Sustaining Malaysia's Future

The Mega Science Agenda

AKADEMI SAINS MALAYSIA

Agriculture

A MEGA-SCIENCE FRAMEWORK FOR SUSTAINED NATIONAL DEVELOPMENT (2011 – 2050)

CONTENTS

EPILOGUE

1. Introduction

Science has been universally touted as the main engine of economic growth and national development. Science from its Latin name ‘scienta’ means knowledge. A knowledge-based economy is essentially a science-based economy. New knowledge i.e. “science” is generated by undertaking research, experiments and strategic studies or R&D. R & D and strategic studies provide the means to fulfill market needs and find solutions to various problems. The results and findings are delivered in the form of new or enhanced knowledge, technology and products or services. This results in productive economic activities which contribute to wealth creation and economic growth.

Malaysia, as a country, should adopt the concept of a Mega-Science Framework as a comprehensive vehicle to drive the use of science, technology and innovation (STI) to contribute towards economic growth. Mega essentially means big, therefore the discipline of Mega-Science implies a pervasive (broad-based), intensive (in-depth), and extensive (long period of engagement) use of science or knowledge to produce technologies, products and services for all sectors of the economy to derive economic growth and development. It also calls for extensive investment in research activities to enhance the knowledge base for the targeted sectors. Since knowledge in marketing and finance is equally important in promoting the success of a commercial venture as compared to technical needs, it is envisaged that the Mega-Science approach will require research to be conducted both in non-technical sectors as well as in traditional scientific sectors.

2. A need for national knowledge generating mechanism

As we are aware, national economies are classified into 5 sectors namely: agriculture, mining, manufacturing, construction and services (Table 1). Efforts to generate knowledge by establishing research institutions and universities and centers of excellence to support agricultural, mining and manufacturing sectors are well established. The construction and services sectors are also dependent on new knowledge and technology in order to progress and remain competitive.

R & D and strategic studies are also necessary to drive the development of these two sectors.

Table 1 NATIONAL ECONOMIC SECTORS (% OF GDP)

SECTOR	2010*	2015**
SERVICES	58.5	61.1
AGRICULTURE	7.6	6.6
MINING	7.9	5.9
MANUFACTURING	26.2	26.3
CONSTRUCTION	3.2	2.9

*Source:*Economic Report 2009/2010 (MoF)*
***RMK10 Report (EPU)*

The Mega-Science approach would emphasize the need to strengthen R & D and strategic studies to be undertaken in these non- traditional sectors. For example, to enhance the development of the tourism industry (service sector), dedicated R&D and strategic studies should be undertaken to generate new knowledge that will lead to the delivery of new tourism products, services and innovative strategies which will improve competitiveness of the industry. Similarly, research studies, market surveys and financial models are proposed especially for the services sector as the knowledge created will fulfill a need or solve a problem which eventually will generate revenue and contribute to economic growth. The Mega Science approach therefore identifies R&D and strategic studies as the key enablers to economic growth in all targeted sectors of the economy.

3. A need to invest sufficiently in knowledge creation: R & D and knowledge acquisition

To become a high income developed economy, Malaysia as a country has to intensify knowledge generating capacity by investing in R&D and strategic studies. The expenditure in R & D must reflect the norm usually associated with countries having a developed economy. While past expenditure in R & D for Malaysia as a developing country has hovered at 0.5% of the national GDP, the present and future rate of spending should be increased to above 2.0% as benchmarked against the rate of spending for countries with developed economies (Figure 1). Towards achieving this goal, it is proposed that the Government formalize the rate of spending of 2% and above through the promulgation of a Science and Technology Act ("S&T Act"), which is long overdue.

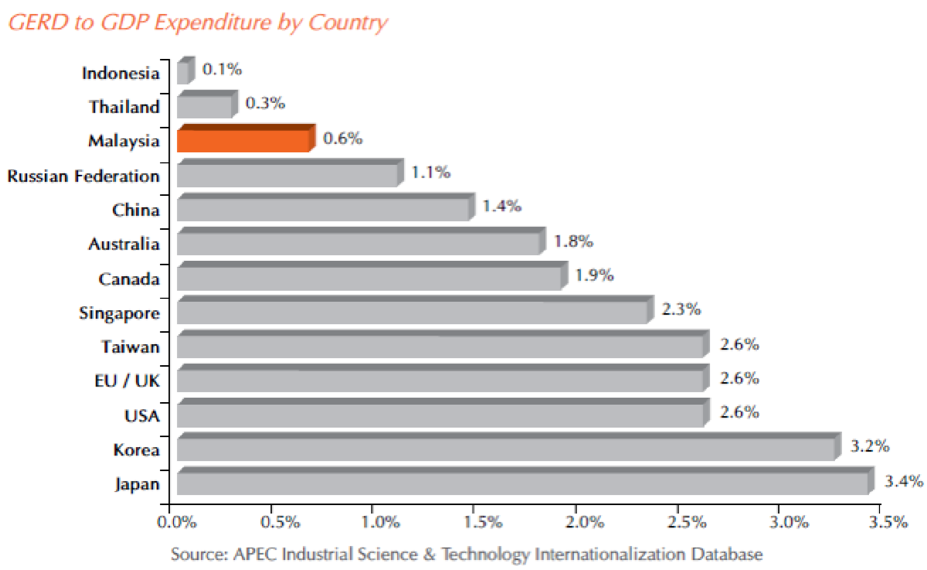

Figure 1 Malaysia's Low R&D Investment

R&D needs a long lead time before beneficial results can be harnessed to contribute to the economy through commercialization of research results and development of expertise (Figure 2). To fulfill the need to have pervasive, intensive and extensive R&D activities and satisfy the long lead time needed for R&D to mature, bold up front investments in R&D spending will be necessary. While this is financially difficult to reconcile, extensive and expensive upfront investment in R & D is necessary and forms a critical dimension of the Mega-Science Framework approach. These long lead times from R&D to Commercialization are amply demonstrated in Malaysia in the rubber and palm oil sectors of agriculture. In rubber, we took some 50 years to see Malaysia "topping the world" in rubber technology since initiating R&D in rubber. Similarly, in palm oil, Malaysia took about 40 years to "top the world".

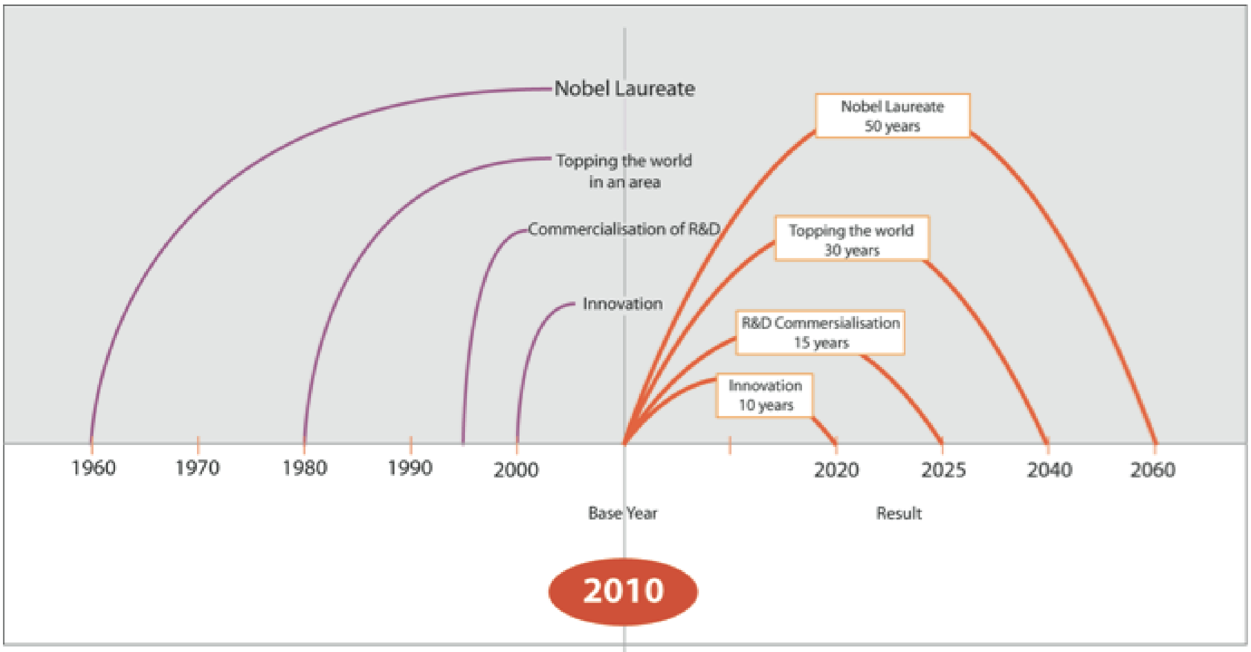

Figure 2 Time Lag on Increase in HR and R&D Investments and the Resultant Key Indicators Stimulating Economic Growth

Although a certain amount of knowledge, technology and research inputs may be imported especially through FDI activities, these are often out-dated or out-of-sync with business and economic needs. Therefore, the process of knowledge renewal and enhancement must continue to be undertaken for the country to remain competitive.

4. A need to manage knowledge generation and acquisition nationally through private and public sector participation

The Mega-Science Framework looks at national efforts in generating new knowledge and STI deliverables. The country's science infrastructure must exist to help deliver the desired results. The science infrastructure should also ensure the evolution of more R&D to be undertaken by the private sector vis-à-vis the public sector as is typically found in a developed country economy.

The present proposal to establish the National Research Council (NRC) and the National Innovation Unit (UNIK) should be encouraged as these provide the management function of ensuring that funding and management for R & D and strategic studies will be maximized. A significant role of ensuring the timely development and availability of STI deliverables for economic growth must be emphasized. In this respect, the role of MIGHT and other Technology Development Corporations in technology foresight scoping, development and acquisition are highly crucial especially bearing in mind that some technologies can be obtained through offset programmes of government international tenders.

5. Knowledge gaps in various economic sectors

In the past, economic growth was a function of knowledge (technology) and capital accumulation. Past investments in R&D in the relevant sectors would have generated knowledge to stimulate economic growth. Continuous knowledge enhancement (training) or accumulation of human capital development (expertise) adds to facilitate and accelerate economic growth. The serious lack of researchers in basic and applied sciences has to be urgently addressed such that it does not hamper the generation of knowledge and hamper sustained economic growth of the nation (Figure 3).

Future economic growth may be limited by natural limits to growth effected by population growth and excessive demand for non-sustainable and non-renewable resources. There is the possibility of reaching limits of environmental carrying capacity. Therefore, future economic development may not only depend on accumulation of capital and technology, but also on natural resources including energy and land, and the carrying capacity of the environment. These additional factors of economic growth must be factored in to the future development of the country’s economy.

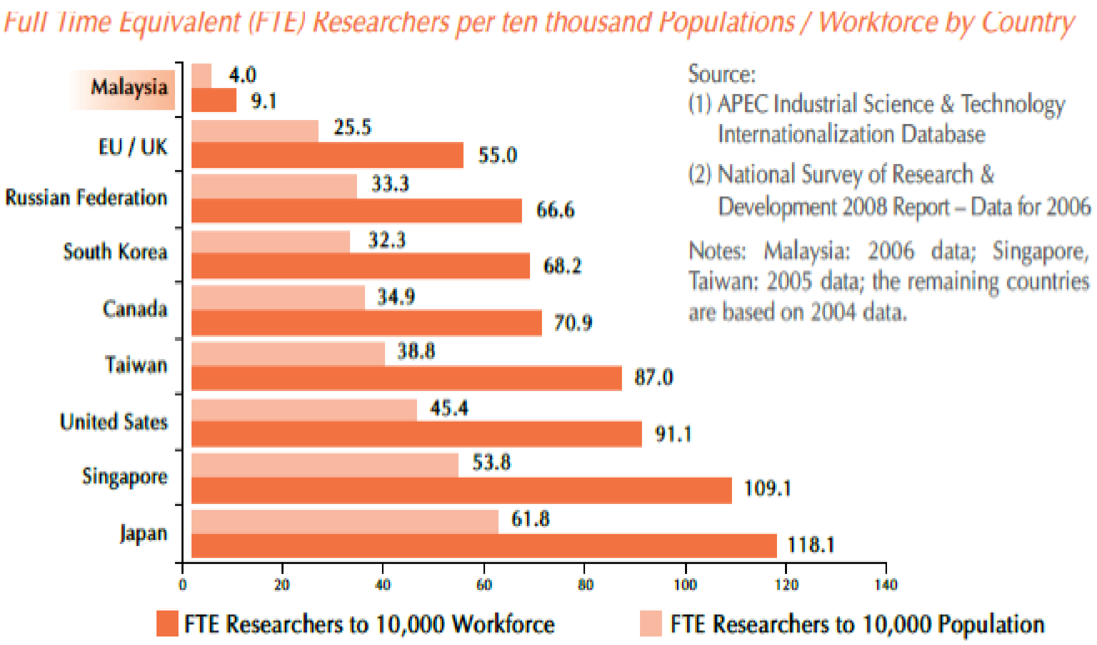

Figure 3 Low FTE Researchers – A Barrier to Sustained Economic Growth

To sustain future economic growth in Malaysia, investment in knowledge creation must be continued or enlarged. The knowledge creation (R&D) function of the Mega-Science Framework will rightly identify and address these needs.

6. Malaysia needs to intensify knowledge generation in niche sectors

Part of the Mega-Science Framework calls for pervasive, intensive and extensive use of science to identify and develop competitive knowledge and STI opportunities for commercialization in various sectors of the economy. Subsequently, another part of the Mega-Science Framework will require prioritizing of sub-sectors so that returns to strategic R&D investments are maximized. This will naturally lead to more efforts being devoted to developing of niche key sectors where Malaysia has certain competitive advantages.

Identification of the niche sub-sectors may employ the process of consultation and short term evaluation of opportunities such as the "laboratory retreats" studies undertaken by the Malaysian government recently. In addition, long term development of niche areas at the national level and the private sector will be necessary. The process is iterative. The more the investment in knowledge (R&D and STI development) the more will be the discovery of niche areas for commercial exploitation where Malaysia has the competitive advantage. But in-depth knowledge developed through the Mega-Science Framework is firstly needed to identify the niche areas.

7. Sectoral knowledge gaps and STI requirements

Studies of various economic sectors have identified the need to invest in knowledge gaps to sustain current and future needs, maintain competitiveness and contribute to the country's economic development. Firstly, cost must be kept optimally low and secondly revenue must be maximized. Ideally, the sector will generate enough commercial revenue to cross-subsidise the need to maintain the sector at minimal cost. For example, in the health and medical sector, knowledge enhancement is continuously needed to maintain the capacity of the sector to provide a high standard of health service. Efforts include promotion of preventive activities which will reduce health treatment in the long run. But there are also opportunities to generate revenue by supplying and exporting competitive health services and products such as health tourism which can contribute directly to economic growth. Similarly, in the Water Sector, ASM's Mega Science Study has identified opportunities in S&T in various niche areas.

