil palm mandate. The oil palm farmers both existing and potential will be better abreast of their socio-economic challenges, the requisite production costs expected in the venture, the expected revenue, viability statement of the enterprise helps farmers take managerial decision on the worthiness or otherwise of the integrated system and encourage their participation. Farmers are equally educated on input selection, the better efficient system among the two integrated systems studied and the analysis of factors affecting efficiency helps farmers to know which variable to adjust for better efficiency.

To the government, this research avails information on policies to embark geared towards maximum utilization of land (scope economics) and solving some of the constraints farmers encounter. Research bodies with mandate on oil palm may find this research worthy in that it will guide them in knowing the perceived limitations of their current technologies (oil palm cultivar) for a redress in their subsequent technology packages. The benefit of this research to the consumers (house hold and industrial) of oil palm products is basically the multiplier effect associated with the economic viability and adoption of the livestock-oil palm concept which translates into favorable market price to the consumers. Finally this work provides vital information to validate or refute past research findings which is useful in teaching and further research in the oil palm industry.

1.8 Statement of Hypotheses

Research hypotheses for mean comparison were tested at 1%, 5% and 10% levels of significance to determine the existence of statistically significant relationship between the integration systems studied. The hypotheses tested were:

Hypothesis 1 (H_o): There is no change in fresh fruit bunches (FFB) yields between the goat-oil palm integration and the cattle-oil palm integration systems.

Hypothesis 2 (H_o): There is no difference in animal stock between the goat-oil palm integration and cattle-oil palm integration systems.

Hypothesis 3 (H_o): There is no difference in the efficiency scores obtained between the DEA-methodology and the DEA-bootstrap methodology.

Hypothesis 4 (H_o): There is no change in the fresh fruit bunches (FFB) yields between the Federal Land Development Authority (FELDA) farms and independent (unorganized) farms.

1.9 Scope of the study

This study covered only smallholder livestock-oil palm farms: both independent and organized smallholder palm oil farmers; analysis of plantations was not a prerogative of this research and out of the scope of this research. The smallholder farms were targeted, particularly the independent ones due to their relatively lower productivity and higher production limitations. The study covered the entire ten (10) oil palm production districts in Johor and research findings is generalized across the entire state and perhaps Malaysia at large due to similarities in the socio-economic status of oil palm producers and geographical characteristics.

1.10 Organization of Research

This research report on livestock-oil palm integration in Johor, Malaysia is organized in to five distinct chapters. Chapter one focused on introduction of the study where relevant introductory issues such as: oil palm and livestock production systems, issues and challenges, policy environment for livestock and oil palm production systems were discussed. Other issues include: statement of research problem, objectives, significance of the study, hypothesis, scope of the study and organization of research. Chapter two, reviewed related literature on empirical studies on economics of sole oil palm production, empirical studies on economics of livestock-oil palm integration and empirical studies based on different efficiency estimators.

Chapter three captured the conceptual framework for livestock-crop integration (economy of scope), analytical framework, the study area, sources and nature of data collected, questionnaire pre-test, sampling techniques, analytical techniques, descriptive statistics, inferential statistics and gross margin model. Others include: Production efficiency and choice of estimators, estimation of data envelopment analysis, estimation of technical, scale, cost and allocative efficiencies. Others were: Free disposal hull estimator and its derivation, order-alpha estimator, its derivation and its Monte Carlo technique. The chapter also captured extensively the concept of DEA-bootstrap estimator, procedure of data generating process, selection of bootstrap method and steps involved in the selected method. Furthermore, estimation of bootstrap bias, confidence interval, determinant of technical efficiency and definition of inputs and output variables were also addressed.

Chapter four, the result and discussion chapter focused on socioeconomic attributes of smallholder livestock-oil palm farmers, result of costs and returns based on gross margin and net income models, summary of costs and returns analyses, summary of production constraints in livestock-oil palm integration. Other issues include: outlier detection and descriptive statistics of data used in the efficiency analyses, result of technical, cost and allocative efficiency based on DEA, result of technical efficiency based on FDH, result of input and output slacks based on DEA. Others include: result of homogenous smoothed bootstrap for optimizing technical efficiency, T-test results for testing hypotheses for mean difference and the tobit and OLS results for determinants of technical efficiency. Finally, Chapter five focused on summary, policy implications, policy measures and limitations of the study and suggestion for further study and conclusion. Reference section and appendices appear immediately after chapter six.

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