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Bertajuk

SUSTAINABILITY OF TROPICAL ANIMAL-AGRICULTURAL PRODUCTION SYSTEMS:
Integration of Dynamic Complex Systems

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TI PUTRA MALAYSIA

SUSTAINABILITY OF TROPICAL ANIMAL-AGRICULTURAL PRODUCTION SYSTEMS : INTEGRATION OF DYNAMIC COMPLEX SYSTEMS

SUMMARY

Animal agriculture will remain critically important despite its declining relative contribution to the national economy. Demand for animal products will increase with better economic status of most developing countries. However as input sources of land, feed resources and labor become increasingly scarce for animal-agricultural production, new technologies will be required to improve the efficiency of the production systems. A more sustainable agriculture would be in tune with the local resource base, make maximum use of internal production inputs, and have potential for sustained production and bring benefit into the future. The new millennium approach for animal-agricultural production systems in most of tropical or developing countries in the world must be based on an integrated approach. Systems analysis is the methodology to be used to evaluate and plan for the future development of integrated production systems. This methodology applies a holistic approach and considers multi-disciplines and multi-components in complex agricultural production systems.

INTRODUCTION

Malaysia as a tropical country is hot and humid all the year round (temperatures ranging from 25°C – 35°C; relative humidity 55 % - 95 %; summer throughout the year, copious rainfall, averaging 200 – 250 cm). The vegetation is always green and productive the whole year round. There are no distinct seasonal variations. Thus, our country can be the future "food bowl of the world". Malaysia has a land area of 33.04 million hectares, of which 13.04 million are to be found in Peninsular Malaysia. About 68% is forest and woodland. Of the remaining area, a million hectares is arable land, 3.3 million hectares are under permanent crops and 0.4 million hectares are irrigated land. Oil palm, rubber and rice are the major crops.

By way of tradition, animal-agriculture is not the mainstay of Malaysia's farming activity. It had never existed side by side with the crop farming system or the plantation sectors (oil palm, rubber and other primary industries). That being the case, animal production must increasingly compete with other forms of production for resources, especially energy (feed sources), but also for land, water, finance and labour. This creates a greater need to develop systems which maximize efficiency. At the same time, these systems need also meet other requirements. They must be environmentally beneficial, ethically defensible, socially acceptable and relevant to the particular aims, needs and resources of the community they are designed to serve. Indeed, they should also be sustainable with the dynamic changes of the system.

Sustainable agriculture implies a system that is in balance. The sustainability of animal-agricultural systems such as beef, dairy, poultry and pig production system should be evaluated in terms of their ability to balance the inputs and outputs of biological, ecological, economical and sociological considerations in the long term. The real issue of sustainable agriculture in the tropics is not that we should be aiming to develop farming systems that can be repeated over generations without change, but one that must work towards a sustainable future where agriculture is considered within the broader context of sustaining the quality and quantity of life on earth. It is society and people within it that we want to sustain. A more sustainable agriculture would be in tune with the local resource base, make maximum use of internal production inputs, and have potential for sustained production and bring benefit into the future.

Animal-agriculture is recognized as the main producer of animal protein food for the nutrition of the world's population. Malaysian farmers, livestock producers and entrepreneurs should consider animal-agricultural production as one of the fundamental sources of income and wealth creation rather than subsistence type of ventures, and make it part of their main business activity. Needless to say, sustainable animal-agricultural production in this region requires some changes that are appropriate to their unique and integrated production systems.

The objective of this lecture is twofold: to explore the sustainability of animal-agricultural production systems in the tropics in relation to the availability of resources, system of farming or production, marketing system, and to evaluate recent development in animal-agricultural production in tropical countries especially Malaysia.

CONTRIBUTIONS OF ANIMAL-AGRICULTURE

Animals provide protein foods – a complete food (meat, milk, egg) for human diet. Animal protein contains most of the essential nutrients for the human dietary requirements in term of amino acids, minerals, vitamins and energy. Animals also provide items of pharmaceuticals, biological (hormones, antibodies, vaccine, enzymes, etc), and cosmetic importance, aside from also providing mineral supplements (Dicalcium phosphate, Fe, etc). These products are essential for human nutrition especially for growth, health maintenance and normal body function.

Other contributions come in the form of:

- Draught power – for ploughing, pulling cart, transportation e.g. pulling oil palm fresh fruit bunch in plantation.
- Equipments, tools and clothing – bone tools, wool, leather, hide, skin, etc.
- Fertilizer – from faeces, urine and abattoir by-products and waste.
- Biological recycle machine – utilizing agricultural by-products fibrous material as feeds (ruminants and herbivores).
- Biological weeder – grazing weed in plantations.
- Recreations – main component in bio-parks and agro-tourism activity, pets, hobbies, sports, games and etc.
- Biological experimental animal – testing drugs, vaccine and diseases, development of vaccines and antibodies, and sentinel animal.
- Bio-fuel – bio-gas (methane gas).

Animal-agricultural industries also contribute towards national food security. This is accomplished in two ways; it provides adequate important food items for the country and it reduces the import of food items and forex outflow to other countries. This diminishes Malaysia's over-dependency on foreign producers.

Recently, most of the important livestock commodities in Malaysia recorded a downturn in terms of production and population numbers (Table 1). This phenomenon, of course, was brought about by the economic slowdown in the country. Investment in livestock industries drop tremendously for various reasons: poor market structure, perishability of

Table 1: Livestock Population in Malaysia (1999)

Region	Buffalo	Cattle	Goat	Sheep	Swine
Peninsular	88,200	662,000	190,500	140,300	1,355,300
Sabah	50,750	45,000	37,300	2,000	100,000
Sarawak	10,640	6,400	7,900	9,400	374,000
Total	149,590	713,400	235,700	151,700	1,829,300
Changes (%)*	- 2.36	- 1.20	- 0.24	- 8.59	- 35.44

* Percentage change between between 1999 and 1998. Source : Ministry of Agriculture

commodities, and the very real risks afflicting the enterprises. To make it worse, there was also little financial support for the same. The Swine industry, for example, took a lashing from the outbreak of diseases incurred by the zoonotic Nipah virus. The output and export of livestock products were thus severely impaired. The disease outbreak and the economic down turn meant the woes doubled for the swine industry (Table 2). It must be noted that animal feeds showed the highest export value and Malaysia has good potential to produce feeds, especially feedstuff derived from agricultural by-products such as palm kernel expeller.

Table 2: Output and Export of Livestock Products in Peninsular Malaysia (1999)

Commodity	Quantity	Export (Quantity)	Value (FOB) (RM million)
Buffalo beef (M.ton)	2,848		
Cattle beef (M.ton)	14,544		
Total beef (M.ton)	17,392	1,365	7.74
Goat chevon (M.ton)	556		
Sheep mutton (M.ton)	261		
Total mutton (M.ton)	817	7.83	0.03
Pork (M.ton)	134,169	246.62	4.53
Poultry ('000 M.ton)	628.1	9,610.46	56.72
Egg (mil. Eggs)	5,687	1,028.53	189.37
Milk (mil. Litre)	23.94	355.59	358.84
Animal Feeds		1.37	438.61
Others (hide, leather, sausages)			126.38
Total			1,632.50

Source : Ministry of Agriculture

Importation of livestock commodities amounted to RM 1.62 billion in 1999 (Table 3). Dairy products were the highest import items for 1999 amounting RM 1.014 billion. About 21.2 % of total food import for 1999 was feedstuff. This was worth RM 2.12 billion. Imported feedstuff comprised mostly of grains such as corn and soya bean. These grains are for poultry and pig feeding and feed milling industries. As such, alternative source of feedstuff should be searched and produced in order to reduce importation of foreign feedstuff. Poultry and pig intensive industries depend almost 100 % on foreign feedstuff (grains). However, it is not the case with the ruminant industry. This livestock industry survives wholly on domestic feedstuff. By virtue of non-dependence on imported feedstuff, it would be well to improve and promote this neglected sector of the livestock industry.