In the biodiversity, energy and agricultural sectors which have been subjected to the Mega-Science Framework Studies undertaken by the Academy of Sciences Malaysia (ASM), it was found that the knowledge creation and STI application opportunities and gaps exist in both the home consumption and exportable components of each sector. The defense sector could similarly fall into the two categories of development, and as more economic sub-sectors are evaluated in the future under the Mega-Science Framework Studies, the pattern will probably be the same: the need to develop both the home consumption and exportable components of the sector in order to improve the country's standard of living directly and to generate revenue for increased income.

Examples of gaps in STI adequacy and niche opportunities have been identified during the Mega-Science Framework Studies undertaken by the ASM recently. The examples clearly show that Malaysia has many niche areas for STI development for commercial exploitation especially for the export component. It is also noted that a sector with well developed export component will also provide for adequate home consumption needs. It implies that developing the export component of a sector should be given greater focus and priority as this will serve to also develop the home consumption sector to bring about improved standard of living while increasing revenue and income.

8. Lubricating the Engine of Growth

The Mega-Science Framework advocates the pervasive use of knowledge and proposes the use of STI as the main engine of economic growth and national development. An engine does not function without lubrication. To facilitate the smooth or lubricated functioning of STI, human resource expertise must be adequately available. Fortunately, the enhancement of expertise of human resource is achieved through the same engagement in knowledge creation process (R&D) and other forms of knowledge enhancement process (training) at universities, research institutes and training centers. The more people are involved in R&D and STI development; the better will be the available expertise of the country. R&D investments therefore contribute to expertise and knowledge enhancement of human resource.

Another dimension of the lubrication process to the engine of growth is the level of income itself. There exists an iterative cycle in the relationship between intensity in investment in R&D and the level of income of the country. The higher the R&D expenditure the higher will be the income level. The higher the income level, the higher will be the R&D expenditure. To break this vicious cycle, it is necessary to adopt a strategy of a high income economy, similar to what the country is currently attempting to do. In the past, Malaysia has adopted a low income and low cost economy with a reasonably high purchasing power parity index compared to other countries. It was found that the low income and low cost economy has severe limitations to promote further growth and consequently, Malaysia was led into the middle income trap. Low income strategies do not attract talents and retention of expertise in the country. Low income strategies also under-exploit the services sector which now becomes a major sector of the economy. Services provided in Malaysia earn much lower revenue compared to similar services provided by the developed economy countries.

High income economy means high salary which means high costs. Malaysia must be prepared to adopt a high income and high cost economy as this is the norm seen in other developed countries. High cost is inevitable because when looked from the income side, high income means high salary, but the same high salary will mean high cost when looked at from the cost perspective. The big advantage of high income and high cost (salary) economy is that expertise is easier to obtain and retain, and in addition, the services sector such as hotels, tourism, banking, airlines, etc will be charging internationally competitive prices to maximize revenue and income for the country. Furthermore, efficiency will automatically be enhanced when an economy operates on a high income and high cost strategy. Such an economy will also be able to pay international prices and avoid most subsidies. The billions of Ringgit of subsidy money currently provided in the government budget can instead be distributed to increase salary. Leaving it to the high income individuals to buy the unsubsidized goods and services will further improve efficiency and reduce wastages which are often encountered in a subsidized economy.

9. S&T Governance

In Malaysia, Science, Technology and Innovation are being given very high priority. However, Academics and Researchers need to play a very strong role in evidence- and data-based decision-making, while bureaucrats should continue to play a supporting role.

In the Korean example, a high-level National S&T Council, chaired by the President with the Minister of Environment, Science and Technology as the Vice-Chair and the Ministry of Environment, Science and Technology as the Secretariat, has 5 Committees (Figure 4) on Key Industrial Technologies, Large-Scale Technologies, State-led Technologies, Cutting Edge and Convergence Interdisciplinary Technologies and Infrastructure Technologies.

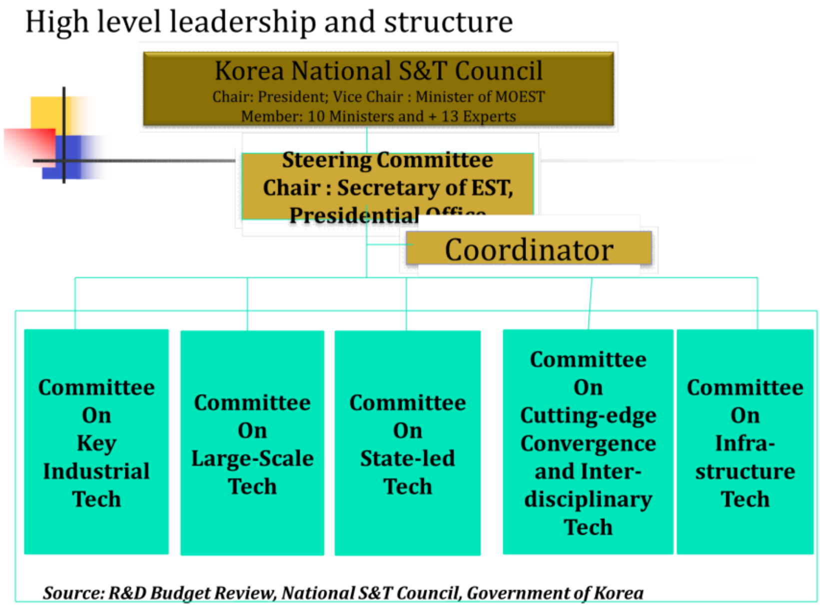

Figure 4 Korean National S&T Council

10. Funding

Malaysia is in the process of improving its science infrastructure to help improve the capacity of the country to use science (STI) as the main engine of growth for its future development. Funding and investment in R&D and strategic studies in all sectors of the economy remain underdeveloped. Such funding is both important and urgent because of the long lead time needed to provide future STI deliverables.

It is proposed that Malaysia makes a 'jump start' and allocates RM 20 billion for an accelerated development of its science industry between now and the year 2020. This fund should be managed by the responsible agencies to ensure both priorities in R&D and strategic studies and the intensification of R&D especially in the private sector can be implemented. Such funding should be increased if necessary during the period of implementation. Commitment to fund the science industry with a RM 20 billion grant would greatly contribute to the achievement of the high income economy strategy as proposed by the government. In comparison, many other countries, both developed and developing, are already providing such mega science grants to invest for their sustained growth in the future. As an example, the Korean Government gave an allocation amounting to US$16 billion to facilitate the R&D programme in the country. UNIK can be authorized to manage, coordinate, distribute and monitor the RM20 billion grant.

As a second option, part of the RM20 billion grant can be created from taxing corporate profits, amounting from ½% to 2%. The corporations will however be exempted from this taxation if they can show that they are undertaking R&D. UNIK can be authorized to verify and certify that the R&D is being carried out. The exemption will be given to corporations able to show that they are undertaking R&D, Strategic Studies and/or undertaking technological acquisitions to further their R&D capacity and capability. In this way, more R&D, of at least 75%, will be carried out by the private sector.

In essence, the following actions are proposed as part of the functions of UNIK which will be authorized to manage, coordinate, distribute and monitor the grant:

(i) Raise R&D funding, amounting to 2% and above of GDP, through the Government initially giving a "launching grant" amounting to RM 20 billion. The grant can be sustained through taxing corporate profits, amounting from ½% to 2% with the necessary tax exemptions given as described above;

(ii) Prioritise R&D areas with advice from the National Science Research Council; and

(iii) Migrate to improving the R&D activities to be mainly private-sector driven with the ratio being private sector: public sector at 75%:25%.

11. Conclusion

A Mega-Science Framework can be the national vehicle to promote the application of knowledge (science) through STI commercialization to generate better standard of living and new sources of revenue and income to achieve economic growth and national development. The advocacy of science (STI) as an engine of growth can be reinforced through the strong recognition given via the Mega-Science Approach on the need to have extensive investment in R&D and other strategic studies in both traditional 'scientific' sectors and the newly-emphasized services sector.

The scientific STI system as an engine of growth can be further 'lubricated' to deliver the end objectives by the adoption of knowledge enhancement strategies through R&D and training, as well as the adoption of a high income and high cost economic system as practiced by other developed economy countries. By systematically evaluating the knowledge and technology gaps in various sectors and sub-sectors of the economy, it is possible to provide the country with a road map of future opportunities in STI implementation for economic growth and national development. Present studies show many fertile areas of future opportunities exist for the sectors evaluated.

Malaysia's rate of knowledge generation is falling far behind the desired target. It can be concluded that science has not be given the needed funding and urgency to enable it to be truly the engine for sustained national growth for the future. It is hoped that the adoption of a Mega-Science Framework approach will help resolve these limitations and assist in the development of the science industry in the country.

Tan Sri Dr. Yusof Basiron F.A.Sc.
President
Academy of Sciences Malaysia

22nd December 2010

PREFACE

One of the most frequently asked questions by decision-makers and scientists themselves is "How can Science, Technology and Innovations (S, T and I) contribute more effectively to economic development and wellness in a sustained manner without compromising the environment's sustainability". There are good reasons to turn to S, T and I because they have a track record to meet critical challenges posed primarily by the growth of human population and their wants. The eradication of small pox by 1979 saved millions of life, the green revolution in the 1960's staved off global famine, nuclear power help to supplement increasing energy demand and the computer enhanced the dissemination of information for education, research and business. Antibiotics and vaccines dramatically increased life spans and improved health all through S, T & I.

Unfortunately, during the past 30 years, the anthropocentric S, T & I approach changed food production, transportation, communications, education, health and even culture (consumption society) which resulted in unsustainable environments including climate change. Designed for efficiency and driven by profit, S, T & I innovated and produced non-biodegradable plastics, toxic DDT, CFC, harmful nuclear wastes and encouraged a new generation of consumption society through automation and mass production - not to mention sophisticated weapons of mass destruction. Today we face the results of "destructive creation" because the innovators failed to factor in the impact on sustainability and wellness.

Once again no doubt, S, T & I will rise to meet the new challenges in response to the national and global demand to factor towards enhancing quality of life in all products, processes, services and development projects. It is now known that there is no positive co-relationship between the rise in GDP and wellness or quality of life. The new awakening of the global community towards a more ecocentric paradigm will change innovations and business. There are already instruments in place such as "eco-labeling" for tropical timber, traceability for food products in EC and green building index in Malaysia.

The biggest challenge to all scientists is how to use the fixed earth resources (especially water, land and minerals) to produce food, water and goods for human needs without depriving habitats for the millions of other species and destroying the ecosystems. Proven existing technologies must continuously be improved to be eco-friendly whilst the emerging one such as renewable energy, genomics, stem cells, nanotechnology, biotechnology and the novo-ICT must conform to the new order of sustainability, ethical and moral obligations whilst contributing to the economic development of the nation.

Malaysia, with its biodiverse wealth, can turn to nature for many of the answers for a developing innovatively (and of course, sustainably) our economy. Scientists only need to uncover them. We need to turn to the sun - a natural nuclear fusion reactor for all our energy needs and to water (rivers and oceans) to provide the additional food needs to begin our new journey towards a sustainable world for all. This journey for Malaysia must begin now.

At the same time, there are vast opportunities in various sectors of the national economy which can be leveraged upon in an attempt to resolve challenges and problems faced by the populace through innovative approaches in the application of Science, Engineering and Technology (SET). Through identifying and developing various tools through SET, it will go towards ensuring that our economy is not only sustained but sustained in a sustainable manner.

The Academy recognizes the importance of cross disciplines linkages that must be integrated during planning, implementation and monitoring of national programs and projects. Social engineering must be designed to match the rapid technical advances to minimize their negative impacts.

In this series, of the Mega Science Framework Studies for Sustained National Development (2011-2050), undertaken by the Academy of Sciences Malaysia, S, T and I opportunities have been identified and roadmaps provided for the short- to long-terms applications of Science, Engineering and Technology in the critical and overarching sectors such as water, energy, health, agriculture and biodiversity.

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Mega Science Framework Study Project Director
Academy of Sciences Malaysia

25th Feb. 2011

PREFACE

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Datuk Ir. Ahmad Zaidee Laidin F.A.Sc. (Vice-President ASM)
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Academician Tan Sri Dato' Dr. Ahmad Mustaffa Babjee F.A.Sc (Project Team Director from 1st May 2010 until present)
Dr. Ahmad Ibrahim (Principal Team Member from 1st September 2008 until 31st December 2010)

EXECUTIVE SUMMARY

This *Mega Science Framework Study (MSFS)* for a sustained growth in Malaysian agriculture towards 2050 was conducted by a multi-disciplinary, consultancy team to develop recommendations for submission to the Academy of Sciences Malaysia. The MSFS-Agriculture consultancy team adopted the *Megatrend-Scenario-Model* approach in implementing a comprehensive study and analyses for opportunities in science, technology and innovations for Malaysian agriculture in the near term (2020), mid-term (2035) and long-term (2050) goals for commodity crops, agro-forestry, livestock, aquaculture and fisheries, and nutrition.

An appraisal-assessment exercise by both comparative and matrix analyses was conducted on emerging issues related to agriculture (*population increase and diminishing arable land, rural-urban migration, aftermaths of Climate Change and nutrition*) against the backdrop of the over-arching need for judicious management of constrained resources (*water, energy, health, agriculture and biodiversity*) of planet earth that define and shape future challenges, scenarios and ST&I strategies in order to enhance sustained growth for Malaysian agriculture in the coming decades. To appraise the level of ST&I culture and adoption of the state-of-the-art technologies, a backstop and check-and-balance strategy was conducted via several fact-finding interviews with groups of middle-management officers from several agro-based agencies (Federal Agriculture and Marketing Agency, Department of Fisheries, Faculty of Agriculture, UPM and Department of Agriculture). Next, a matrix analysis on emerging and current technologies relevant to agriculture was conducted to identify technology megatrends which was done through meta analysis and appraisal of technology as found in many editorials in journals, periodicals, technology-watch profiles in magazines, pundits‘ reviews, popular reviews in technology-related reading materials (*Red Herring, MIT Technology Review, Time, Fortune, Forbes, Humboldt Kosmos, Portico, Health Today, National Geographic, Scientific American, Discovery Channel, Discover, Deutschland, and weblogs and websites*). Once the emerging technologies and megatrends were identified and clustered into defining entities (*Genomics and Molecular Breeding, ICT-enabled applications, robotics, RFID-tagged traceability system for food miles and food safety, precision farming, web-based knowledge portals, space agriculture and life support system, hypobaric chamber for precision farming, etc.*), associated emerging applications, technological convergence, new concepts, evolving policy shifts (European Aviation Biofuel Policy 2012, New Economic Model and NAP4), global trade agreements (WTO multi-lateral agreements), regional economic integration (ASEAN food intra-trade), changing demography (greying Malaysian demography), changing dietary choices, values and life styles (shift to sedentary life styles of the industrial society), growing awareness on biodiversity loss of the agro-ecosystems (agro-forestry), advances in closed-environment technologies (vertical and urban farming) and open field agriculture (enhancing the biodiversity of the mono-cropping system for commodity crops) were identified for further considerations on how our ST&I initiatives can be recommended for development under the Malaysian agriculture scenario.