Table 3: Import and Export of Foodstuff – Peninsular Malaysia (1999)

Commodity	Import (RM million)	Export (RM million)
Live Animals (for consumption)	148.52	444.46
Meat	451.71	69.02
Dairy Products	1,014.79	358.84
Poultry Eggs	1.15	189.37
Total	1,616.17	1,061.69
Animal Feedstuff	2,123.26	438.61
Other Food	8,397.11	5,454.95
Grand Total (Food & Animal Feedstuff)	10,013.28	6,516.64

Source : Ministry of Agriculture

RUMINANTS - SPECIAL CREATURES

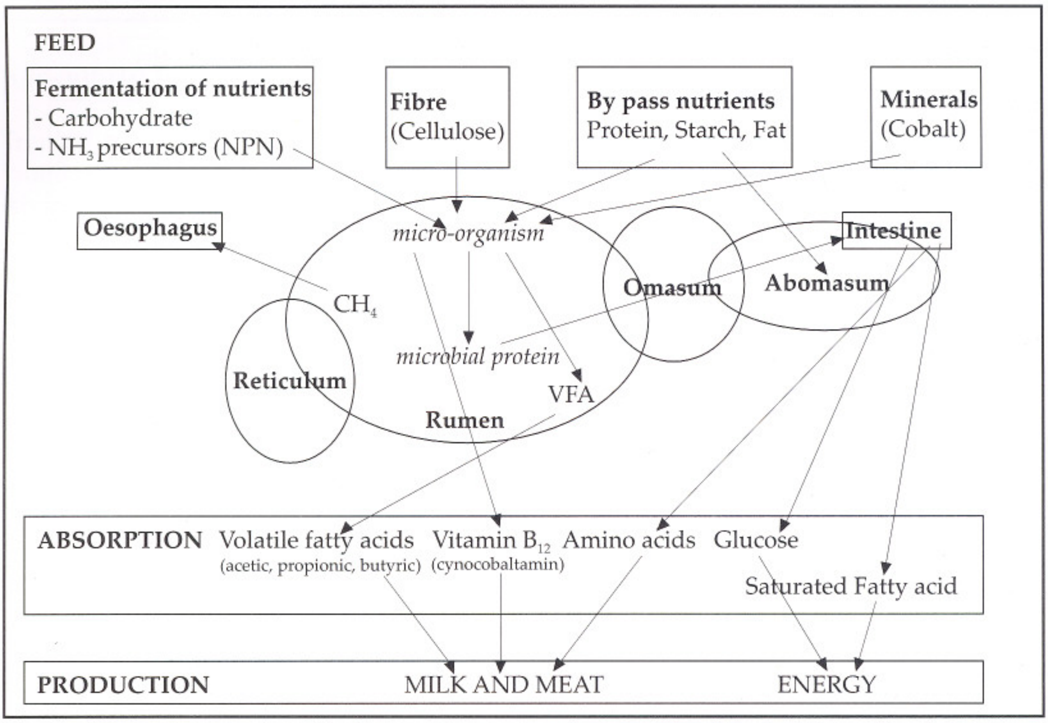
Ruminants (cattle, buffalo, sheep and goat) - Neglected group of animals in most tropical areas of the world especially in Malaysia.

In most sub-urban and kampong areas in Peninsular Malaysia we can see these creatures roaming freely in the fields and along roadsides. Sometimes, too, these animals, often left unattended, disrupt traffic flow when they try to crossover to the other side of the road or worse when they decide to rest or nap right in the middle of the same. But these special animals (cattle, buffalo, sheep, goat, deer, camel, etc.) are of great economic potential (Figure 1).

The following are their specialities.

a. Classified as Herbivores (having rumen, reticulum, omasum and abomasum), they have the ability to digest fibrous plant materials-cellulose. Also, as secondary producers, they are the most important component in the food chain.
b. They are able to develop protein from plant materials. The fact that they themselves do not require protein in their diet means that they do not compete with humans for their dietary needs.
c. Converting fibrous plant materials into energy
d. Developing protein from non-protein nitrogen
e. Forming vitamins from natural resources and minerals
f. Providing milk – dairy animals (cattle, buffalo, goat, sheep and camel)
g. Providing wool, hair, hide (leather, skin)
h. Bio-powering – draught animal, pulling cart, ploughing
i. Bio-weeding- grazing weed in plantation
j. Recreational - agro-tourism and bio-parks animals.

Figure 1: Ruminant Digestive System



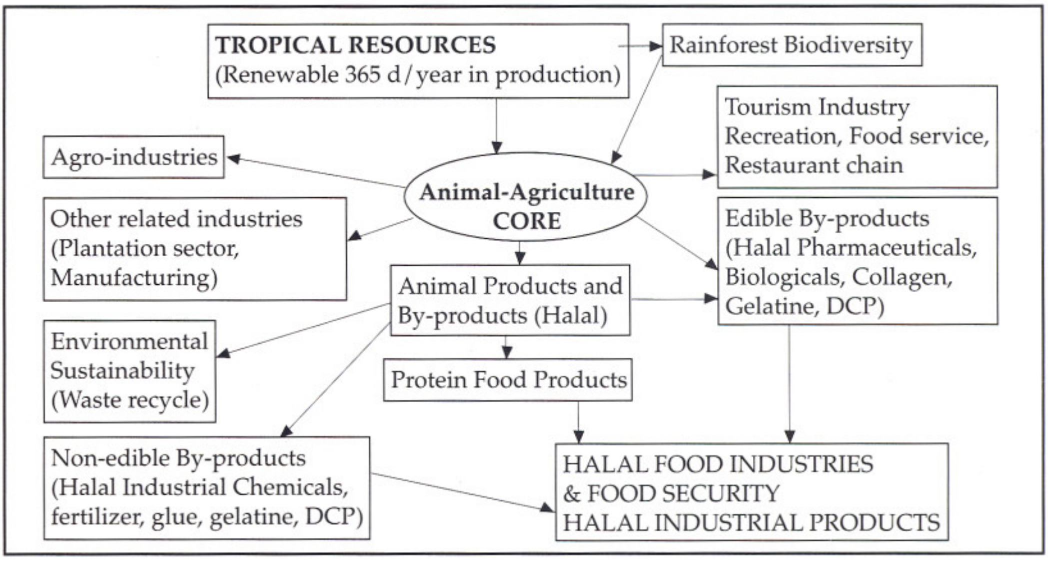
ANIMAL - AGRICULTURAL PRODUCTION LINKAGES

Animal production has great opportunities in Malaysia, especially in the ruminant sector. Animal-agriculture can be the core industry that can be linked to other important industries and act synergistically to effectuate more efficient dynamic production, manufacturing and service systems (Figure 2).

The involvement of animal-agriculture in plantation sectors such as oil palm plantation can be in the form of integrating ruminants into the plantation and utilizing oil palm by-products as their feedstuff. Involvement in tourism industry will be in the form of halal and quality food service, animal recreations and unique bio-parks. The most important contribution of animal-agricultural production is in providing halal quality products (food, pharmaceutical, cosmetics, biological, industrial biochemicals, etc) for the Muslims. Because of the high demand for halal and quality products especially in food industries, synergistic merging of related industries should be encouraged.

High quality, safe, reasonably priced, clean, halal and wholesome products are the key factors influencing animal food production and industry in the new millennium. Animal products are mainly for protein (essential) food in human diet. The animal protein can supply complete human dietary requirements. Healthy and safe animal products are the main concerns in our daily food intake. An example of human health hazards related to

Figure 2: Network of Tropical Animal-Agricultural System



bovine and ovine products is the variant Cruetzfeldt-Jacob disease (vCJD) in human that is related to the Bovine spongyform encephalopathy (BSE) problems in cattle due to eating of contaminated animal based feed and animal products. The animal products should be high in quality values (based on consumer preference and taste), free from hazardous materials and contamination, healthy food such as those low in cholesterol and rich in nutrients of which the omega-3 polyunsaturated fatty acid is an example.

Efficient animal production can be achieved when most animal products, by-products, and animal waste are appropriately utilized. Currently, a high percentage of animal by-products (edibles and non-edibles) are yet to be more economically exploited. Indeed, since its disposal is not carefully supervised, it now becomes an additional source of environmental pollution. Animal edible by-products (offals, glands, blood, fat, ossein and others) can be processed into energy-protein rich food, food supplements – vitamins, minerals and gelatine, pharmaceuticals – hormones, enzymes and biologicals, cosmetics, bio-products – collagen, albumin, plasma and others. Non-edible animal by-products are hide, hair, bone and cartilage. These materials can be developed into bio-industrial products such as glue, gelatine, dicalcium phosphate, leather and others. Animal waste (gasterointestinal content, faeces, and urine) can be biotechnologically processed into many products such as animal digestive enzymes (cellulase, proteinase) from *in vitro* fermentation of ruminal content. Faeces and urine can be converted into organic fertilizer. The stage is thus set for the advent of a "zero-waste system" - a system that utilizes all the by-products and recycles it for beneficial use.

INTEGRATED PRODUCTION SYSTEMS

Agricultural Industry and Land Use

Tropical regions of the world represent a vast land area of agriculture, most of which is found in humid tropic areas of South East Asia, South America and some parts of Africa. About 68 % is forest and woodland. The remaining area is arable land, land under permanent crops and irrigated land. Much of the increases in agricultural production in the past have been due to expansion of cultivated areas. Agricultural development has long been regarded as practically synonymous with land development. Rubber, oil-palm and rice are the major crops and oil-palm products and rubber each contributed significantly to Gross Domestic Product (GDP). However, due to the rapid rate of industrialization and growth of the non-agricultural sectors, the proportional contribution of the agricultural sector to Gross Domestic Product has been steadily declining. Nevertheless, agriculture continues to be a supplier of food and a significant source of rural employment and the main national employment of developing countries. That aside, the major agricultural commodities - rubber, palm oil, cocoa, pepper, canned pineapple and coconut oil - are sources of export earnings for the country. More serious thought has to be given to planning agricultural development in these countries. This would include systematic and efficient management of land resources for increasing agricultural productivity at farm levels, as well as conserving forest resources for future generations.