From the Megatrend-Scenario Model, many emerging concepts are defining and shaping the future of Malaysian agriculture, especially the need to address and mitigate the corollaries of Climate Change; both at the national and global agriculture levels, towards 2050. Some of the deliberated issues and concepts are: adoption of precision farming to reduce wastage and efficient use of constrained resources; vertical farming and urban agriculture to address food security to the populated cities and diminishing arable land; construction of plant walls on city buildings to clean and cool congested cities (horticulture-cum-environment), growing awareness and mindfulness of carbon and water footprints to be watchful on the use of constrained resources of energy and water; employing the close-loop agro-ecosystem of the controlled-environment, greenhouse to ward off the consequences of unpredictable weather from Climate Change (temperature, rains, floods, droughts, disease outbreak, storms, light duration, etc.); growing energy crops and use of organic fertilizers to reduce dependence on inorganic, petroleum-based, chemical fertilizers, insecticides, fungicides, and weedicides; adoption of green technologies and bioremediation of the agricultural pollution in the environment; the practice for sustainable and low-carbon agriculture; retrofitting the food basket to the new food pyramid for improved health.

Two approaches of recommendations and milestones on the commodity crops and technology megatrends were proposed in this MSFS study on agriculture, as to prospect for ST&I opportunities based on the short-term (a decade from now – 2020), mid-term (one human generation of 25 years – 2035) and long-term (when new wave of technological epochs have been monitored to take place every 50 years – 2050).

In the order of priority and importance, the activities related to the emerging technologies that are identified to define and shape the coming decades of Malaysian agriculture are:

i) ***Molecular breeding*** to be preceded with sequencing the DNA genome (Genomics) of important economic crops (oil palm, rubber, cacao, tubers, herbs, commercial fruits, etc.) and establishment of the genome library (Bar Code DNA Technology) and the splicing of the desirable traits from other species (transgenic) with unique genetic traits into these economic crops that already occupy most of the arable land for agriculture (*Genomics* or specifically *Molecular Breeding* for transgenic disease resistance, nitrogen-fixing microbes, improving traits (tolerant to droughts and droughts and transgenic disease resistance) and several folds increase of crop yields and the development of bioterials or new products.

ii) ***Field Robotics*** is recommended to overcome labour shortage and perform in inaccessible areas. Some of these field robots are equipped with vision system for harvesting ripe fruits, and motion-capture aided robots (Avatar-like) for harvesting of oil palm fruit bunches on tall trees, and wearable robots to perform back-breaking tasks of carrying oil palm bunches.

iii) ***New Fishery and aquaculture -*** better knowledge management in the fisheries and aquaculture will be required for increasing the wealth of the seas. Technologies for identifying new stocks and for managing depleted stocks will be the priority. Understanding the seafood science behind safe harvest levels and following them under strong unified management schemes will be the recipe for success over the next few decades to 2050. Research on the status of fish stocks, reproduction, and sustainable catch levels is urgently required together with better management of fishing effort. Genetically improved species for aquaculture will help in augmenting short falls in fish production from capture fisheries. Further adoption of transgenic technology in aquaculture will increase output but this will also depend on consumer acceptance of the new products. These include genes that regulate growth hormones, resistance to a wider range of temperature, disease resistance, hatching, osmoregulation, behaviour, and general metabolism. Developments in engineering, some adapted from offshore oil rig construction, increase the possibilities for a progressive offshore expansion of aquaculture using robust cages.

iv) ***ICT*** –enabled applications generally are used to improve productivity through precision farming practice, such as, the use of satellite remote sensing imagery, sensors, geospatial information system (GIS), global national satellite system (GNSSS); installing barcode-tag in traceability system of farm produce of its origin and to track its process pathway for food safety, health, estimation of carbon footprints and water prints as well as to address labour shortage and improving agricultural productivity.

v) ***Vertical a***nd ***Urban Farming*** to overcome the issue of diminishing arable land to feed the city population and to reduce carbon footprints or food miles

vi) ***Water Technology*** to improve the efficiency of available freshwater for agriculture and spearhead the target to reduce the consumption of 70 % of available freshwater in agriculture via fertigation, irrigation, water storage, redesigning the root architecture of crop plants, recycling and reuse waste water, and instructive construction for more efficient use of scarce and unpredictable availability of water due to Climate Change.

vii) ***Energy Crops*** cultivate and generate indigenous sources of energy from agricultural wastes and sources in the farms.

viii) ***Human Capital*** for the development and appropriate employment and deployment of Knowledge-based Agriculture for the coming decades is very critical to ensure the sustained success of agriculture to be the third engine of economic growth which need to be imaginatively and strategically implemented. Scholarship for strategic knowledge areas but not preferred by students should be apportioned. Scouting for talents and picking the knowledgeable leaders in heading agriculture agencies are recommended.

ix) ***Introduced Crop Species*** for bio-geographical transplant of introduced, allopatric, rainforest‗s flora and fauna species for crops or livestock from other continents with similar habitat for Malaysian agriculture.

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From another perspective, the Mega Science Framework Study team also provided another set of recommendations and milestone roadmap which is modelled along the contemporary commodity approach model of oil palm, rubber, rice, cacao, floriculture and horticulture, fruits, vegetables, livestock, and aquaculture and fisheries with projected milestones for the near-term, mid-term and long-term. Through molecular breeding, genome library sequencing and BarCode DNA Technology, oil palm, rubber and cacao are recommended to be developed as transgenic super crops (vegetable-oil super crop for oil palm, industrial/non-food super crop for rubber, and herbal-based transgenic super crop). ICT-enabled technologies like satellite remote-sensing, satellite-based GIS, GNSS and RFID-tagged traceability system will be used to track the origin of food source, marketing and carbon audit. Controlled-environment agriculture will require web-based and other ICT-enabled features to control humidity, temperature, light duration, timeliness of water availability, as that can be used in vertical farming technology and also on poultry rearing and aquaculture. Farm mechanization will spearhead into a slightly different approach into intelligent farming where automation and field robotics with the adoption of wearable robots to overcome labour shortage in the oil palm oil industry. Wearable and motion-capture-enabled, mounted robotics are recommended for the purpose too. Other technologies, such as, controlled environment, composting and organic fertilizer development of using transgenic cover crops, crop rotation, and plant root system development will improve the efficiency of the nutrient and water uptake and hence reduce the over-reliance on inorganic, chemical fertilizers.

The field of genomics and molecular breeding, ICT and field robotics are apprised and recognized to present as important and critical technologies that will define, shape and uplift Malaysian and global agriculture in the coming decades. Food production can be quadrupled in terms of its productivity and yield through molecular breeding. It is expected that the second wave of GREEN REVOLUTION will be once again be primed by transgenic, molecular breeding through unimaginable, transgenic possibilities to develop disease resistance, quantum increase in yield, production of creative bioterials, tolerance to extreme temperature and environmental conditions. Through appropriate use of ICT-enabled applications and field robotics the productivity of agriculture can be tremendously improved via the development of intelligent agriculture and technological convergence. Other eco-friendly technologies such as bioremediation and the public awareness to preserve the environment by going organic will further add to these trends.

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MEGA SCIENCE FRAME WORK STDUY

For Sustainable National Development on Agriculture
(2011-2050)

FINAL REPORT

EXECUTIVE SUMMARY

This *Mega Science Framework Study (MSFS)* for a sustained growth in Malaysian agriculture towards 2050 was conducted by a multi-disciplinary, consultancy team to develop recommendations for submission to the Academy of Sciences Malaysia. The MSFS-Agriculture consultancy team adopted the *Megatrend-Scenario-Model* approach in implementing a comprehensive study and analyses for opportunities in science, technology and innovations for Malaysian agriculture in the near term (2020), mid-term (2035) and long-term (2050) goals for commodity crops, agro-forestry, livestock, aquaculture and fisheries, and nutrition.

An appraisal-assessment exercise by both comparative and matrix analyses was conducted on emerging issues related to agriculture (*population increase and diminishing arable land, rural-urban migration, aftermaths of Climate Change and nutrition*) against the backdrop of the over-arching need for judicious management of constrained resources (*water, energy, health, agriculture and biodiversity*) of planet earth that define and shape future challenges, scenarios and ST&I strategies in order to enhance sustained growth for Malaysian agriculture in the coming decades. To appraise the level of ST&I culture and adoption of the state-of-the-art technologies, a backstop and check-and-balance strategy was conducted via several fact-finding interviews with groups of middle-management officers from several agro-based agencies (Federal Agriculture and Marketing Agency, Department of Fisheries, Faculty of Agriculture, UPM and Department of Agriculture). Next, a matrix analysis on emerging and current technologies relevant to agriculture was conducted to identify technology megatrends which was done through meta analysis and appraisal of technology as found in many editorials in journals, periodicals, technology-watch profiles in magazines, pundits' reviews, popular reviews in technology-related reading materials (*Red Herring, MIT Technology Review, Time, Fortune, Forbes, Humboldt Kosmos, Portico, Health Today, National Geographic, Scientific American,* *Discovery Channel, Discover, Deutschland, and weblogs and websites*). Once the emerging technologies and megatrends were identified and clustered into defining entities (*Genomics and Molecular Breeding, ICT-enabled applications, robotics, RFID-tagged traceability system for food miles and food safety, precision farming, web-based knowledge portals, space agriculture and life support system, hypobaric chamber for precision farming, etc.*), associated emerging applications, technological convergence, new concepts, evolving policy shifts (European Aviation Biofuel Policy 2012, New Economic Model and NAP4), global trade agreements (WTO multi-lateral agreements), regional economic integration (ASEAN food intra-trade), changing demography (greying Malaysian demography), changing dietary choices, values and life styles (shift to sedentary life styles of the industrial society), growing awareness on biodiversity loss of the agro-ecosystems (agro-forestry), advances in closed-environment technologies (vertical and urban farming) and open field agriculture (enhancing the biodiversity of the mono-cropping system for commodity crops) were identified for further considerations on how our ST&I initiatives can be recommended for development under the Malaysian agriculture scenario.

From the Megatrend-Scenario Model, many emerging concepts are defining and shaping the future of Malaysian agriculture, especially the need to address and mitigate the corollaries of Climate Change; both at the national and global agriculture levels, towards 2050. Some of the deliberated issues and concepts are: adoption of precision farming to reduce wastage and efficient use of constrained resources; vertical farming and urban agriculture to address food security to the populated cities and diminishing arable land; construction of plant walls on city buildings to clean and cool congested cities (horticulture-cum-environment), growing awareness and mindfulness of carbon and water footprints to be watchful on the use of constrained resources of energy and water; employing the close-loop agro-ecosystem of the controlled-environment, greenhouse to ward off the consequences of unpredictable weather from Climate Change (temperature, rains, floods, droughts, disease outbreak, storms, light duration, etc.); growing energy crops and use of organic fertilizers to reduce dependence on inorganic, petroleum-based, chemical fertilizers, insecticides, fungicides, and weedicides; adoption of green technologies and bioremediation of the agricultural pollution in the environment; the practice for sustainable and low-carbon agriculture; retrofitting the food basket to the new food pyramid for improved health.

Two approaches of recommendations and milestones on the commodity crops and technology megatrends were proposed in this MSFS study on agriculture, as to prospect for ST&I opportunities based on the short-term (a decade from now – 2020), mid-term (one human generation of 25 years – 2035) and long-term (when new wave of technological epochs have been monitored to take place every 50 years – 2050).

In the order of priority and importance, the activities related to the emerging technologies that are identified to define and shape the coming decades of Malaysian agriculture are:

i) ***Molecular breeding*** to be preceded with sequencing the DNA genome (Genomics) of important economic crops (oil palm, rubber, cacao, tubers, herbs, commercial fruits, etc.) and establishment of the genome library (Bar Code DNA Technology) and the splicing of the desirable traits from other species (transgenic) with unique genetic traits into these economic crops that already occupy most of the arable land for agriculture (*Genomics* or specifically *Molecular Breeding* for transgenic disease resistance, nitrogen-fixing microbes, improving traits (tolerant to droughts and droughts and transgenic disease resistance) and several folds increase of crop yields and the development of bioterials or new products.

ii) ***Field Robotics*** is recommended to overcome labour shortage and perform in inaccessible areas. Some of these field robots are equipped with vision system for harvesting ripe fruits, and motion-capture aided robots (Avatar-like) for harvesting of oil palm fruit bunches on tall trees, and wearable robots to perform back-breaking tasks of carrying oil palm bunches.

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1 INTRODUCTION

The Academy of Sciences Malaysia (ASM) is undertaking a Mega Science Framework Study for Sustained National Development (MSFS) for the period 2011-2057. The objective of the study is to produce a framework/roadmap document that will provide relevant insight and guidance to the Government of Malaysia in relation to future planning and development of the agriculture sector. This report is the outcome of the work of a team of consultants appointed by ASM in February 2010 to undertake the study.

The scope of the study includes the following:

i) To identify sources of future growth opportunities in the various areas in the agriculture sector.

ii) To identify the current gaps in Science, Technology and Innovation (ST&I) knowledge in the agriculture sector and how (and the areas in which) science and technology can assist in the economic growth in the agriculture sector.

iii) To undertake comparative studies with other developed countries that will allow the local agriculture sector to grow, including the identification and/or development of the policies necessary to sustain this growth.

iv) To identify and propose appropriate measures in the research needs in the agriculture sector that can contribute to sustained economic growth.

v) To conduct a review on international best practices of ST&I Policies and Plans for sustained national development in the Agriculture Sector.

vi) To review and analyze Government's various policies, strategies and plans towards identifying educational (capacity building), technological, and scientific and governance (institutional framework) gaps in the Agriculture Sector.

vii) To propose an Action Plan for implementation.

This final report incorporates the findings of the team of consultants. The report provides a synthesis of development in the region and the world and captures the significance of science and technology in the selection of strategies by the government and industry for the development of the agricultural sector. Some suggestions for investment in the subsector are also proposed.

1.1 Early Agriculture

We examine the historical past of our agricultural heritage and infer the changes we can possibly make to the agriculture of the future. The success of the tropical agricultural system of the Angkor Wat (Cambodia), Borobudur (Indonesia), Mayans of the Aztecs (Mexico) and even the apocalyptic Noah’s Ark enabled us to count on our imagination and foresight to plan for the future. From the recent past, we draw inspiration from the history of food production, such as, the *Old Spice* route by Marco Polo, we have been able to assess our achievements and shortcomings. Men were hunters’ gatherers ca. 12,000 years ago. In time, food productivity increased with the change in the “hunt-gather” method to grow-care-own, signifying the advent of agriculture.