Food, including livestock and minor crops, has always been the smallholders' concern, and agriculture in this sub-sector has mainly been a subsistence-type venture. As more and more land is devoted to export crops, it is also inevitable that there will be less land suitable for the expanded production of food crops and livestock. There is an obvious need to boost food crop and livestock production; firstly because an enormous expenditure is incurred importing food and feedstuffs. Secondly, because of the demand for food commodities (including livestock products, which in turn will swell the volume of required feedstuffs) is expected to grow at a rate commensurate with that of the population in the case of the more basic food items such as rice and sugar, and at a much faster rate in the case of fruits, vegetable and livestock products due to the increasing standard of living. It is a nation's duty to ensure that her growing citizenry has access to reasonably cheap and nutritious food. The production of food (and feed) crops should not, therefore, be put at a disadvantage as far as their location and cultivation on suitable soils are concerned.

Potential areas and resources for livestock (ruminant) development in the future will be integrated with crops commodities such as ruminant and primary crops integrated production systems, utilization of agricultural by-products as animal feed and rearing animals on reclaimed (tin tailings land) or idle land such as right of way of gas pipelines (Dahlan, 2000).

Integrated Systems

New concepts need to be created, explored and introduced for agriculture to remain competitive with other industries in developing (tropical) countries. The new millennium approach for agricultural production systems in most of tropical or developing countries in the world must be based on an integrated approach (Dahlan, 2000). Efficiencies and economies will come by sharing land space, labour, management, professionals, products and by-products utilizations, and infrastructures for production of multiple commodities and activities (Figure 2).

Integrated livestock-crop production system (LICRO)

Grazing animals on land used simultaneously for crop production is commonly known as integrated or 'land-sharing' livestock-production system. Similar systems for the production of timber and food crops or animals on the same land unit are called 'agroforestry'. Sometimes the latter is distinguished as 'sylvo-pastoralism". This system offers great promise yet this potential is only lowly realized. The system has several advantages over integrated crop production. It includes improved fertility of the land via the return of dung and urine, control of waste herbage or weed growth and reduced use of herbicides, easier management of the crop and distinct possibilities of increased crop yields per unit area. Also, the sale of animals and their products adds to the returns from the systems. In other words, this system offers more efficient resource utilization.

In Malaysia, several livestock-production systems have been ventured and investigated, such as open improved pastures, intensive feedlot systems and extensive systems of smallholders. The development of livestock through integration with plantation crops such as oil palm, rubber, coconut, and forest replantation such as acacia show particular promise. The system demonstrates that the feeds such as the undergrowth or ground vegetation which forms part of the ecosystem of oil palm, rubber, coconut and acacia cultivation, which are the most critical factor in ruminant production, may be made available at a much lower cost than the other conventional, monoculture animal production system or other extensive (open pastures) animal production systems. Further advantages to animal production are that the canopy provides shade that reduces the heat stress problem facing animals in the tropics. Extra activities such as agro-tourism can be included in the production systems (Figure 3).

The natural botanical composition and quality of herbage (undergrowth) under oil palm and other crops plantations are constantly changing because of many interacting factors such as light, soil type, palm age or crops age, species interaction and agronomic management (Figure 4). Most of the factors influencing the botanical composition and also nutritive value of the herbage under palm / crops canopy are not fully exploited and it is really impossible to describe the complex interaction in the changing ecosystem of undergrowth. The dynamic changes in this ecosystem can best be explained through a systems approach that considers the many interacting factors affecting the growth of

Figure 3: Total Concept of Livestock Production System

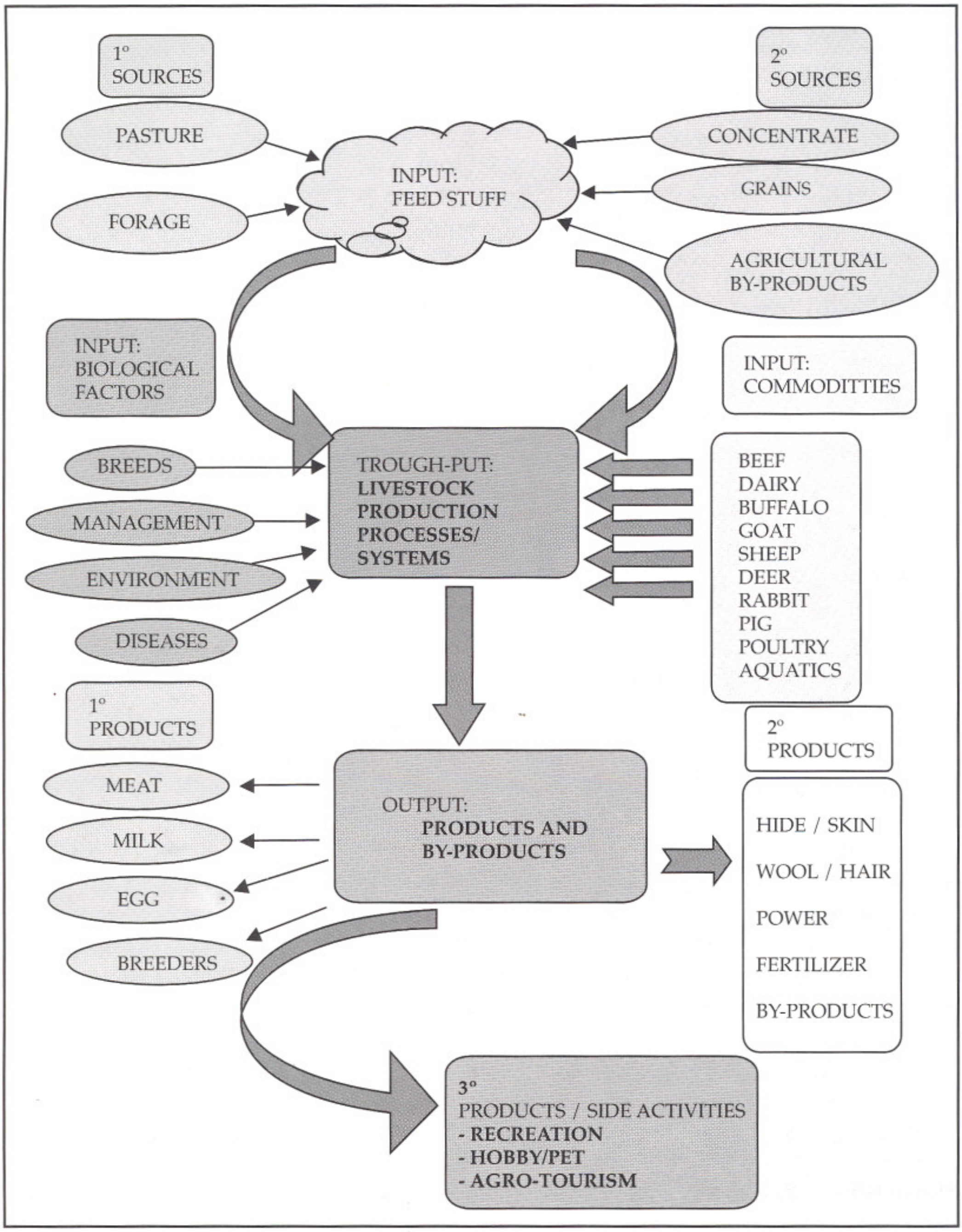
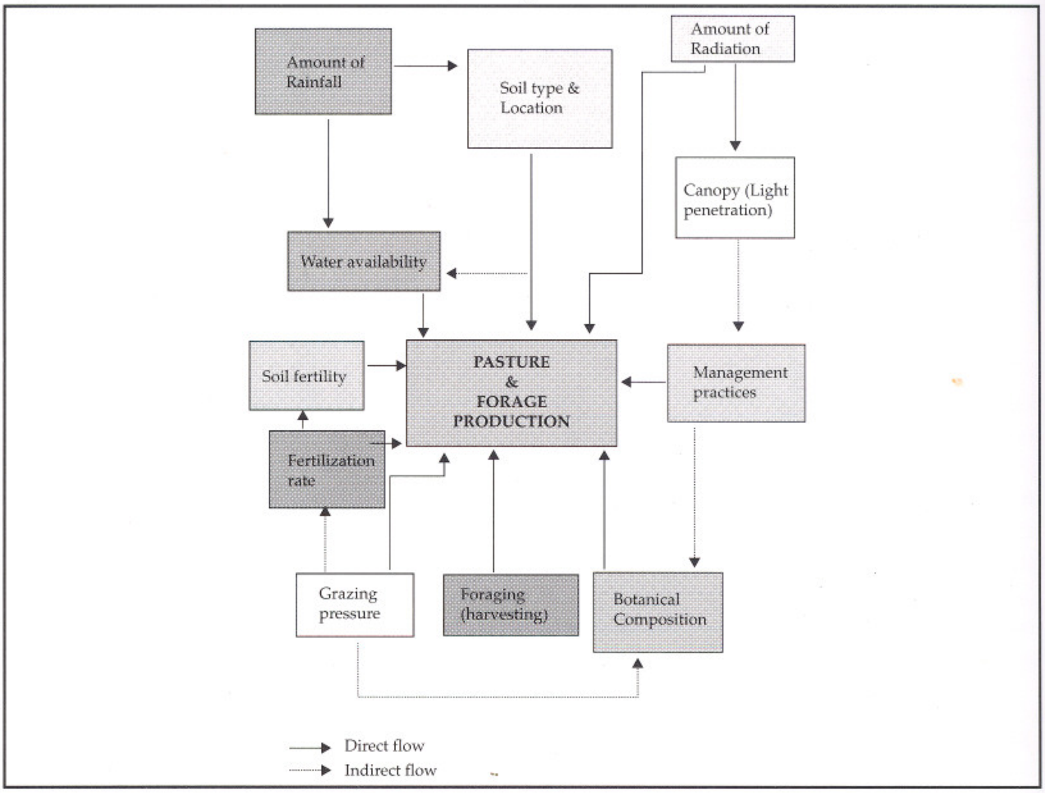


Figure 4: Conceptual model of Pasture / Forage Production



herbage. The availability of undergrowth is essential for integrating ruminants into oil palm and crops plantations and this type of production system has the advantage of diversifying income and controlling weeds (Dahlan, *et al.* 1993).