However, humans have the lessons from the past sustainable farming systems. In the case of Angkor Wat, the old kingdom became a victim of its own success. The head water of the Siem Reap River was the Kulen Hills. As the population grew, the hills were quarried for rock to build Angkor's temples. The hills were also logged for timber and firewood and to open land for farming. It is believed that deforestation had caused floods that choked some of Angkor's canals with sand and silt.

A lesson can also be learned from the story of the great flood and Noah's Ark that was built to preserve the various species of the planet. In the context of modern times, global warming can lead to great floods of biblical or Quranic proportions. Thus, the concept of a modern day Noah's Ark in the form of Floating Villages to survive a future global deluge has been developed. Each of these villages would be able to support 50,000 people and inspire the need for a sustainable agroecosystem. The four key areas of sustainable agroecosystem are biodiversity credits; CO_2 offset credits, renewable electricity and certified sustainable timber.

There has never been a shortage of ideas for the concept of sustainable lifestyles. One such idea is the Biosphere 2, a closed system that houses a collection of the germplasms of the world and promotes a low carbon lifestyle. Figure 1.1 shows the Biosphere 2 was viewed by the space activist community as a precursor to future human colonies on the moon and other planets.

Figure 1.1: Biosphere 2

Malaysia has been very successful in developing the country via organized and focused, economic development plans. Since the 1970s, within less than three decades, the development approaches have brought unprecedented GDP increase and economic well-being of her citizens. However, after 40 years of 8 successive a 5-year phases of economic development plans, now it is clear that the current tenets and paradigms of the global development on this planet of finite earth have changed in both emphasis and values. Emerging new constraints are defining the new tenets for sustained development and co-existence. The new orientation is sustainable development and inclusiveness. Now agriculture on finite earth is experiencing a new world of challenges of greater resource-constraints, food security and the ominous Climate Change. Hence, the agriculture sector is burdened with the daunting task to feed the ever-burgeoning world population, whilst arable land has become marginalized and the world's climate is not cooperating. Malaysia need to be circumspect in her agricultural planning and embrace a longer term view of SUSTAINED, WELL-BEING of the nation by adopting green-friendly values, equitable and inclusive in the next 40 years of agriculture development (2011-2050). Simultaneously, sustainable development must be inclusive enough to cater and address the population's wider needs for food, feed, fuel, fibre, furniture, pharmaceuticals, felicity, etc. For agriculture, emerging constraints, pressing health and environmental concerns are beckoning the government to reset its mode of development mantra towards being trim, mean, focussed, not wasteful, savvy, and compliant to the global environmental and health standards.

On the outset, the premise of this Mega Science Framework Study is guided by the following definitions and concepts with the objective to recommend an array of possible solutions for a long-term, sustained and inclusive, agriculture development in the broadest sense, expanse and meaningful well-being of Malaysians.

Agriculture involves the production of food and goods through farming. It was the key development that led to the rise of human civilization; with the husbandry of domesticated animals and plants (i.e. crops) creating food surpluses that enabled the development of more densely populated and stratified societies. The major agricultural products can be broadly grouped into foods, feed, fibres, fuels, furniture, pharmaceuticals and felicity. In the 2000s, plants have been used to generate biofuels, biopharmaceuticals and bioplastics. Specific foods include cereals, vegetables, fruits, and meat. Feeds encompass grains and fodder for the production of food for livestocks (animal and aquaculture). Fibres include cotton, wool, hemp, silk and flax. Rattan and rubber can be grown for the wood by-products that can be processed and treated for the production of furniture. Flowers are grown for celebration, commemoration and felicity. Plants produce resins and other useful materials. Biofuels include methane from biomass, ethanol, and biodiesel. Cut flowers, nursery plants, tropical fish and birds for the pet trade are some of the ornamental products.

1.2 New Agriculture

Borderlessness has broken down knowledge barriers in many fields and it creates inter-link and connectivity between many fields and knowledge domains. That seamless border consequence to globalization which is triggered and enabled by the advances in information and communication technology (precision agriculture), and the vast field of agriculture, being multi-disciplinary, it is no exception. An expanse of far-reaching implications of borderlessness creates mergers and allied fields of growing importance to agriculture in the knowledge spheres of crops for energy, environmental conservation and health. These allied knowledge domains brought new dimensions, in that; it has brought a renewed meaning of 'new agriculture'. New agriculture retains the extant meaning of conventional agriculture but it has expanded the concept that allied to the convergence of knowledge in multi-disciplines areas which includes health, environment, agrotourism, agroforestry, bioremediation and biopharmaceuticals. This allied entity engenders the immediacy of knowledge of far-flung disciplinary to be merged creating new possibilities, accurate understanding, new opportunities, and extending and diversifying the value-chain and the delivery system of the product development.

A case in point of new agriculture is the transgenic insertion of the protein-silk production gene from spider into the goat's milk by molecular breeding (recombinant DNA technology) to produce a new biodegradable (bioterial), biosteel. Conventionally, we get mutton and milk from goat rearing. But through molecular breeding, we can procure biosteel silk from the goat's milk. Biosteel silk is seven times stronger than steel which is produced to make new products like, biodegradable sutures, for tennis, bullet-proof vests and enhanced badminton racket string. Another example, the area of growing or cultivating of herbs for pharmaceuticals and medicinal purposes which is inter-linked to the convergence of knowledge common to new possibilities. The food delivery chain is extended beyond the from-gate-to-plate to from-field-to-flatulence. Both the future job of vertical farmers in agriculture and vertical pharmers in pharmacy have been identified as prospects for the future. Agrotourism (homestay), agroforestry, bioremediation, biopharmaceuticals, neutraceuticals, and many others, are examples of the blurring of boundaries between agriculture and the allied knowledge areas.

The increased convergence and linkage to other disciplines create new opportunities for job, new possibilities, and product development.

1.3 Sustainable Development

It is the capacity of humans to endure over at least one generation. For human being, the time-frame for one generation is about 25 years not withstanding the diversity and variety of the agro-ecosystem. In ecology the word describes how biological systems remain diverse and productive over time. For humans it is the potential for long-term maintenance of wellbeing, which in turn depends on the well-being of the natural world and the responsible use of natural resources as in the example shown in Figure 1.1. Therefore, this study for the duration from 2011 to 2050 is sufficient duration to be considered as sustained well-being of one generation of Malaysians into 2050.

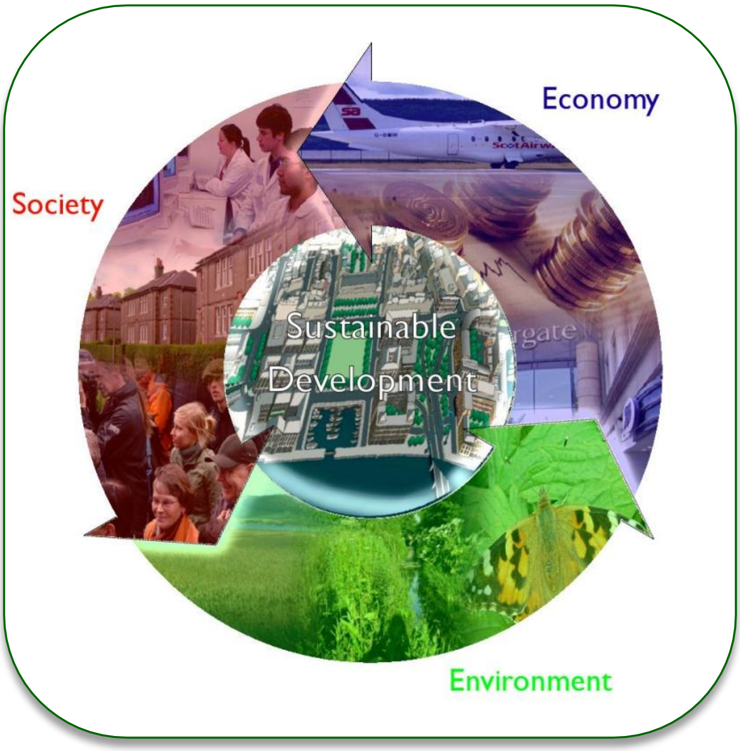


Figure 1.2: Sustainable development circle

1.4 Cycle-loop Production Systems

The world order in production agriculture is departing beyond the linear production supply-chain, industrial model into the all-inclusive, cycle-loop ecosystem production model. The cycle-loop ecosystem approach for agriculture requires the practitioners to be knowledgeable, comprehensive, precise and accountable on the ultimate fate of all inputs and outputs of the production system. The concept of New Agriculture embraces the elements of sustainability and inclusiveness, which is in consonance with the recently launched, New Economic Model (NEM) part by the Prime Minister of Malaysia, 1. (New Economic Model for Malaysia, part 1, 2010). The upgrade of the linear, supply-chain, commercial production concept of the conventional agriculture into an inclusive, optimal, cycle-loop production ecosystem is meant to sustain for the longer-term, well being of the finite earth. It takes into considerations all factors that are associated with the production ecosystem which encompasses the environmental conservation and human health. The new agriculture works best when it combines fresh knowledge with older wisdom. An example of the inclusive, cycle-loop production system is a new chicken coop in Bangladesh which produces not just eggs and meat, but 'wastes' that feed the fishpond, which in turn produces thousands of kilograms of protein annually, and a healthy crop of water hyacinths that are fed to a small herd of cows, whose dung in turn fires a biogas cooking system. Hence, through traceability tagging system by RFID or barcodes, whatever changes on the inputs and outputs introduced or removed along the agriculture production ecosystem will be traced for safety and health.

1.5 Wellness

It takes more than just the economics of achieving high GDP to bring about wellness or happiness in people-first government development plans. A study on the relationship between GDP and wellness/happiness indicates that higher GDP does not necessarily mean people are happy and feeling good. It is a matter of concern that there are element other than GDP, like health and environment, to make people feel happier. This element of wellness will be considered in this MSFS assignment. In simple terms, we observed that the moral fibre that is foundational to the indigenous, ethnic communities in the rainforests is that it thrives on the well-being of the community which is shared and considered as premium of livelihood by the community. Putting the community's interest first before oneself lends stability and trust amongst members to share resources and risks by the community.

1.6 Mega Science Framework

The framework for Mega Science connotes the study expanse or the total embodiment of larger areas of scientific disciplines with other far-flung disciplines that can be connected or unified to emerge as a meaningful domain of knowledge that can bring creative and innovative ways and technologies for sustained and inclusive agriculture. It is so encompassing and the total inclusive fitness of the production agroecosystem is of paramount importance. This framework study is premised even on the extant and co-existence between the science and the traditionally, non-science areas (economics, management, hospitality, logistics, etc.), but they are relevant in the quest on the sustenance or well-being of humans, in particular, Malaysians.

The focus of the MSFS Study in the thematic areas of Water, Energy, Health, Agriculture and Biodiversity is in consonance with the WEHAB initiative proposed by Kofi Annan and subsequently adopted in the World Summit of Sustainable Development of 2002. This underscores the overarching goals of sustainability and inclusiveness, which incidentally taken together with high income are exactly the goals of the recently launched New Economic Model (NEM)**.** The NEM is one of the four pillars[1] of national transformation of the Najib Administration towards achieving Vision 2020. This provides a convenient framework to dovetail the output of the present study on agriculture with that for the other sectors into the NEM and Vision 2020 for the initial period of 10 years at least. Beyond that, and as part of this strategic foresight study or research, we will have to be guided by global and regional megatrends in agriculture as well as the promises of nanotechnology, biotechnology, ICT and the development of agric-food supply chains and trading networks.

Subsequently, we have to take stock of where we are; then consider or benchmark what's happening around us; ascertain what inherent and potential advantages we have or can

[1] The other 3 pillars being 1Malaysia launched in April 2009; Government Transformation Programme (GTP) launched in January 2010; and the 10th Malaysia Plan to be launched in June 2010

develop; determine where we want to be as a nation; and work out collectively how to get to 2050. These sequential steps will guide the subsequent drawing up of the Roadmap.

At this juncture, it bears reminding that the history of science cautions us that discoveries and breakthroughs can only eventuate when we emancipate our minds, break down conventional barriers, and make foresighted plans which are as inclusive and sustainable as possible. As always, the challenge is in getting the basics and balance right, including in our case, the balance between top-down guidance on research and financial support and involvement of a wide range of talented scientists and entrepreneurs with market or demand driven research and free discovery of science.

In so far as agriculture is concerned, the key strategic thrusts would be to ensure food security and safety; create wealth and employment through sustainable agriculture; intelligent/precision agriculture; and high-value agriculture via increasingly comprehensive and interconnected supply chains and trading networks. These are geared towards meeting the rising demand and total quantity, quality, safety and multi-functions of agricultural goods and services. We must ensure that through the next 40 years of focused efforts, food and agricultural product quality, food safety, food nutrition and functions are substantially improved; agriculture will be modernized via ICT, nanotechnology, biotechnology, digitization and precise technologies; and high-value ecological, multi-functional and sustainable agriculture will be firmly established, in tandem with developments in the other sectors in WEHAB, of water, energy, health, and biodiversity.

2 STUDY APPROACH AND METHODOLOGY

2.1 Appointment of Consultants in the Appropriate Area of Expertise

We subscribe to the concept of the value-chain network in and along the all inclusive and sustainable production system that, correspondingly, we chose the team of experts to comprise more than just those in the sciences only but to include those in the complementing fields. The Consultants Team are made up of specialists in Crops, Livestock, Fishery and Aquaculture, Agroforestry, Future Agriculture, Precision Farming, Agricultural Economics and Food Nutrition.

2.2 Interviews with Key Officials in the Various Subsectors

Interactive interviews with groups of professionals from agriculture-related institutions were conducted to bench mark and get a feel of these professionals' evaluation and assessment of the status of agriculture and its trend in the future. Key personnel from FAMA, DOA, UPM and the Department of Fisheries were interviewed.

2.3 Reference to Key Journals, Websites and Other Publications

Our reference for this study were sourced from diverse and wide-ranging media such as Scientific journals, websites, magazines, editorial columns, newspapers professional insights opinion, technology trends and comparative evaluations..

2.4 Brainstorming Seminars among Members of the Working Group

Regular discussions among members of consultancy team were held to develop consensus and resolving contentious issues of the group members.

2.5 Workshop with Stakeholders

After the series of discussions, analyses and presentations to the working committees, the findings and recommendations were presented to a group of stakeholders in order to obtain their views and comment on the various critical areas identified in the Report.