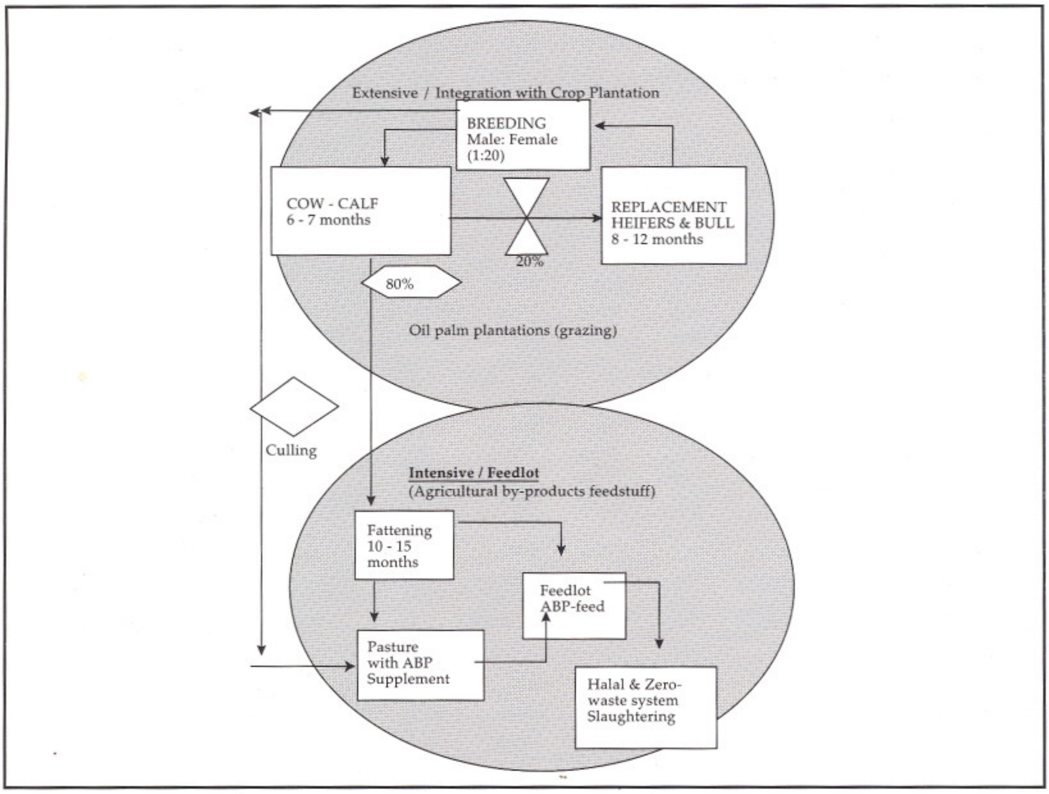
Livestock production in conjunction with tropical plantation crops is an established practice (Dahlan, 1989). Most of the work to date has involved the integration of cattle with coconuts and oil palm plantations (Figure 5) but recent work in Malaysia has demonstrated considerable potential for the integration of sheep in young rubber plantations and deer in forestry replantation using Acacia mangium.

Other plantation crops, with the possible exception of forest plantations, are of lesser significance in terms of potential for integration with livestock.

UTILIZATION OF AGRICULTURAL BY-PRODUCTS (ABP)

In most developing countries, agriculture is traditionally oriented to production of export crops. Food and feed crops play a secondary role in the national economy. As such, local production of feeds for the livestock is small relative to the requirement. Livestock (non-ruminant) feed requirements are met largely by importing cereal grains, particularly maize. For ruminant animals agricultural by-products from export crops like palm kernel cake, palm oil mill effluent and palm press fiber from oil palm, pineapple waste, cocoa

Figure 5: Beef Cattle Production Cycle



pods and husk from cocoa and others can be used as feed sources. Feedlot beef has potential in Southeast Asia because of the abundance of agricultural by-products. Utilization of oil palm frond / leaf (OPF) is of interest to Malaysia as this renewable resource is considered a by-product and is available in great abundance.

Monogastric animals such as pigs and poultry are the main consumers of the feed grains and the industry must therefore deal with the high importation cost of raw feed ingredients such as maize, soybean and other grains. Despite increasing prices of animal products, animal protein is still a very important food source in the world and the demand keeps increasing annually. However, we are lucky enough to have plenty of agricultural by-products especially from the oil palm industry that can be utilized to substitute some of the imported feed ingredients for the livestock. Ruminants such as cattle, buffalo, goat, sheep, deer and non-ruminant herbivores such as horses and rabbits are the best converters of these agricultural by-products into animal protein. Pigs and poultry can also use these agricultural by-products to some extent in their feed ingredients. With new technologies, improvement of the nutritive quality of agricultural by-products can be effectuated in most developing countries if the raw material is available.

Most ABP are fibrous type of material. These materials are suitable for feeding ruminants. In Malaysia the most abundance ABP are oil palm by-products (OPBP), cocoa, pineapple, coffee, and rice by-products. Other ABP or crop residues are available in small quantities and the production is seasonal. Table 4 shows the agriculture land use in Malaysia. The availability of ABP is related to the size of crop area. Oil palm plantation is the largest area of agriculture land use in Malaysia. Due to this condition, many research works and most of ABP used in ruminants feeding especially cattle are from OPBP.

Table 4: Agricultural land use in Malaysia

	'000 hectares	%	average annual growth rate (10 years, %)
Oil palm	2,540	44.0	5.5
Rubber	1,690	29.3	-1.4
Cocoa	190	3.3	-4.6
Paddy	670	11.6	0.2
Coconut	250	4.3	-2.9
Pepper	10	0.2	6.4
Vegetable	42	0.7	2.8
Tobacco	11	0.2	-3.8
Others*	106	1.9	1.2

* Sugarcane, coffee, sago, tea, banana and floriculture.

FACTS AND TECHNICAL INFO : CURRENT ISSUES ON AGRO-WASTE OR AGRICULTURAL BY-PRODUCTS (ABP)

The issues on ABP can be listed as:

- Abundant – main bio-mass from agriculture industry, mostly from industrial crops
- Mostly, they are fibrous materials – in wet and bulky form
- Causing disposal problems – environmental pollution, incur cost and labour
- Low quality feedstuff as in its original form – contains unbalanced nutrients, toxic materials, high cost of processing, limitations in feed formulation and usage
- High cost of handling, processing and storage
- Incomplete information on utilisation and commercialisation

Agro-wastes / ABPs are secondary sources of ruminant feedstuff. They are in the form of:

- Extracted cake or expeller pressed materials
- Fibrous materials
- Pods or peel
- Part of crops other than fruit / seed

Main products: oil, starch, sugar, etc – for human consumption
ABP – mostly utilised as fibrous feed source for ruminants.

Three groups of ABP

1. Crop residues and green bio-mass
   e.g. rice straw, cocoa pods, coffee pulp, sugar cane top, bagasse, banana peel, oil palm fronds, etc.
   - High fibrous materials
   - By-products from crops
   - Low crude protein content (3.3 – 13.0 % of DM)
   - Low organic matter digestibility
   - Had limitations for utilization as ruminant feed
2. Agro-industrial by-products
   e.g. palm kernel expeller, pineapple waste, molasses, rice bran etc.
   - Obtained from primary product processing industry
   - Less fibrous
   - More concentrated
   - Higher nutrient content
3. Non-conventional feed resources
   e.g. prolima, single cell protein, censor
   - Derived from ABP
   - Not fully commercialized
   - From ABP and livestock by-products

Processing and treatment methods of agro-wastes materials

Objective : to improve utilization and quality, and to produce clean and safety feedstuff.
Methods use in agro-waste processing;

1. Physical methods
   - Chopping / chipping / cutting
   - Grinding
   - Pelleting
   - Wetting, steaming under pressure
2. Chemical treatments
   - Hydrolysis - acid
   - Solvent
   - Oxidation
   - Alkalis
3. Physico-chemical treatments
   - Combination of treatments : e.g. alkali + steaming
4. Biological treatments
   - Microorganisms – degrade lignin (cellulase)
   - Fermentation
5. Miscellaneous treatments
   - Gamma irradiation – Cobalt-40 destroying cell wall structure

Storage of ABP

Two methods usually use for storage and preservation ;

1. Drying
   Dry up to < 10 % moisture
   The product usually in the form of hay
   Sun dry or heat power dry (rotary dryer)
2. Silage
   Anaerobic fermentation for ABP materials contain > 60% moisture
   Accumulation of lactic acid and reduce pH < 4
   Require high carbohydrate/sugar content material

Selection of ABP for ruminants feed

Important criteria of selecting ABP can be listed as ;

Availability
Transportation
Storage
Processing
Price
Nutritional quality
Optimal limits in feed formulations

ABP utilisation in cattle feedlot

Five types of formulated diets from ABP were fed to cattle in feedlot (Dahlan et. al., 1992). The ABP used were palm kernel cake (PKC), palm press fiber (PPF), palm oil mill effluent (POME), cocoa pods (COP), coffee pulp (COF), and pineapple waste (PAP). The study showed that all ABP formulated diets produced high quality carcasses which were better than those of grazed cattle, aside from incurring lower production cost.

MOST ABUNDANT ABP IN MALAYSIA: OIL PALM BY-PRODUCTS (OPBP) AS LIVESTOCK FEEDSTUFF

Oil palm has numerous by-products that can be used as animal feed. Most of oil palm by-products (OPBP) are used in its fresh form or after processing it as ruminant feed. Two important OPBP are palm kernel cake or expeller (PKC/PKE) and oil palm frond (OPF). Both OPBP can be used in almost all livestock species. By maximizing the utilization of OPBP as livestock feed, Malaysia can feed up to 4.8 million heads of cattle. Numerous research works have been undertaken on the utilization of OPBP for livestock feeding. Ruminants can utilize OPBP up to 90% as dry matter basis in the diets. Also, quality of livestock products can be improved through proper feeding and formulation of OPBP in the diets. The utilization of OPBP as livestock feed will thus present significant contributions to the development of livestock industry in Malaysia.

Among the plantation crops in the country, oil palm has numerous types of by-products that can be used as animal feedstuff. Palm kernel cake (PKC), palm oil mill effluent (POME), palm press fibre (PPF), oil palm frond (OPF) and oil palm trunk (OPT) are the popular by-products being used especially for ruminant feeding. By having 2.54 million hectares of oil palm plantation in the country in 1995 and increasing it to 2.9 million hectares in the year 2000, the production of oil palm by-products (OPBP) will be abundantly available for the livestock industry.

OPBP production

Based on the 2000 figure (2.54 million ha of matured plantation), the country can produce about 907,000 m.tan/year of PKC and about 8.2 million m.tan/year of dry OPF for livestock feed. Other OPBP that can be used for ruminant feeding such as PPF can be produced to about 6.05 million m.tan/year and POME about 181,400 m.tan/year.

When considering only PKC and OPF alone as the main supply of ruminant feedstuff, the country can feed about 1.74 million heads of cattle based on PKC and 3.1 million heads of cattle based on OPF production in the country. Thus, by maximizing the utilization of OPBP as livestock feed, Malaysia can produce about 4.84 million heads of cattle, which is 9.7 times higher than the current population of cattle in the country. The availability of OPBP in the future based on current information will be quite substantial for the ruminant industry. Numerous research works have been done on the utilization of OPBP for livestock feeding. Dahlan (1996) gives the summary of the results on the utilisation of OPBP in livestock diets and % inclusion of OPBP in the diets of various livestock species.

Quality of livestock products fed on OPBP

OPBP has been used in many dietary composition of livestock raised in intensive system and has also been used as supplementary feedstuff in almost all types of livestock species. The major contribution of OPBP is as feed ingredients for the ruminant animals. Higher % of OPBP in the diets formulation of ruminant has been evaluated in many research institutions and universities (Dahlan,1996).

The quality of local beef from local cattle usually varies and is questionable. This is due to improper production systems and poor feeding practice (low quality and quantity of diets). Experimentation by using OPBP as a diet in feedlot feeding showed that the quality of local beef could be improved through planned feeding systems by using the right combinations of OPBP in the diet of the animals.

Studies on the effect of feeding OPBP in intensive feedlotting using Kedah-Kelantan cattle and crossbred beef cattle showed that a diet consisting of 52% PKC, 15% PPF and 30% POME was one of the best formulated diets for the feedlot operation in order to produce prime carcass characteristics from local and crossbreds cattle (Dahlan et al 1992). The carcass produced had the highest % carcass meat and the lowest % of carcass fat. The diet also enhanced the quality of the beef through the formation of marbling, increase juiciness and tenderness in the meat of local and crossbred cattle (Dahlan 1985). The meat of swamp buffaloes fed on OPBP diet showed more tender and lower cooking loss than meat from pasture-fed animal (Dahlan *et al* 1988a, 1988b).

THE OIL PALM FROND (HIDDEN GOLD OF MALAYSIAN GOLDEN CROP)

Oil palm frond (OPF) is the leaf like part of oil palm tree, produced continuously from the oil palm (*Elaeis guineensis jacq.*) plant.
OPF is a readily available by product of the oil palm plantations when

- fresh fruit branches are harvested
- senescence fronds are pruned
- the palm is felled during re-plantation.

Economic life span of oil palm: 25 - 30 years - during replanting a huge amount of OPF also generates. To get the FFB from the oil palm plant, usually 2-3 OPFs were cut. Based on 2-3 OPF/FFB and 144 plant/ha, the OPF production is about 3974 fronds/ha/year and thus the total DM production of OPF is near 5484.6 kg/ha/year. Estimated figure of OPF (dry matter) production based on 2.6 million ha of matured oil palm plantations is about 27 million tone/year.

Chemical composition and quality of OPF

The nutrient content of OPF :

- The average crude protein (CP) value of OPF is about 7 %
- OPF contains a considerable amount of lignin and silica which reduce its nutritive value when fed to ruminants.
- The average CP composition (11.0%) in the leaflets suggests its potential value for livestock feeding as its CP contents is far above the critical 6.25% CP level required to maintain normal intake by ruminants
- OPF leaflets had a higher ($p<0.05$) CP value and crude fat content than petiole (stem of frond). Cellulose levels are usually lower than hemicelluloses in both petioles and leaflets.
- The fibrous (CF and NDF) content and long fibre type of OPF is suitable for higher butter fat content in milk of dairy animals.

The collection, processing, preservation and utilization of oil palm frond (OPF) have the potential to be exploited for dairy animal production in intensive and extensive systems. OPF can be utilized in fresh, silage or processed (pellet) form for ruminants. OPF silage has been used for dairy goat production. Experiment in UPM shows that Saanen cross goat, body weight of 28 kg, fed with 0.4 kg of OPF silage and 0.9 kg PKC daily can produced an average of 0.86 litre of milk per day for 133 days lactation. The quality of the milk was comparable with other recorded results elsewhere (Table 5). A summary on OPF works was written by Dahlan (2000a).

Table 5: Quality of goat's milk fed on OPF silage and PKC.

Values	pH	colour	s.gravity	acidity	milk fat	SNF*
means	6.25	white	1.028	0.09%	3.63%	7.85%
Values	water	Protein			Body weight : 28 kg Milk yield : 0.86 + 0.26 liter/d	
means	87.6%	3.7%			Lactation length : 133 days.	

* SNF - solid not fat.

RECLAIMED AND IDLE LAND FOR RUMINANTS

The tin mining industry is an important contributor to Malaysia's economy, producing about one third of the total world production. The continuous mining operations that began about 150 years ago have resulted in large areas of barren land (called tin tailings). About 200,000 hectares of land fall under this category. Tin tailings are deficient in almost all nutrients and have very low water retention capacity. Agricultural production on tin tailings is intensive and requires high capital input and therefore is beyond the reach of many farmers. The use of these areas for ruminant rearing (dry-lots) has an unexplored potential. The area can be used for ruminant stocking and at the same time improve soil fertility through animal feces and urine.

Idle land such as right-of-ways of gas pipelines, irrigation bunds and low fertility soil areas also can be utilized for animal grazing and stocking (Dahlan, et al.,1994). Agricultural by-products can be used as a source of dry-lot feed in tin tailings and idle land area. Ruminant rearing on tin tailings area help to speed up land reformation back to more fertile agriculture land, and can be used for other agricultural activities and perhaps can be developed into recreation parks – bio-parks (Dahlan, 2001).