3 STATUS OF AGRICULTURE

3.1 Evolution and Paradigm Shifts towards Sustainable and Inclusive Agriculture

In the quest to formulate a proposal on the MSFS in agriculture, we decided to trace the deductive beginnings of farming from historical records and made a comparative analysis of it against the ecological backdrop and history of farming. We tried to comprehend how did our agriculture evolved and in what way it stayed in a pattern-like fashion that make it sustainable over the years. How is our agriculture similar and different from the agriculture of the neighbouring countries of ASEAN? What are the sciences and technologies involved that sparked the research and innovations, which have contributed to the advances of the overall Malaysian agriculture? We noticed the disparities that have developed over the years and where needed, we sought to redress the imbalance and rectify the deficiencies and uplift the overall development from the inclusiveness standpoint. Within the context of our national economic development agenda, we strive to make our proposition to agriculture in 2050 to be sustainable and inclusive. The sustainability and inclusive plan is to move up the productivity average of agriculture production with the consideration that no one is to be left behind. The seeds of sustainability in tropical agriculture are probably seated in the ecological and historical evolution of farming practiced by the indigenous tribes in the region.

i) Natural History and Evolution from Hunting-Gathering to Farming

We reflect the past to glean the future, so that hopefully we will not repeat the mistakes of the pasts and seize the opportunities and benefits that arise in the future. The evolution of how humans gather and grow their food is there to be understood for posterity. From studies on fossils records and carbon-dating estimates, there are circumstantial evidences that indicate that the shift from the pastoral life style of hunting-gathering to domesticating-cultivating of crop and livestock (agriculture/farming) by humans might have probably started only recently , about 10-12 thousand years ago-mitochondrial DNA studies on the human genetic origin shows the probability that early humans may have been on this earth roaming (oipedalism) across the continents (pastoral life style) by about 200 000 years ago . Higher productivity with less energy expended (low-carbon footprints) on food cultivation and production via farming activities stems from the selection, breeding and domestication of flora and fauna species from the forests for crops and livestock on arable, owned/rented land.

Land ownership is the key to the sustained practice of farming because it affords the needed time duration for the growing of food crops or domestication of livestock. Hunting-gathering of food can thrive when there is no ownership of land and the result of the research is unpredicTable and full of risks and uncertainties as shown in Figure 3.1. Farming enables cultivation and breeding (perpetuating the selected gene traits) and the improvement of selected traits of crops or livestock, hence ensuring greater success and certainty of yield and therefore saving efforts for the future well-being of not only oneself, but the family, community or even the nation. Such concentration of cultivated food crops and livestock on a given area of arable land affords the saving of energy, greater yield certainty and volume of food produced for the family, community and the nation. That epochal shift in the acquisition of food from agriculture/farming by humans brought about immediate increased in productivity and predictability of yield or harvest. Less energy (lesser carbon footprints) is expanded and higher probability and greater certainty of success in farming or livestock rearing are achieved in procuring and cultivating crop plants and livestock for food, when compared to the hunting-gathering of the pastoral life style. That life style shift from hunting-gathering to farming is a welcome culture to sustainable approach in food-growing and less destructive to the biodiversity of the flora and fauna species of the rainforests With more food produced from farming it ensures food security for the family and the community and hence the wellness of the community and the nation. There is sanguinity between food security (sharing of food harvest/hunting booty) and convivialism found in the indigenous traditional community because of kinship ties and shared values, and hence wellness value of the community. This is probably the DNA to wellness in ASEAN tribal communities and the potential to translate this sanguinity into a regional bonding for food security.

Figure 3.1: National history and evaluation from hunting-gathering to farming

Traditional Agriculture

Traditional agriculture is sustainable as its practices contain critical elements or keystone components of the ecosystem for sustainability because it evolves through honing the salient features of the natural ecosystem. However, there exist elements that are considered to be detrimental and not in-sync with the concept of sustainable agriculture, as in shifting cultivation, which is destructive and untenable in the context of increased population pressure. The traditional agriculture in Malaysia is very much characterized by the multi-ethnic cultures in the rainforests as practiced by the natives in the Peninsular Malaysia, Sabah and Sarawak. The food preference of the indigenous people, whether they are living by the river or seas (Bajau laut, Melanau, etc.), or in the terrestrial inlands (Dayaks, Jakuns, Muruts, Penans, Kelabits, etc.), are reflected in their food gathering or agricultural activities, diets and food habits. Food gathering activities, like hunting-gathering and fishing by these ethnic tribes, over time shifted towards agriculture in that the flora and fauna species of the rainforests that are hunted and gathered, and were then selected, cultivated and bred for their benefits for food, feed, fibre and fuel. It can be considered that those farming activities arise from species of the rainforest were founded for the sustainable development of tropical agriculture based on the rainforest ecosystem. The natural evolution of the pastoral life style from hunting-gathering to farming was based on the rainforest ecosystem blueprint in that it is sustainable agriculture which mimics the rainforest ecosystem. This aspect of the science of the Malaysian agriculture has not been scientifically dealt with and that the natural history of farming under rainforest ecosystem should have been addressed to found a sustainable ecosystem approach to agriculture. This scientific aspect of the ecological approach to tropical agriculture should be pursued for the purpose of developing a sustained farming system under our climatic conditions. Comparatively, we notice that our traditional farming practices are not much different from the farming practices in the neighbouring countries. However, we are apart from the traditional, regional farming in that we have a successful, world-class plantation subsector of the agriculture industry that has served to be the backbone of the Malaysian economy for almost a century.

Indigenous farming practices: The plethora of flora and fauna species of the hot and humid tropical rainforests of Malaysia is elixir to the indigenous, pastoral life styles, and the genetic resources that generate variety for the farming life styles to the more than 40 native tribes of Malaysia, viz. Jakuns, Batiks, Penans, Kelabits, Rungus, Bajau etc. who are low in population numbers. Most of these ethnic tribes thrive on the pastoral life styles of hunting-gathering in the rainforest, and at best, a temporary, domiciled, mixed life style of hunting-gathering and farming as practiced in shifting cultivation. With the increased population density and greatly reduced rainforest areas their shifting cultivation life style are not sustainable anymore, and they have to make adjustments to a more sedentary or permanent domiciled life style of farming or agriculture. It is interesting to note that some of the pastoral-cum-farming are steep in beliefs and cultural traditions and there exists a huge body of indigenous knowledge on agriculture associated with their farming practices (e.g. the sago palm food diets and beetles (Penans), fish dietary habits (Bajau), collection of wild fruits (Murut), etc.), food habits, medicinal herbs and age-old diets of these ethnic tribes of the rainforests.

Nucleated Community Settlement and the Evolution of Community Landholders and Later Smallholders: The nature of the nucleated, extended family and community settlement of the natives in Peninsular Malaysia, Sarawak and Sabah reflects the mix of hunting-gathering and farming activities of the community. The infrastructure build up for communal living of the multi-ethnics of Jakuns, Melanau, Bidayuh, Muruts, Kelabit, Penan, etc., in the form of their dwellings or houses on stilts with high wooden flooring, such as, long houses, are designed for communal living for living near the rivers where floods are frequent. Sediments of alluvial soils settled by the river banks after floods provide fertile soil for farming activities. Water is crucial to the growth of plants and animal lives and settling near a river is an insurance and access of water, alluvial soils and transportation waterway for agriculture and trade. The river banks or riverine settelment is ideal for agriculture to take foothold. Rivers are major transportation routes and means, apart from providing sources of protein procured from fishing activities, hunting of wildlife and even into domestication of wildlife (poultry, pigs, goats, etc.) sourced from the forest and raised for protein source for the community. As the community population size enlarges, we can expect that the community cannot rely on hunting-gathering alone to ensure sustainable and sufficient amount of food from hunting-gathering to survive. They have to resort to the domestication of their preferred choice of plants and livestock via farming. The cultivation of wild fruits and tubers ensures and secures food supply (food security) food storage (tubers) and variety for carbohydrates, protein and fruits. Hunting alone is not enough to ensure sustainable harvest of meat or protein source, fruits and energy sources of carbohydrates from the cultivation of crops (tubers like yam and potatoes, etc.) and medicinal herbs around the compound of the community.

Fragmentation of arable land: As time goes on, the thriving community becomes a large settlement of closed kins and relatives in a village. They have both the hunting gathering and farming activities adopted by the villagers. The system of inheritance and legacy practised by the villagers requires them to share the farmland into smaller holdings between the siblings of the nucleated family in most villages. For instance, the Adat Pepatih of the Minangkabau culture, which originates from Sumatra, epitomizes this debilitating land-fragmenting culture through inheritance. Continuously practised, farmlands are fragmented into even smaller, uneconomical parcels or land holdings. In the modern era, the smallholders of the oil palm and rubber holdings arose through the traditional farming family, with the exception that the technology and critical massing of processing of farm products have become standardized and subjected to similar quality control as in the estate crop of plantations. Until today, FELDA is still grappling with this dilemma of social inheritance system and ownership amongst the second-generation of FELDA settlers to continue the agriculture renaissance to the economy of the Malaysian proletariat in the agriculture sector. Small holders account for 40 percent of the land area under the cultivation of oil palm and rubber. The productivity of the smallholders is varied and less than the plantation sector, but they have to rely on the estate plantation holding for technology transfer. Fragmented small holders' land scattered all over the district or state were then attempted to be amalgamated via the government agency, FELCRA. However, the smallholder's community requires the assistance and technology transfer from the estate plantation management to uplift their product quality, move up the value-chain, and be compliant with the global market standards.

Other Agroecosystems*:* Apart from the oil palm, rubber and paddy ecosystems, there exist several production agro-ecosystems in the country indigenously developed by the smallholders. Some of these agroecosystems are clusters of mixed orchards (Carambola/banana) ecosystem, cacao-coconut/coconut-pineapple, floriculture-cum-vegetable controlled-environment (Cameron Highlands),forest species with crops(agroforestry), poultry controlled-environment, animal husbandry (cattle/goat/etc.), riverine estuaries for fishing, and few others. The framework of these agroecosystems captures the essence of sustainability elements from the species diversity for the crop and animal husbandries that are derived or sourced from the rainforests.

ii) Agricultural Footprints of Past Civilizations in the Tropics

There are many clues and lessons on tropical agriculture that we can learn and draw inspirations from past civilizations in the tropical rainforest area of the hot and humid conditions. Access, availability and distribution of water have been the key source factor to the rise of the great agriculture of the previous civilizations along the world's great rivers where water and frequent floods bring alluvial soils for agriculture. Efficient use and management of water by irrigation and drainage systems, flood mitigation and easy access of water from the river were the hallmarks of traditional agriculture of the Aztecs (Mayan Empire), Nasca tribes (Peru), Angkor Wat (Cambodia) and Borobudur (Indonesia). A glimpse on the locations of oil palm and rubber estate plantations in the country indicates vast tracts of estate plantation on fertile areas of alluvial soils along the many rivers in Peninsular Malaysia (Sungei Muar, Sg. Pahang, Sg. Perak, etc.) by the estate plantations of IOI, KL Kepong, Sime Darby, etc. except for those areas where paddy-growing has taken foothold earlier.

Waterways for Agriculture: Rivers of the world were great waterways for transportation, as well as for sourcing of protein from fish and other aquatic life. Satellite imagery studies on the area surrounding the Angkor Wat revealed that excellent water reticulation system of canals and bunds were intricately built to regulate the river/lake water via drainage and irrigation of the monsoon rains for paddy-growing in the surrounding Angkor Wat ruins. Deforestation of the surrounding rainforests around the Angkor Wat was deemed to be the key feature to the destruction of the water-holding/regulating capacity of the Angkor Wat built with massive reticulate irrigation and drainage system for rice growing. The *Tonle Sap Lake* (Mekong River) and the deposition of alluvial soils along the overflowing river banks provide the necessary fertile soil conditions for rice-growing through irrigation flow of the river water into the paddy fields. The same can be said about the Borobudur temples that relished water for its agriculture. Suspected droughts or famine was probably being the factor to cause the fall of the Mayan empire by the Aztecs. Similar river-waterway setting for irrigation exists in the Muda area of Kedah, Kemubu of Kelantan and Tanjong Karang of Selangor which were dammed or diverted to irrigate of paddy fields.

Paddy Growing Ecosystem: Similar water engineering feat of the Kedahans were exemplified in the construction of the Wan Mat Saman canal, Kedah for rice-growing in the rice bowl state of Kedah, Malaysia. In the early seventies, several dams were constructed for the purpose making available water from major rivers in Kedah and Perak for paddy-growing. The Malays in Kedah and Kelantan have established a cultural and ecological setting for the paddy-growing ecosystem. We can observe these traits from the idioms, parable, folklores, nursery rhymes, mores, taboos, and the much touted farmers' cooperation in the spirit of collective harvesting (semangat paddy/gotong royong). The nursery rhymes Bangau O Bangau depicts the environmental or ecosystem awareness on ecological concept of inter-connectedness of the elements of the paddy-growing areas and how they are inter-linked. The construction of the Muda and Pedu dams have enlarged the paddy-growing area in Kedah but similarly it is now highly likely that the frequent droughts is similarly triggered by the deforestation of the rainforest in the upper parts of the river origin. Somehow, probably, we should consider using tube wells to complement the untimely water scarcity from the drying dams of rivers, which have been tried elsewhere. This ensures timeliness of water availability for growing of the paddy.

3.2 The Rise, Fall and Rise Again of Agriculture

Development economists in general, and agricultural economists in particular, have long focused on how agriculture can best contribute to overall economic growth and modernization, premised on their in-grained believe that robust agricultural growth and productivity increases are crucial to sustained economic development, at least up till the mid 1980s. Since then, and despite this widely acknowledged role of agriculture in economic development, many policy makers, policy analysts and academics in developing countries, international agencies and donor communities appear to have lost interest in the sector, often relegating its role 'from engine of growth to sunset status'. However, after almost two decades of relative neglect, interest in agriculture has returned in a big and passionate way, as manifested in Malaysia where it was heralded as the next (third) engine of growth and promoted as 'New Agriculture' in Malaysia's current 5-year development plan in 2006– the Ninth Malaysia Plan.

In retrospect, the role of agriculture in economic development is sometimes complicated and controversial despite a long historical literature examining the topic . Part of the controversy stems from the structural transformation itself, which involves a multi-sectoral and general equilibrium process that is not easily understood from within the agricultural sector alone. By and large, agriculture's role seems to evolve through four basic stages: the early 'Mosher' stage when 'getting agriculture moving' is the main policy objective ; the 'Johnston-Mellor' stage when agriculture contributes to economic growth through a variety of linkages ; the

'T.W. Schultz' stage when rising agricultural incomes fall behind those of a rapidly growing non-agricultural economy, inducing serious political tension (Schultz, 1978); and the 'D. Gale Johnson' stage where labour and financial markets fully integrate the agricultural economy into the rest of the economy . Relatedly, empirical evidence suggests that most Asian countries encounter difficulty in transitioning from the 'food security' to the 'farm income' and on to the 'rural productivity' objective for public policy.

After about two decades (since mid 1980s) of neglect or disinterest by academics, researchers, donor communities and some developing countries, interest in agriculture is resurging since the turn of the century. This resurgence of interest was largely fuelled by a new understanding that growth in the agricultural sector plays a major role in overall growth and poverty reduction through the sector's linkages to manufacturing and services. These linkages are affected through evolving supply chains and international trading networks. They connect the poor along the agri-supply chain to growth.