BIO-PARKS : INTEGRATED ANIMAL-WILDLIFE PRODUCTION AND RECREATIONAL SYSTEMS

Malaysia and most tropical countries are rich in bio-diversity and by utilizing appropriate natural resources, technology and together with the knowledge in wildlife management, animal science, ecology and landscape, a unique bio-park can be developed for the purpose of bio-diversity conservation, edu-entertainment, research and development, eco-tourism and agroforestry production systems.
Bio-parks and recreational areas is an Integrated Eco-system for the purpose of

* wildlife and bio-diversity conservation
* agroforestry production
* ecotourism

Unique and natural bio-park with specially introduced native wildlife species together with natural landscape and native flora will attract more visitors and tourist to the area. The concept of Bio-park is to generate the habitat of the appropriate animal by using suitable plants and consideration of other physical, physiological and biological needs of both animals and plants and the convenience of visitors (human). Its would combine the elements of existing zoos, aquariums, natural history museums, botanical gardens, arboretums, agroforestry and ethnological/anthropological museums to create a holistic form of bio-exhibitory (International Bio-park Foundation, 1997). The distinction between zoological park and bio-park is that a bio-park puts animals in their appropriate context with all other living things, thereby offering a holistic experience, one which integrates human culture, animals, plants and the past. The aim of bio-park is to promote good animal welfare, genetic diversity and accurate education of the visiting public about animal behavior and habitat (Dahlan, 2001).

Bio-park offers opportunities to simulate more accurately the natural habitat of animals as well as allowing the display of more natural behavior and utilizing the extra resources produced by the system. The basis of plant and animal selection for bio-park is 'goes to native' concept. Local or native species of both flora and fauna should be considered first, before introducing new flora or fauna. Fauna species introduced to the bio-park can be monospecies or multispecies combinations. Small herbivores and pheasants were most preferred compare to carnivores, omnivores, reptiles and large mammals. Herbivorous animals were most preferred. *Cervidae* (deer) and *Tragulidae* (mousedeer) are the most suitable bio-park animals. Other small mammals like shrews, squirrels and non-predator animals are also suitable. The selected flora and fauna should then be combined within a suitable and balanced landscape and ecologically balanced environment in order to create sustainable bio-park systems (Dahlan, 2001).

EVALUATION OF TROPICAL ANIMAL-AGRICULTURAL PRODUCTION SYSTEMS

SYSTEMS ANALYSIS METHODOLOGY FOR EVALUATING INTEGRATED PRODUCTION SYSTEMS

Systems analysis is the study of systems, groups of interacting, interdependent parts linked together by complex exchanges of energy, matter, and information (Costanza, 1993). These are key distinctions between classical science and system science (Squires and Tow, 1991). Classical (or reductionist) science is based on the resolution of phenomena into isolatable causes and search for basic, atomic units or parts of the system. Classical science depends on weak or non-existent interaction between parts and essentially linear relations among the parts, so that the parts can be added together to give the behavior of the whole. These conditions are not met in the entities called systems. A system is characterized by strong (usually non-linear) interactions between the parts, feedbacks and the inability to simply 'add-up' small-scale behavior to arrive at large-scale results (Cleland and King, 1983). Ecological and economic systems obviously exhibit these characteristics of systems, and are not well understood using the methods of classical, reductionist science.

One might define systems analysis as the scientific method applied both across and within disciplines, scales, resolutions and systems types. It is an integrative manifestation of the scientific method, whereas most of the traditional or classical science disciplines tend to dissect their subjects into smaller and smaller parts hoping to reduce the problem to its essential elements. Beyond this distinction between synthesis and reduction, system analysis usually has connotations of mathematical modeling applied to these integrative problems. Whereas this is neither a necessary nor sufficient condition for system analysis, it is a common characteristic, if for no other reason than that systems tend to be complex and mathematical modeling (especially on computers) is usually necessary to handle that complexity (Doucet and Sloep, 1992).

The concept of systems analysis has gradually emerged into an accepted body of theory in the last several decades. Initially, systems analysis was conceived as an integrating framework whereby complex systems, possibly involving several disciplines, could be studied together. Complex livestock-crops integrated production system (LICRO) comprising components such as tree crops systems, management systems, animal production systems, and others cannot be successfully handled within the confines of a single discipline. Isolated studies of parts of the system are not adequate for understanding the complexity of the system. A multidisciplinary approach is needed (Dahlan and Shahar, 1992).

If agriculturalists ignore the ecological setting of integrated farming systems, the result will be harmful exploitation of the natural environment. Ecological concepts can easily be incorporated into decisions about resource management in LICRO systems. A farm may be considered as a bio-economic complex controlled by humans to achieve economic objectives. The aim of integrating grazing animals (ruminants and herbivores) into plantation crops of oil palm, rubber and coconut is to optimize the utilization of resources for meat, wool, and possibly milk production. This strategy becomes important in the tropics because the development of open pastures and intensive animal production systems is costly and environmentally damaging.

Systems analysis methodology can be started with the evaluation of the systems or system behavior through the used of strengths, weaknesses, opportunities, and threats (SWOT) analysis. The stages involved in systems analysis are:

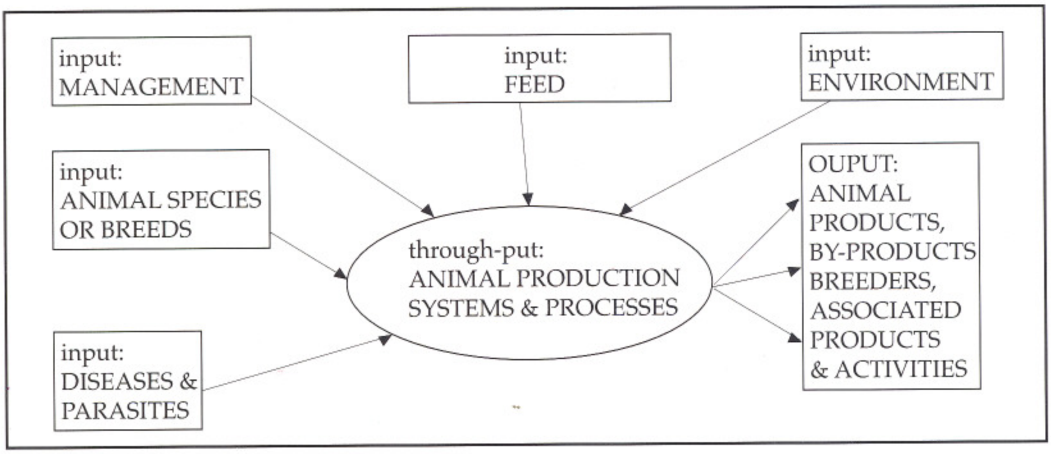
- Observation of system behavior,
- Formulation of hypothesis or theories that account for observed behavior,
- Formulation of theory using mathematical description,
- Prediction of future behavior of the system, assuming that the hypotheses are correct, through computer simulation runs, and comparison of predicted behavior with actual behavior.

Consider the simulation of a system that does not yet exist, such as the LICRO system. Obviously observing such a system is not possible, but simulation on the basis of hypothetical requirements is possible if the analysis is carefully conducted and if the ultimate system requirements are known.

System thinking (Checkland, 2000) needs to be used in order to plan tropical animal-agricultural production system. Understanding the system behaviour by applying system science to evaluate a dynamic system – changes according to time (rate of changes). Using model and modelling techniques (set up boundaries, scope, and transform biological systems into mathematical formulas and equations). Simulation models can be used to see the behaviour of the simulated system.

The system methodology should be used to sustain tropical animal-agricultural production systems through understanding of the system behaviour and simulating the future based on current information and rate of changes (in the population, industries, etc). Future changes can be visualized and quantified through simulation runs of the dynamic systems. Conceptual diagram/models should be derived in order to visualize the interactions among the components in animal production systems (Figure 6).

Figure 6: Principle components in animal production system.



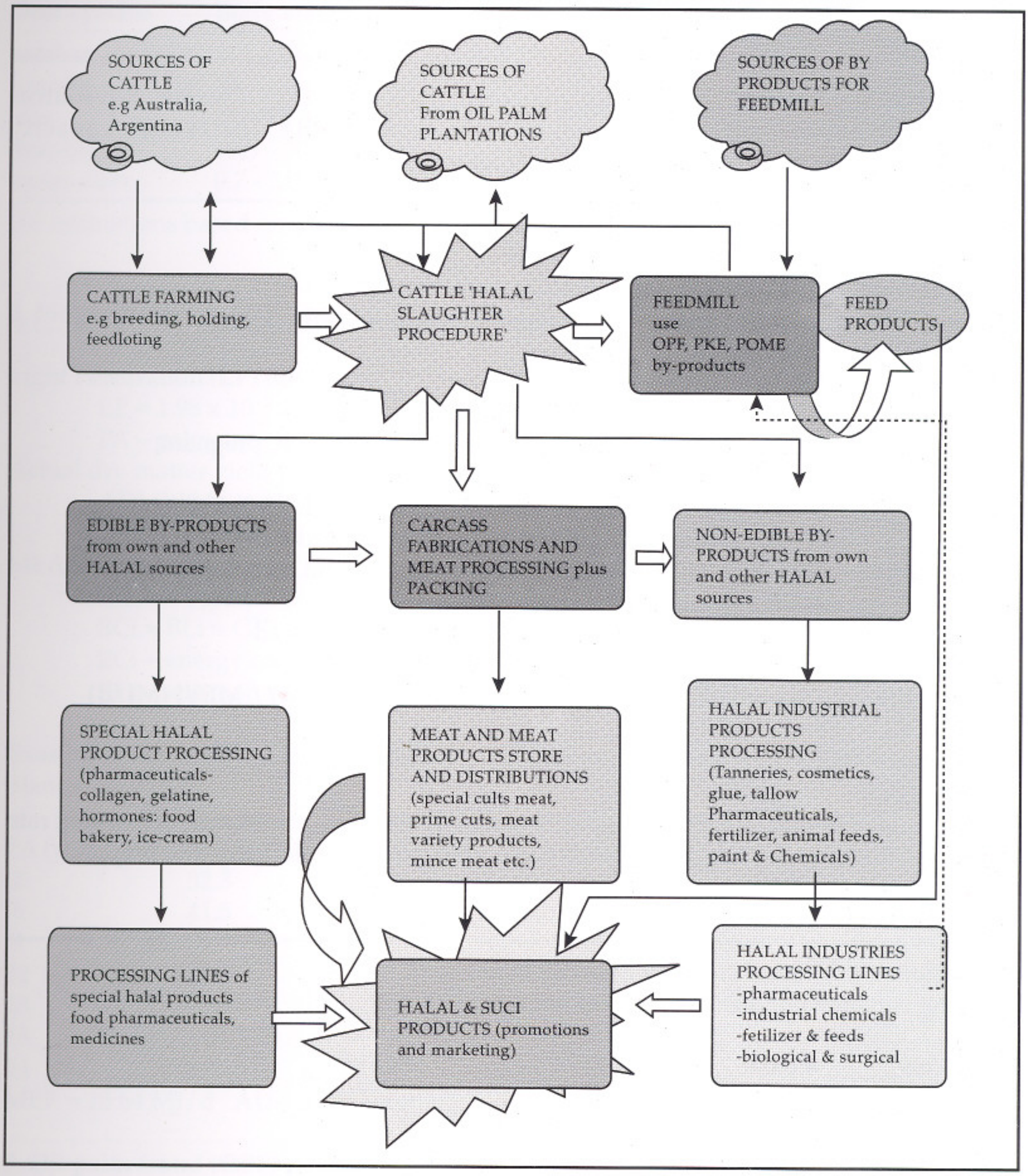
Steps to be used in the development of conceptual models are as listed below:

1. Identify commodities
2. Production systems
3. Recognized environment & matching
4. Appropriate management needed – skill, professional
5. Quality production procedures and products targeted
6. Constrains, risk and problems encountered - Disease control program, hazardous monitoring procedures.

Types of livestock production systems in Malaysia:
Extensive, intensive and combination of both systems.
Examples

1. LICRO – is combination of integrated production systems and intensive system (Dahlan, 1993).
2. Bio-park – semi-intensive and integrated system (Dahlan, 2001)
3. Feedlot-ABP- intensive production systems (Dahlan *et. al.* 1992, Dahlan, 2000).
4. Halal Beef Integrated Production System - Total concept of integrated Production systems (Figure 7) (Dahlan, 2000a)

Figure 7: Synergistic and Integration of Halal Beef Production Systems



MATHEMATICAL MODELS FOR TROPICAL ANIMAL-AGRICULTURAL SYSTEMS

Mathematical models can be used to quantify the future. Simulation runs based on current info can provide 'almost true / real' future condition of the system – "to see the future at present time".

Examples of some important models

1. Carrying Capacity Models

Concept: In equilibrium stage = optimization ; P/R = 1, P-production, R-resources
Optimum carrying capacity = ecologically carrying capacity
Carrying capacity per unit area = stocking rate (SR)

Nutrient requirement ;
Maintenance + Production = f (DMI)
Maintenance = normal body function. ;
Production = (growth, reproduction, milk, wool)
DMI – dry matter intake = f (quality + quantity) ; DMI = f (DMD)
MER = MEm + MEp

Since, MEVI = MER
MER = 14.58 x VI x DMD (MJ/d)
Based on animal physiological stages – growth, lactation, pregnant, and maintenance
VI = 0.025 x BW (kg DM/d) ; Voluntary intake (VI) = 2 – 3 % BW
DMD = 45 - 70 % (*in vitro* Digestibility for tropical feedstuff)
MEVI = GE x VI x 0.81 x DMD ; (Energy loss, CH_4 and urine) = 0.81
GE (gross energy) = 18 MJ for tropical feedstuff
MEA = GGR x MEC, GGR (asystacia) =31.5 kg DM/ha/d
SR = MEA / MER
SR(head/ha) = GGR (kg DM/ha/d) x MEC (MJ/kg DM) / MEVI (MJ/d)
CCi = MEAi / MERi
SRi = CCi / AREAi

The formula of optimum carrying capacity can be used for determination of stocking rate in open pasture, range, integration with plantation crops, agroforestry and biopark

Example

Estimation of ecological carrying capacity in bio-park.
Carrying capacity per unit area = stocking rate (SR)

$$SR_{(head/ha)} = GGR_{(kg\,DM/ha/d)} \times MEC_{(MJ/kg\,DM)} / MEVI_{(MJ/d)}$$

Since, MEVI = MER
$MER = 14.58 \times VI \times DMD_{(MJ/d)}$
$VI = 0.025 \times BW_{(kg\,DM/d)}$
DMD = 60 % (*in vitro* Digestibility)
MEC (asystacia) = 7.6 MJ/kg DM
SR = GGR x MEC / MER

Based on total available edible forage biomass (GGR=708.5 kg/ha DM) and metabolizable energy (MEA=5037 MJ/ha) under 14 years old acacia plantation the estimated ecologically carrying capacity of *A. mangium* forest per hectare for deer species as in Table 6 ;

Table 6: Stocking rate of deer species in acacia plantation (bio-park)

Deer species	Body weight (kg)	Stocking rate (animal/ha)
sambar	110-220	0.7 – 1.5
timorensis	60 – 150	1.1 – 2.7
axis	25 – 75	2.2 – 6.6
muntjac	11.5 – 20	5.6 – 9.8
mousedeer	0.7 - 2.0	40 - 120

All estimations based on carrying capacity model

2. Metabolizable Energy Availability (MEA) models

Light Penetration (LP) model

$LP = 1.98 \times 10^{-5} \times \exp^{(0.58 \times (PA - 3))} + 106.17 \times \exp^{(-0.14 \times (PA - 3))}$

PA – palm age

Actual dry matter yield (ADMY) model

$ADMYHA_{LP} = 32.88 \times (100 - LP) \times \exp^{(-0.05 \times (100 - LP))}$

MEA model

$MEA_i = ADMYHA_i / 30 \times (BC_i \times EC_i \times PF_i)$

BCi = BLi + GRi + FNi + LGi + PSi ; botanical composition (%)

ECi = energy concentration of the vegetations (MJ)

PFi = selection of vegetations by the grazing animal (0.01…1.00)

Example: Simulated carrying capacity of timorensis deer under 100 ha oil palm plantation.

PA (year)	MEA(MJ/ha)	CC_{100}ha(AU)
2	32.3	206
6	41.5	265
9	24.3	155
12	12.9	82
15	9.9	63
18	8.9	57
24	5.5	35

MER = 15.64 MJ/d AU – animal unit (timorensis deer – 65 kg)

3. Oil palm frond (OPF) models

OPF model can be used to estimate the availability of OPF for planning of setting up OPF feed mill, availability of fibrous feed from oil palm plantation and feeding strategies of animal.

OPF growth; $OPF_{growth} = MFL \times (1 - \exp^{(-0.17 \times PA)})$

where mean frond length (MFL) for DxP palm = 7 m

Leaf DM weight ; LDMW = 1.38 kg DM/OPF

OPF production ; FPHY = FPM*12*PDH, FDM = 2.3 (wet season), PDH = 144 palm/ha,

FPHY = 3974 OPF/ha/year
OPF DM production ; OPDM = FPHY*LDMW, OPDM = 5484.67kg DM/ha/year
ME production ; MEP = OPDM*MEC, MEC = 7.01MJ/kgDM

Estimated oil palm frond dry matter (OPDM) in Malaysia = 8,227,005 tonnes/year, can feed 3,640,000 heads of local cattle.