There are four basic drivers of this renewed interest in agriculture, namely:

i) Agri-biotechnology (or green biotechnology) revolution in the development of genetics, both genetically modified organisms (GMOs) and non-GMOs, microbiology and diagnostics, coupled with ICT and nanotechnology, will continue to revolutionarize and expand agricultural production and profit frontiers. The 21st Century is touted as the 'Biology Century' and there are great expectations that agri-biotechnology can contribute greatly to innovations, cost reductions, productivity improvements, new processes, and new products.

ii) Supply chain and trading network expansion ensure that future competition will no longer be merely between firms but rather between supply chains and trading networks, comprising groups of companies intricately linked through a series of partnership and strategic alliances at the various levels of the supply chain. They would provide linkages for agriculture to the manufacturing and service sectors in a broader and more holistic agri-business framework, and in so doing contribute towards local, regional and overall growth.

iii) The rise of supermarkets in Asia has transformed agric-food supply chains, especially food retail markets. There are new important opportunities for farmers to diversify into high-value crops with greater demand potential, and thus capture some of the value-added being generated by the supermarkets and increasingly sophisticated and stochastic supply chains and international networks. They also increasingly connect farmers and other stakeholders more directly to changing consumer preference and demand. They also provide convenient 'export platforms' to regional as well as global markets. Whether this is a boon or bane for farmers and stakeholders at different levels of the supply chain depends as much on public policies as on the ability of the farmers and stakeholders to be proactive, adapTable and work together.

iv) The recognition that as urbanization occurs at unprecedented rates, economic growth generated by agriculture (and the value adding along the supply chain) showed as example in Figure 3.2 and 3.3 is the main vehicle for reducing poverty and preserving the environment in the rural areas with introduction of the future direction for agribusiness.

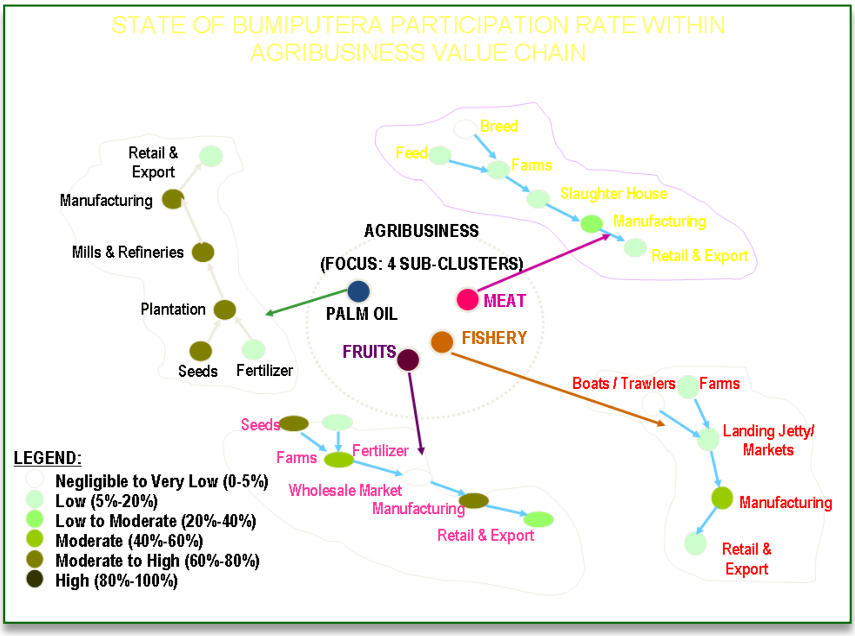


Figure 3.2: State of Bumiputera participation rate within agribusiness value chain.
(Source: Agribusiness Cluster Report, 2007)

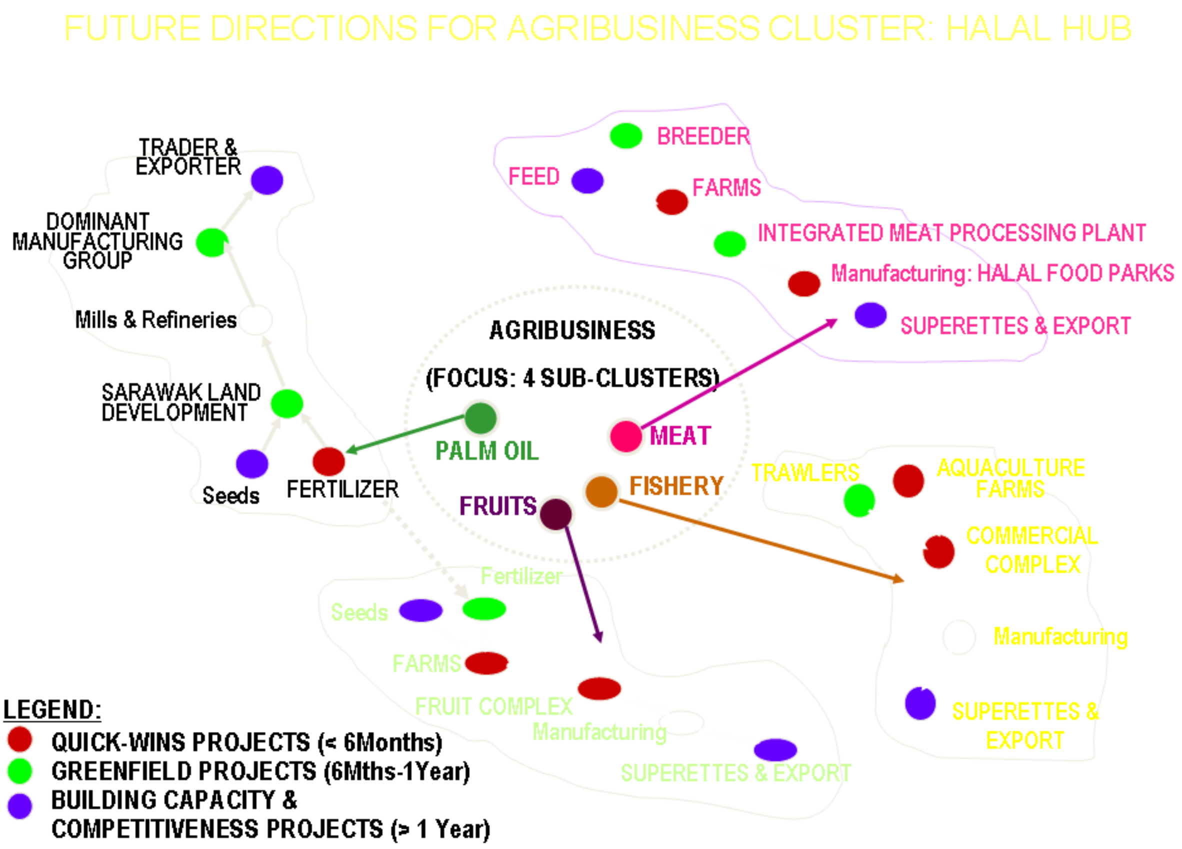


Figure 3.3: Future direction for agribusiness cluster Halal hub
(Source: Agribusiness Cluster Report, 2007)

After almost two decades of declining real prices of food commodities, prices have picked up significantly since 2003 and peaked in 2008, and in that process precipitated the Food Crisis of 2007-2008. This underscored the negative impact of almost two decades of neglect of agriculture, particularly in the funding of R&D, as well as the need for its urgent redresses, as future agri-food supply is predicted to be more uncertain and prices more erratic in the wake of climate change and escalating population, especially in urban areas. Elatedly, FAO has predicted that globally, only 10 percent of future food production increases will come from area expansion, 20 percent from crop or farming enterprise intensification, and some 70 percent from R&D, innovation and policies (the "10:20:70" rule).

It should also be pointed out at this stage that with the economic downturn in late 2008, the construction and manufacturing sectors in most economies were the first to be affected and perhaps hit the hardest. However, within manufacturing, in most countries food manufacturing still grew. Furthermore, especially in developing countries, the agriculture sector (and to a certain extent the informal sector) cushioned the problem of rising unemployment. Agriculture, by its nature, has great propensity to 'soak up' unemployment and diffuse related tension, largely due to the rural population's ability to share poverty.

Taken together, all the above go compel many researchers and governments to re-examine the role of agriculture in economic development, reassess the sector's relative strengths and endowments, and re-build development plans and programs. It is thus important to better understand and track the drivers, especially in current and future turbulent times.

i) Ninth Malaysia Plan (9MP)

In many important ways, Malaysia had a head-start as agriculture was accorded a very different treatment in the Ninth Malaysia Plan (2006 – 2010), starting with the revitalizing of the sector as one of the key aims of the Plan; and the sector itself featured strongly in each of the five key thrusts of the National Mission. Following on from the restructuring and renaming the Ministry of Agriculture (MOA) as the Ministry of Agriculture and Agro-based Industry (MOAAI) in 2004, Chapter 3 of the Plan was entitled, "Strengthening Agriculture and Agro-based Industry" and for the first time presented and discussed corresponding growth, export and employment Figures for agriculture and agriculture plus agro-based industry combined. The country also witnessed the introduction of the term "New Agriculture" as well as MOAAI's tag-line that "Agriculture is Business".

> "During the Ninth Plan period, the agriculture sector will be revitalized to become the third engine of growth. The emphasis will be on New Agriculture which will involve large scale commercial farming, the wider application of modern technology, production of high quality and value-added products, unlocking the potential in biotechnology, increased convergence with information and communications technology (ICT), and the participation of

entrepreneurial farmers and skilled workforce. The function of agricultural services will also be streamlined to enhance service delivery and efficiency." [9MP, p81]

Interestingly, value-added agriculture grew at three percent per annum over the 8th Plan period, higher than the target of two percent as shown in Table 3.1. Agriculture and agro-based industry grew at 3.6 per cent. Over the 9MP period agriculture is expected to grow at 5 percent per annum and agriculture and agro-based industry is expected to grow at 5.2 percent. In 2005, agriculture value added RM21.6 billion (in 1987 constant prices) or 8.2 percent of GDP while taken together with agro-based industry, value added in 2005 was RM38.5 billion or 14.7 percent of GDP. This is targeted to increase to RM49.7 billion or 14.2 percent of GDP in 2010.

Table 3.2 provides the corresponding data going back to 1990, computed from recently available national accounts statistics and hence providing a better indication of the relative changes in agriculture and agro-based industries as well as their individual components. The dominance of oil palm and vegeTable and animal oils and fats is striking. To a lesser extent, all the food commodities and Other Food Processing, Beverages and Tobacco also stand out.

In terms of export earnings, (see Table 3.3), agriculture and agro-based exports are expected to grow from RM74.9 billion in 2005 (14 percent of total exports) to RM115.7 billion (14.5 percent of total exports) in 2010.

Table 3.1: Value added of agriculture and agro-based industry, 2000-2010

Commodity	RM Million (in 1987 prices)			% of Total			Average Annual Growth Rate (%)		
							8MP		9MP
	2000	2005	2010	2000	2005	2010	Target	Achieved	Target
Agriculture	18,662	21,585	27,517	100.0	100.0	100.0	2.0	3.0	5.0
Industrial Commodities	11,033	13,278	15,521	59.1	60.6	56.4	0.7	3.8	3.2
Oil Palm	5,860	7,915	10,068	31.4	36.7	36.6	3.4	6.2	4.9
Forestry and Logging	3,055	3,016	2,761	16.4	13.0	10.0	-5.6	-0.3	-1.7
Rubber	1,868	2,264	2,554	10.0	10.5	9.3	1.1	3.9	2.4
Cocoa	250	83	138	1.3	0.4	0.5	0.1	-19.6	10.8
Food Commodities	7,629	8,308	11,996	40.9	39.4	43.6	4.0	1.7	7.6
Fisheries	2,493	2,389	3,875	13.4	12.6	14.1	4.1	-0.9	10.2
Livestock	1,520	2,089	2,483	8.1	8.1	9.0	6.0	6.6	3.5
Paddy	590	632	988	3.2	3.4	3.6	2.7	1.4	9.4
Other Agriculture[1]	3,026	3,198	4,650	16.2	15.2	16.9	3.2	1.1	7.8
Agro-Based Industry	13,584	16,928	22,221	100.0	100.0	100.0	4.0	4.5	5.6
VegeTable and Animal Oils and Fats	2,526	3,639	5,614	18.6	21.5	25.3	6.3	7.6	9.1
Other Food Processing, Beverages and Tobacco	4,010	4,790	6,333	29.5	28.3	28.5	2.0	3.6	5.7
Wood Product Including Furniture	2,934	2,972	3,761	21.6	17.6	16.9	0.6	0.3	4.8
Paper and Paper Product, Printing and Publishing	2,293	2,640	3,275	16.9	15.6	14.7	3.4	2.9	4.4
Rubber Processing and Product	1,821	2,887	3,238	13.4	17.1	14.6	4.7	9.7	2.3
Total Agriculture and Agro-based Industry	32,246	38,513	49,738				2.7	3.6	5.2

Commodity	RM Million (in 1987 prices)			% of Total			Average Annual Growth Rate (%)		
							8MP		9MP
	2000	2005	2010	2000	2005	2010	Target	Achieved	Target
Gross Domestic Product at Purchaser's Prices (contd.)	210,558	262,029	351,297					4.5	6.0

Source: Department of Statistics and Economic Planning Unit
Note: [1]Include coconut, vegetables, fruits, tobacco and pepper

Table 3.2: Value Added of Agriculture and Agro-Based Industry, 1990-2010

Commodity	RM Million (in 1987 prices)				
	1990	**1995**	**2000**	**2005**	**2010**
Agriculture	17,308	17,114	18,662	21,585	27,517
	-16.33	-10.27	-8.86	-8.24	-7.83
Industrial Commodities	12,041	10,980	11,033	13,278	15,521
Oil Palm	3,350	4,235	5,860	7,915	10,068
Forestry and Logging	5,194	4,139	3,055	3,016	2,761
Rubber	2,634	2,129	1,868	2,264	2,554
Cocoa	863	477	250	83	138
Food Commodities	5,267	6,135	7,629	8,308	11,996
Fisheries	1,534	1,964	2,493	2,389	3,875
Livestock	1,098	1,531	1,520	2,089	2,483
Other Agriculture[1]	2,635	2,640	3,616	3,830	5,638
Agro-Based Industry	8,102	11,174	13,584	16,928	22,221
	-7.64	-6.71	-6.45	-6.46	-6.33
VegeTable and Animal Oils and Fats	1,036	1,203	2,526	3,639	5,614
Other Food Processing, Beverages and Tobacco	2,642	3,504	4,010	4,790	6,333
Wood Products including Furniture	1,776	3,030	2,934	2,972	3,761
Paper and Paper Products, Printing and Publishing	1,116	1,888	2,293	2,640	3,275
Rubber Processing and Products	1,532	1,549	1,821	2,887	3,238
Total Agriculture and Agro-Based Industry	25,410	28,288	32,246	38,513	49,738
	-23.97	-16.98	-15.31	-14.7	-14.16
Gross Domestic Product at Purchaser's Prices	105,977	166,625	210,558	262,029	351,297

Source: Compiled from Department of Statistics, 2006 and Government of Malaysia, 2006
Notes: [1]Includes paddy, coconut, vegeTables, fruits, tobacco and pepper. Figures within parenthesis refer to % contribution to GDP.

Table 3.3: Agriculture and Agro-Based Manufactured Export, 2000-2010

Commodity	RM million			% of Total			Average Annual Growth Rate (%)	
							8MP	9MP
	2000	2005	2010	2000	2005	2010	Achieved	Target
Agriculture Exports	22,892	37,421	54,992	48.1	50	47.5	10.3	8
% to Total Exports	6.1	7	6.8					
Industrial Commodities	18,428	31,509	37,244	38.7	42.1	32.2	11.3	3.4
Palm Oil	9,948	19,036	26,735	20.9	25.4	23.1	13.9	7
Rubber	2,571	5,787	5,156	5.4	7.7	4.5	17.6	-2.3
Sawn logs	2,489	2,465	2,100	5.2	3.3	1.8	-0.2	-3.2
Sawn timber	3,020	4,051	2,995	6.3	5.4	2.6	6	-5.9
Cocoa	33	50	128	0.1	0.1	0.1	8.8	20.5
Pepper	367	120	130	0.8	0.2	0.1	-20	1.6
Food Commodities	4,464	5,913	17,748	9.4	7.9	15.3	5.8	24.6
Agro-Based Manufactured Exports	24,686	37,442	60,660	51.9	50	52.5	8.7	10
% to Total Exports	6.6	7	7.6					
Food	4,509	8,627	15,803	9.5	11.5	13.7	13.9	12.9
Beverages and Tobacco	1,207	1,755	2,446	2.5	2.3	2.1	7.8	6.9
Wood Product	6,801	9,665	13,909	14.3	12.9	12	7.3	7.6
Furniture and Parts	6,077	8,454	14,335	12.8	11.3	12.4	6.8	11.1
Paper and Paper Product	1,397	2,018	2,799	2.9	2.7	2.4	7.6	6.8
Rubber Product	4,695	6,923	11,368	9.9	9.3	9.8	8.1	10.4

Commodity	RM million			% of Total			Average Annual Growth Rate (%)	
							8MP	9MP
	2000	2005	2010	2000	2005	2010	Achieved	Target
Total Agriculture and Agro-Based Exports	47,578	74,863	115,652	100	100	100	9.5	9.1
% to Total Exports	12.7	14	14.4					
Total Exports (contd.)	373,270	533,790	803,163				7.4	8.5

Source: Department of Statistics and Economic Planning Unit

In terms of employment (see Table 3.4), agriculture and agro-based industry employed 2.39 million workers (21.9 percent of total employment) in 2005, and this is expected to increase to 2.43 million workers (20.3 percent of total employment) in 2010. It is interesting to note that over the 2000 to 2010 period, the expected increase in employment in the agro-based industry is expected to more than off-set the continuing decline in the agricultural workforce, resulting in a net increase for agriculture and agro-based industry taken as a whole.

To complete the backdrop, Table 3.5 provides an indication of land use over the 2000 to 2010 period. Again the dominance of oil palm and other tree crops is more than obvious.

In retrospect, Malaysia has tremendous inherent strengths in agriculture, particularly in tree-crop agriculture and management of large scale production of industrial crops like oil palm and rubber as well as selected crops, livestock, and fisheries enterprises. We are also getting increasingly good at developing and managing the respective agri-food supply chains and international trading networks. In so doing, we have developed a comparative and competitive advantage in selected supply chains, leveraged on end-uses of these commodities. We have been operating at their respective production and profit frontiers, especially with respect to palm oil as well as rubber. This has not only allowed us to stay ahead of the curve but also best positioned us to benefit from the potential and possibilities arising from the convergence of ICT, biotechnology and nano-technology.

Now, from another perspective, we note that developed countries' expertise in tree crops is invariably confined to timber, fruits, and nuts. Furthermore, the nerve-centers or nucleus of value-adding and ST&I for oil palm and rubber are also in Malaysia. Consultancies and management expertise in the oil palm and rubber industry in ASEAN and further afield is dominated by Malaysians. Consequently, Malaysia must build on and exploit this comparative advantage as we march towards 2050.

It follows that this focus on agriculture and its role as an engine of growth means that it should not only drive the production of oil palm, rubber and the range of selected crops, livestock and fisheries, but also the economic activities in their entire supply chains, 'from seed to shelf' or from inputs to final consumer, be they local or in far away and more lucrative markets (Table 3.6).

Table 3.4: Employment and Value added per Worker in Agriculture and Agro-Based Industry, 2000-2010

				Average Annual Growth Rate (%)		
	RM million			**8MP**		**9MP**
Employment	**2000**	**2005**	**2010**	**Achieved**	**Target**	**Target**
Agriculture Employment						
Number ('000)	1,423.00	1,405.70	1,323.80	-1.4	-0.2	-1.2
% of Total Employment	15.3	13.3	10.9			
Value Added Per Worker						
(RM in 1987 prices)	13,115	15,752	21,299	4.5	3.7	6.2
Agro-Based Employment						
Number ('000)	844	981.9	1,110.20		3.1	2.5
% of Total	9.1	9.3	9.1			

Employment					
Value Added Per Worker (RM in 1987 prices)	16,107	17,002	19,688	1.1	3
Total Employment in Agriculture and Agro-Based Industry	2,267.00	2,387.60	2,434.00	1	0.4
% of Total Employment	24.4	21.9	20.3		

Table 3.5: Agriculture Land Use, 2000-2010

Crop	Hectares ('000)			Average Annual Growth Rate (%)		
				8MP		9MP
	2000	2005	2010	Target	Achieved	Target
Oil Palm	3,377	4,049	4,555	3.2	3.7	2.4
Rubber	1,431	1,250	1,179	-2.7	-2.7	-1.2
Paddy[1]	478	452	450	-0.5	-1.1	-0.1
Fruits	304	330	375	5.1	1.7	2.6
Coconut	159	180	180	-0.6	2.5	0
Cocoa	76	33	45	-2.4	-15.2	6.2
VegeTables	40	64	86	4.2	9.9	6.1
Tobacco	15	11	7	2.5	-6	-7.4
Pepper	13	13	14	2.1	0	0.6
Total[2]	5,893	6,383	6,891	1.5	1.6	1.5

Notes: [1]Based on paddy parcel.

[2]Excludes areas for other crops like tea, coffee and herbs, as well as aquaculture.

Table 3.6: Self-Sufficiency Levels in Food Commodities, 2000-2010 (%)

Commodity	2000	2005	2007	2010	Revised 2010
Rice	70	72	72	90	86
Fruits	94	117	105	138	106
Vegetables	95	74	89	108	91
Fisheries	86	91	97	104	103
Beef	15	23	25	28	28
Mutton	6	8	9	10	10
Poultry	113	121	121	122	122
Eggs	116	113	114	115	115
Pork	100	107	116	132	132
Milk	3	5	n/a	5	n/a

Source: Ninth Malaysia Plan (9MP) and MTR 9MP

3.3 Crops

Agriculture has played an important role in the economy of the country in providing employment, income, food, raw materials, and health and wellness products. In the early development, agriculture was devoted to the growing of food crops, fundamentally, the staple crop- paddy and other crops that supplemented meeting the food requirements of the population – vegetables, fruits and coconuts grown in mixed orchards around the simple dwellings of the farmers. When commercial consideration came into being, coconut and coffee became the first plantation crops. As part of the alleviation of rural poverty and crop diversification programme, the Government embarked on the Coconut Replanting and Rehabilitation Scheme in the 1960s and 1970s where smallholders were encouraged to replant their holdings with high yielding varieties and at the same time intercrop coconuts with bananas, coffee and later cocoa, in the effort to increase income of the farmers. In the 1980s, coconuts occupy a land area of 280 000 ha. In the 1990s and 2000s, the low prices of coconut products and the better returns to oil palm resulted in the conversion of coconut holdings into oil palm. The area declined to the low of 121,000 ha in 2005, but increase slightly to 180,000 ha in 2010 (Table 3.7).

Table 3.7: Agricultural Land Use In Malaysia: 1995 - 2010

Fruit	Hectare (‘000)			
	1995	2000	2005	2010
Oil Palm	2508	3377	4051	4555
Rubber	1727	1431	1250	1179
Paddy	480	478	452	450
Fruits	244	304	330	375
Coconut	273	159	121	180
Cocoa	234	76	33	45
VegeTables	42	40	64	86
Tobacco	10	15	10	7
Pepper	10	13	13	14
Total	5528	5893	6324	6891

Source: Ministry of Agriculture and Agro-based Industries

The rubber seedling was introduced by Henry Nicholas Ridley, into the Malaysian agricultural scenario in the late 19^{th} century. The first commercial planting was in 1896 in Malacca. The subsequent development of the automotive industry in the 1950s triggered the expansion of the commodity. From 140 ha in 1897, the area occupied by rubber expanded reaching the highest in 1989 covering a land area of 1.86 million ha. Labour shortages and competition with the more lucrative oil palm resulted in the diminishing land area under the crop. In 2010 rubber occupies an area of 1.2 million ha.

Though oil palm commercial planting came 20 years later than rubber, its rapid expansion occurred in the 1960s with the Government’s Crop Diversification Policy and the opening up of land for the landless by the Federal Land Development Authority (FELDA) where oil palm was one of the selected crops for planting. From an area of 54 000 ha in 1960, it expanded rapidly to 0.8 million ha in 1980, doubling in the next 10 years to 1.6 million ha in 1990 and finally attaining 4.5 million ha in 2010 (Table 3.7). It occupies 12.5 percent of 32.86 million ha of the total land mass of Malaysia. Interest in the crop remains bullish. However, limited land availability in the country limits its further expansion and additional planting of the crop will be confined to logged forest areas and land converted from other crops.

The planting of fruits has expanded from 244,000 ha in 1995 to 375,000 ha in 2010 and remained predominantly smallholdings. Durian occupies the biggest land area with 106 000 ha, followed by *Langsium sp* (38,000 ha), bananas (26,000 ha), rambutan (25,000 ha), pineapple (16,000 ha), mango (9,300 ha) and watermelon (9,100 ha) – Table 3.8. Other fruit types grown include, guava, starfruit, papaya, jackfruit, mangosteen. pomelo, dragon fruit, sapota, rock melon, soursop and orange.

Concomitant with the expansion of land area, planted to fruit production has also increased from 1.2 million in 1996 to 1.9 million tonnes in 2007. The major fruits produced were durian, pineapple, banana, watermelon, rambutan and papaya. Per capita consumption of fruits in Malaysia has also increased from 44 kg (1990) to 72 kg in 2007 and the more popular fruits consumed are pineapple, watermelon, papaya, mango and starfuit.

Table 3.8: Planted area of major fruits 1996 – 2007

Fruit	1996	2000	2005	2007
Durian	110,000	122,800	111,000	106,000
Langsium sp	37,800	35,000	38,000	38,000
Banana	29,000	34,000	28,000	26,000
Rambutan	18,000	26,000	25,000	25,000
Pineapple	12,000	16,000	15,000	16,000
Mango	8,000	10,000	9,400	9,300
Watermelon	5,400	8,500	8,700	9,100
Papaya	1,300	2,300	2,800	300

Research undertaken by MARDI was devoted to 16 fruit species, principally in the hybridization and selection for better varieties/clones. Among the clones/varieties released over the years were MDUR78, MDUR79, MDUR88 (durian), Josapine and Maspine (pineapple) and Eksotika (papaya). Eksotika was particularly attractive as the variety, because of its yield, size, shape, flavor and aroma, has caught the imagination of consumers from all over the world, particularly in China. Its high demand pushed the development of the fruit to the extent that Malaysia became the largest exporter in the world.

Fruits provide challenges and opportunities to the agricultural sector. They are still largely being cultivated by the smallholders. Farm size is small and uptake of technology is low. Tropical fruits have short shelf life and perishable and this restricts export and contributes to the high cost of handling and transportation. Above all, the most serious drawback in the development of the more popular fruit types for export are pests and diseases – fruit borer (mango and starfruit), viral leaf spot (papaya) and greening (citrus). Nevertheless, the interest in cultivating fruits will remain high. Consumers with higher income and greater awareness of the positive attributes to health with the consumption of fruit will continue to push the demand of the commodity. In addition, some fruit types contain phytochemicals and metabolites that have the potential to be extracted for the nutraceutical industry.

Cacao whose home is the tropical rainforest of Central America was introduced into Malaysia in 1770 as shown in Figure 3.4. Interest in growing the crop was stimulated by Dr. Cheesman's feasibility report, which indicated that Malaysia's climatic condition was suiTable for the cultivation of the crop. The first commercial planting was in the 1950s at Jerangau, Terengganu and Bal Plantation, Tawau, Sabah. High prices in the 1970s and 1980s propelled its rapid expansion to its peak in terms of land area to 416,300 ha in 1990 and bean production of 247,000 tonnes, placing Malaysia as the third highest producer in the world. However, this golden crop suffered a long period of price depression in the 1990s and with the high prices of palm oil, significant areas of cocoa were replanted with oil palm. The industry was further burdened with the outbreak of the debilitating pest, the cocoa pod borer, which contributed to the rapid decline of the crop. Recent data indicated that the area under cocoa remains only around 45,000 ha, primarily smallholdings in Sabah.

Figure 3.4: Cocoa Plantation

The more exciting part of the industry is its downstream activities. Grinding has a phenomenal expansion from its first facility established in 1973 to 11 plants, processing an estimated tonnage of 300,000 tonnes in 2010, putting Malaysia as the fifth largest grinder in the world after Netherlands, USA, Ivory Coast and Germany. The availability of secondary products such as cocoa liquor, cocoa butter and powder from grinding stimulated further down streaming in the manufacture of chocolates, confectionery products and beverages. These products have found markets all over the world. The cocoa industry is contributing RM 2.2 billion in foreign export earnings (2009).

Cocoa is versatile in its utilization. As food it is popular as varied forms of chocolates, beverage and confectionery products which range from biscuits, cookies, cakes, sweets, sorbets, sauces, milk shakes. Formulations with the incorporation of medicinal and wellness herbs such as Tongkat Ali, Kacip Fatimah are marketed as health food. It has also been utilized in pharmaceutical, cosmetics and toiletry products. Cocoa is said to contain more than 300 useful chemical compounds and metabolites that remain to be exploited.