4. Model of Animal Products

Total Lean Meat (TLM)
TLM = 1.68 x HG – 159.6
(HG-Heart girth (cm), for all breedtype of beef cattle)
TLM = 1.98 x HG – 197.6
(for Brahman x Kedah-Kelantan cattle)

Total Digestible Nutrient (TDN)
TDN (%) = 53.5 + 2.5 x BCF (%) for swamp buffalo ; BCF –body cavity fat
TDN (%) = 5.2 + 0.87 x TCF (%) for swamp buffalo ; TCF –total carcass fat

Total Tissue Weight (TW)
$TW_{carcass} = 0.48 \times EBW^{0.97}$ for sheep ; EBW – empty body weight (kg)
$TW_{meat} = 0.23 \times EBW^{1.09}$ for sheep
$TW_{bone} = 0.36 \times EBW^{0.62}$ for sheep

Meat quality for Kedah-Kelantan crosses cattle base on ultimate pH
$pH_u = 8.85 - 0.42 \times$ flavour
$pH_u = 8.03 - 0.05 \times$ cooking loss
$pH_u = 5.19 + 0.09 \times$ tenderness

5. Growth and Lactation Models

Growth
$BW = a \times (1 - b \times e^{(-k \times AGE)})$
a- the asymptotic weight, b-constant, k-rate of maturity

Sheep (Dorset x Malin)
$BW = 17.97 \times (1 - 0.91 \times \exp^{(-0.005 \times AGE)})$; BW-body weight (kg)

Sambar deer
BW = 0.9 x AGE + 36.85 ; max BW = 170 kg, max AGE = 146 mo

Lactation curve
$MY = a \times WEEK^b \exp^{(-c \times WEEK)}$
For crossbred Saanen on OPF+molasses diet ; a=0.097, b=1.0014, c=0.0807,
Total goat milk production = 70.6 kg for 245 d lactation
For pure Saanen on concentrate feed ; a=0.607, b=1.0018, c=0.1207,
Total goat milk production = 271.15 kg for 273 d lactation

6. Draught animal power models

Fresh Fruit Bunch (FFB)
Swamp Buffalo pulling cart in oil palm plantations
$FFB_{optimal\ load}$ = 0.0772 x BW + 12.97 for flat surfaces
$FFB_{optimal\ load}$ = 0.0732 x BW – 2.1 for ascending surfaces
1 FFB = 25 kg, BW ranges : 200 – 650 kg
Example : BW = 600 kg, Optimum load of FFB = 59 equivalent to 1,482 kg load

7. Optimum feed ratio models

Determination of optimum feed ratio for feeding timorensis deer in bio-park
Feed mixture : Banana peel and grass (BP : Grasses)
$BWC = -2.451 + 0.251BP - 0.00276\ BP^2$
BWC – Body weight changes (kg)
BP - % banana peel in the mixture

Optimum mixture for highest BWC ;
$d\,(BWC)\ /\ d\,(BP) = 0$
$BP_{max} = 0.251 - 0.00552BP$
Optimum BP in the mixture that gives the highest weight gain = 45.47%

Determination of digestibility (%) in banana peel – grass mixture feed
Optimum digestibility ;
$DIG = 36.306 + 1.0332BP - 0.00919BP^2$
$d\,(DIG)\ /\ d\,(BP) = 0$
$BP_{max} = 1.0332 - 0.01838BP$
Optimum BP in the mixture that gives the highest DIG (65.3%) = 56.2%

S.W.O.T. ANALYSIS OF MALAYSIAN'S ANIMAL AGRICULTURE

Since animal-agriculture in Malaysia can be divided into two main groups i.e. intensive production (commercialized) systems of pig and poultry and extensive (subsistence type) production systems of ruminants, the evaluation is quite complicated. The best approach of the analysis will be based on the current contributions and resource utilization of the respective components in the whole animal-agricultural sector. The S.W.O.T evaluation for animal-agricultural industries are as listed below.

Strengths
List of "Have" for Malaysian's animal-agricultural industries

1. Tropical production environment -365 d continuos production
2. Integrated production systems- plantation sectors
3. Feed – Plenty of ABP especially from oil palm industry.
4. Hardy native breeds / species.

5. Halal quality products, free from BSE, genetically modified organisms (GMO) and rich in omega-3 polyunsaturated fatty acid
6. Availability of advance technology- from production and processing
7. Low cost of production – extensive system & sharing management, human resources utilization, etc

Weaknesses

List of "Do not have" for Malaysian's animal-agricultural industries

1. Animal-Agricultural Industries in Malaysia are not under the Ministry of Primary Industry (not categorized under priority #1).
2. Incomplete in production cycle (not A to Z), only small farming or subsistence type, no complete processing system, marketing, and support facilities not available.
3. Rely on subsistence farming and small investment – pawah scheme, depend on subsidy, etc.
4. High Risk, no proper safe guard or insurance system to cover the farming system
5. Do not have improved local or native animal breeds or species
6. Exotic breeds or species, mostly from temperate region - adaptation to tropical environment is the main problems and expensive to import.
7. No big venture from investor for animal-agriculture in Malaysia except Poultry.
8. Better choices from other non-agricultural industry- cleaner, less risk, better facilities, full support by government e.g. automotive and ICT industries.
9. Most animal-agricultural projects are in remote areas, away from residential areas and not in urban areas.

Opportunities

List of "Will have" for Malaysian's animal-agricultural industries.

1. Integration with permanent crops – example oil palm, rubber, orchard, agroforestry
2. Halal quality plus hazard analysis critical control points (HACCP) system will produce supreme halal quality products.
3. Utilization of products (by-products) for halal hi-tech bio-sciences materials-restructured tissues and human spare parts.
4. Total integration concept – multiple-purpose and multiple products – primary products, secondary products, tourism, etc.
5. Utilization of ABP feed and development of ABP feed industry.
6. New institutions and corporate agencies development and involvement.
7. R & D works on animal related bio-technology, production and processing.
8. Pilot projects – pioneer status on animal-agricultural industries.
9. Venture into related activities – recreations and tourism

Threats

List of "Will not have" for Malaysian's animal-agricultural industries.

1. Disease outbreak- high risk without insurance and poor government support
2. Low volume of production cannot compete or not competitive – not enough & no

continuous supply. To compete in international market outlets.
3. Poultry oversupply-market glut, perishable, feeding cost.
4. Product quality – still questionable due to using cheap processing facilities.
5. Animal products and human diet – health aspect – high cholesterol – obesity, colonic cancer, high blood pressure, arteriosclerosis etc.
6. Pollution – mostly caused by intensive production systems such as poultry and pig industries.
7. High cost and poor interest capitalist ventures, sceptical towards intensive production – venture elsewhere.
8. Cheaper and higher quality of imported animal products.

STRATEGIES FOR MALAYSIAN'S ANIMAL-AGRICULTURAL INDUSTRIES

Sustainable animal-agriculture should be based on total integrated production concept, Thus ;

1. Combine all resources from various industries to maximize production.
2. Develop "Mega" size projects to cater all aspects of animal-agricultural industries, with high capital investment and competitive business ventures.
3. Must have complete (A – Z) cycle of production system from farm to marketing outlets.
4. Activate linkages with other related industries- make use of win-win or synergistic cooperations.
5. Ensure success of short, medium and long term production by continuosly monitoring changes occurring in the dynamic systems.
6. Include other activities – tourism and services.
7. Upgrade the national or ministerial status of animal-agricultural sector into Primary Industry status due to national food security function (vital).

CONCLUSION

Food security is of vital importance to animal-agriculture. The future of animal-agriculture for the country is towards involvement in the hi-tech bio-science of the biological era. Advancement in technology may elevate the status of the industry and will ensure the production of sufficient high quality and halal protein food for the nation.

Optimized utilization of resources can be done through understanding of the animal production system behaviour, trends, changes and through the creation of new production systems- through system approach.

Integrating livestock especially ruminant with export crops or tree plantations notably oil palm, rubber and coconut and also agroforestry production systems will solve some of the problems of land use for food production. By adopting this production system, land use can be intensified for the purpose of export crops and food production on the same land area at the same time. Plantation crop areas are currently underutilized for livestock farming. They represent a resource for livestock development that would alleviate the need for expensive clearing cost and reduce direct competition of labor and land for food or cash crop production.

Agricultural by-products from oil palm, cocoa, pineapple and others can be used as a cheap source of animal feed in intensive livestock production systems. The combination of these resources and new technological development will promote more efficient animal-agricultural industry in developing nations.

Effective utilization of OPBP especially OPF may provide a new feedstuff for the livestock feed industry in the tropics and the world. By having a huge amount of a cheaper source of livestock feed from oil palm plantations, the production costs of livestock rearing will be reduced and this will also promote further development of herbivores/ruminants livestock production in the tropics. The "Mega" investment approach needs to be used in order to make the OPF as a World Fibre Feed Commodity, and the key factors for successful export market are the maintenance of high quality standard and to produce high quantity of the material continuously.

Bio-park should be considered as a component in animal-agricultural production system. The concept of managed bio-parks is very important in most tropical countries of the world. The main function of bio-parks is to conserve nature and its perspective of bio-diversity. Inclusive, too, are the other multipurpose functions: wildlife conservation and sanctuary, bio-diversity conservation and propagation of genetic materials, public education about nature and wildlife, edu-entertainment based on animal behavior, eco-tourism and recreational activities, and bio-diversity materials or agroforestry production. Bio-parks must have balanced eco-system which closely resembles the natural eco-system. Bio-parks require long term planning. To establish a sustainable bio-park requires knowledge about eco-systems, wildlife management, animal science and landscape management. Knowledge on animals especially native wildlife species need to be gathered in order to develop suitable bio-parks, particularly in the tropics.

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