Research on the primary production has yielded superior high-yielding clones, identified shade trees with appropriate shade regimes, discovered fertilizer formulations and measures in the integrated pest and disease management. The biotechnology laboratories have made progress on genomic studies, identifying and selecting markers with the desired traits that can be used in the subsequent breeding and selection. It is in the areas of genomics and biotechnology that the cocoa beans offer possibilities for BioFarming, BioPharming, BioFuels and BioRemediation that impinge on a new spectrum of economic possibilities. Other crops of importance include vegetables, root crops and medicinal herbs.

Vegeables occupy a land area ranging from 29,000 to 38,000 ha cultivated with 32 types in the lowland and 13 types in the highlands (Figure 3.5). The lowland vegetables include cucumber, chilly, green mustards, spinach, kangkong and lady's finger. The more important types in the highlands are broccoli, sweet peas, cabbage, cauliflower, leek, lettuce and tomato. The per capita consumption has increased over the years and currently it is estimated at 52 kg. The more popular vegeTables consumed are cabbage, chilly, ginger, tomato and cucumber.

Sweet Potato has attracted a special interest as a potential crop for development as the new varieties released such as Vitato is rich in complex carbohydrates, dietary fibre, beta carotene, vitamins C and B6 and minerals (iron and calcium). In addition it has other useful constituents such as phytin, phytosterolin, resin and tannin. It is an established staple food in a number of island nations in the Pacific and countries in Africa. Its versatility in food preparations (boiled, fried and baked), processed into powder and manufactured into confectionery products coupled with high nutritive value make this commodity such a viable alternative as an important food crop in the country.

Medicinal Herbs in Malaysia as one of the mega diversity centres in the world, is a storehouse of plants with medicinal and wellness properties that can be exploited for the pharmaceutical, cosmetic and wellness industries. Of the 13,000 species of flowering plants found in the country, 2,000 are reported to have medicinal values and among these 200 species are commonly used among the diverse ethnic groups as shown in Table 3.9.

An active group of researchers in the universities and research institutions are undertaking investigations in to the various aspects of medicinal herbs – the growing (breeding and selection, propagation, agronomic practices, pest and disease control), post harvest handling, analytical chemistry to identify the compounds and metabolites and their efficacy, processing and manufacturing. Out of the 30 widely used species, those with the high potential rating are as given in Table 3.9.

Figure 3.5: Vegetable farm in Cameron Highlands

Table 3.9 : List of Selected herbal species with potential for development

Common Name	Name in BM	Botanical Name
King of bitter	Hempedu bumi	*Andrographis paniculata*
Indian pennywort	Pegaga	*Centella asiatica*
Turmeric	Kunyit	*Curcuma domestica*
Tongkat Ali	Tongkat Ali	*Eurycoma longifolia*
Kacip Fatimah	Kacip Fatimah	*Labisia pumila*
Noni	Mengkudu	*Morinda citrofolia*
Java tea	Misai kuching	*Orthosiphon stamineus*
Pick-a-back	Dukung anak	*Phyllanthus niruri*
Ginger	Halia	*Zingiber offinale*

Source: InduBala Jaganath and Ng Lean Teck. Herbs – The Green Pharmacy of Malaysia.

3.4 Livestock

Technologies developed from R&D and innovations in technological advancement throughout the decades after Independence in 1957 have propelled the Malaysian agricultural sector to produce adequate food for the local populace and raw materials for the industrial world. Investment in science and technology is expected to yield dividends in terms of further advancing our agriculture to become an active engine of growth in the new knowledge-based national economy. Innovation in modern practices of agriculture would complement the effort of research and development as both would bear the golden harvest from agriculture.

In our quest for rapid economic growth, often times we have neglected the wellbeing of the environment leading to deterioration in air and water quality and loss of diversity of indigenous flora and fauna. The activities of agriculture have contributed to some of these negative repercussions on the wellbeing of our environment. It is imperative that we institutionalize better stewardship of the environment where we co-habitate with the huge repository of flora and fauna in our country. For it is through a better understanding of this co-existence of convenience in the decades ahead that man and nature can survive.

Livestock or food animal agriculture consists of major species of farm animals for the production of meat (cattle, goats, poultry (chickens and duckss) and pigs), milk (dairy cattle and goats) and egg (chickens and ducks). There are also other under-exploited species such as buffalo and sheep and minor species such as deer, ostrich and quails that have the potential to contribute to the nation’s basket of meat and milk sources. Breeding and feeder stock and feed are two important components in livestock production and thus they require serious attention when formulating any livestock development strategies.

i) The Livestock Industry Today – Malaysia and the world

Malaysia has attained self-sufficiency levels in poultry meat, eggs and pork since the middle of the 1990s. The achievement of both poultry and pig industries in meeting more than the domestic demand for poultry and pig products is driven principally by the efficient assembly of the two major inputs: grow-out animals and feed, both of which are available locally and competitively priced. Unfortunately, the ruminant industries lack these important inputs of breeding and feeder stock and feed in sufficient quantity and at reasonable cost for efficient production of beef, mutton and milk.

In 2008, the Malaysian livestock industry had an ex-farm value of RM9.84 billions. Poultry meat took a major slice of the total national output of livestock produce, generating 54 percent of the total ex-farm value. Poultry eggs and pork contributed 20 and 19 percent, respectively, of the total farm output (Figure 3.6). Beef, mutton and milk had a total share of less than 8 percent of the total national livestock output.

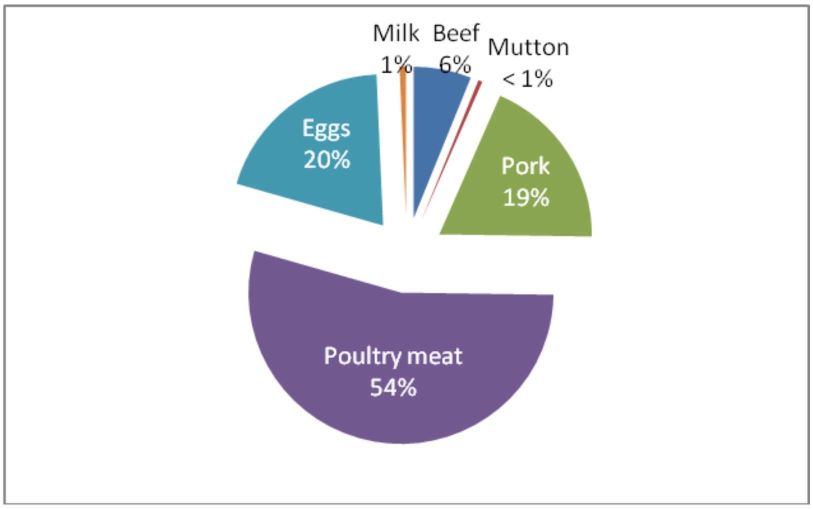


Figure 3.6: Ex-farm Value of Livestock Produce in Malaysia - 2008
Source: DVS (2010)

The importance of the broiler chicken industry is reflected in its significant contribution to the Malaysian livestock economy – exceeding RM 4 billion in total ex-farm value since 2004 (Table 3.11). The egg industry is another major contributor to the national economy with an ex-farm value of RM 1.5 billion in 2004 and increased to RM 2.09 billion in 2008. In spite of being confronted with a major outbreak of Japanese Encephalitis virus in 1998 the pork industry has rebounded and continued to be a significant contributor to the national livestock output registering an ex-farm value of RM 1.73 billion in 2008 .

Table 3.10: Ex-farm Value of Livestock Produce in Malaysia: 2004 – 2008 (RM million)

Commodities	2004	2005	2006	2007	2008
Beef	464.59	535.41	580.74	637.04	696.67
Mutton	33.51	37.06	40.61	50.46	55.52
Pork	1,424.80	1,701.91	1,836.68	1,371.52	1,728.64
Poultry meat	4,135.06	4,369.38	4,616.15	4,904.16	5,183.12
Eggs	1,512.58	1,544.60	1,621.36	1,968.27	2,091.65
Milk	52.79	52.96	61.62	79.12	87.55
Total	7,623.33	8,241.32	8,757.16	9,010.57	9,843.15

Source: DVS (2010)

During the period 2000 to 2008 the two livestock sub-sectors shown very encouraging growth were beef and mutton with respective annual growth rate of 24.4 and 29.1 percent. The beef industry saw initiatives carried out by the government and government-linked agencies to further increase the cattle population in the country through importation of breeder cows of several breeds. Revived interest and big investment by the private sector have lifted the goat industry to register strong growth in the last several years. The dairy industry has showed a steady growth too of 13.2 percent due to investment by the private sector.

The broiler and egg industries have maintained a steady growth above 8 percent annually during the period 2000 to 2008. Both of these industries have attained maximum capacity in meeting domestic demand and future growth would depend on the expansion of the export markets for chilled and frozen chickens or processed products. The pork industry registered a reasonable growth rate of 5.9 percent in the last ten years ending 2008.

The self-sufficiency levels for livestock commodities in Malaysia mirrors the contribution of each of the commodities to the total ex-farm value of livestock produce (Figure 3.7). The major contributors to the total ex-farm value of livestock produce were poultry meat, eggs and pork and their self-sufficiency levels have far exceeded domestic demand for such commodities since the 1990s. However, the self-sufficiency levels for beef have remained below 30 percent and mutton and milk below 8 and 5 percent, respectively. Much of the domestic demand for beef, mutton and milk are being met through imports. In 2007, Malaysia imported RM735.06 million worth of beef, RM2, 792.09 million of milk and dairy products and RM159.95 million of mutton.

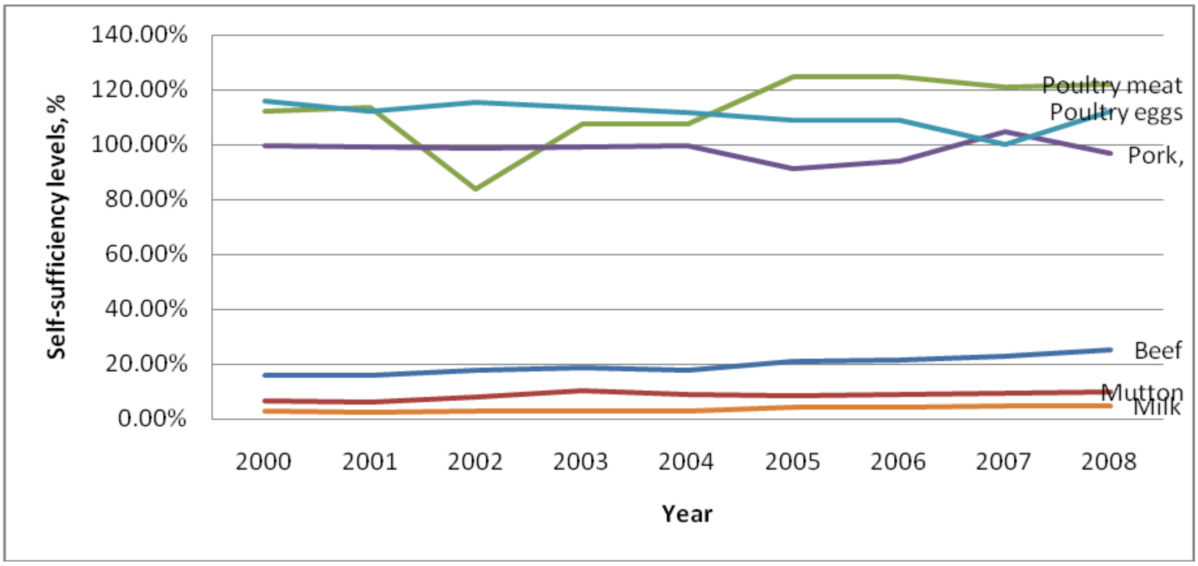


Figure 3.7: Self-sufficiency Levels of Major Livestock Commodities in Malaysia
Source: DVS (2010)

Poultry meat, being an important animal protein source, has enjoyed a healthy trend in consumption with 34.38 kg of chicken meat consumed per capita in 2008 (Figure 3.8). Similarly poultry eggs indicate a growing consumption pattern with per capita consumption of 280 eggs (Figure 3.9). In 2008 milk and dairy products were consumed on average of 41.46 litres per capita. The total per capita consumption of beef and mutton was around 6.1 kg, among the lowest in the advanced developing countries. However, totals meat consumption per capita for Malaysia of 47.79 kg for 2008 was still higher than the average of 17.2 kg for developing countries but lower than the total meat consumption per capita of 88 kg for the industrialized countries.

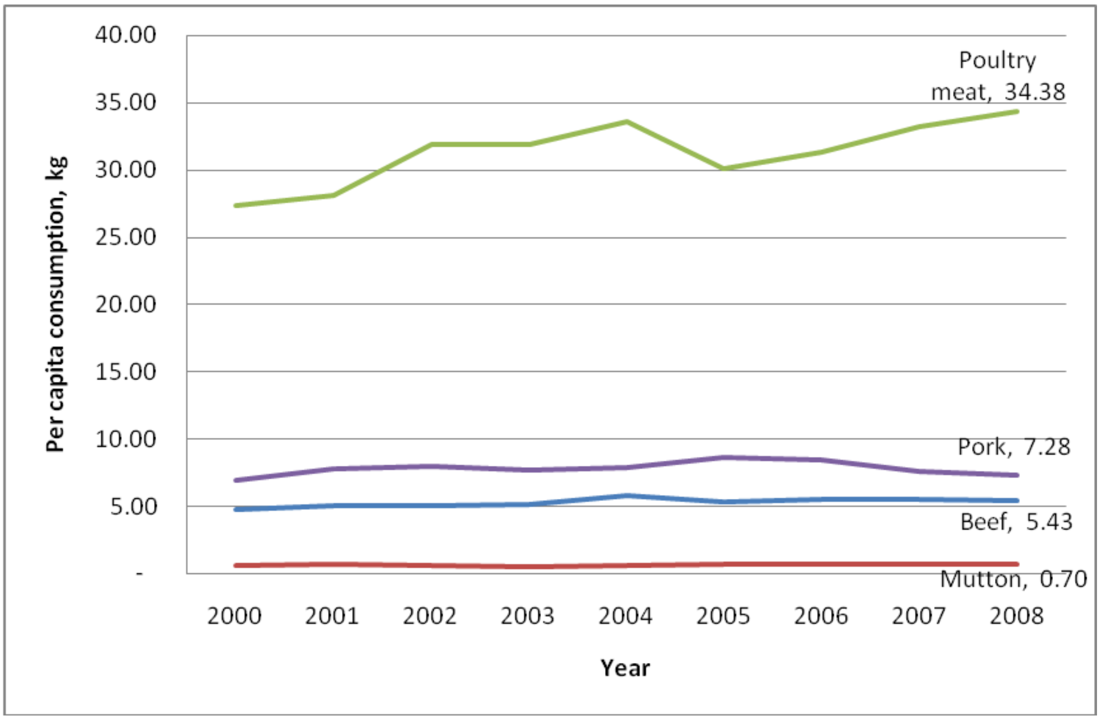


Figure 3.8: Per Capita Consumption of Livestock Products
Source: DVS (2010)

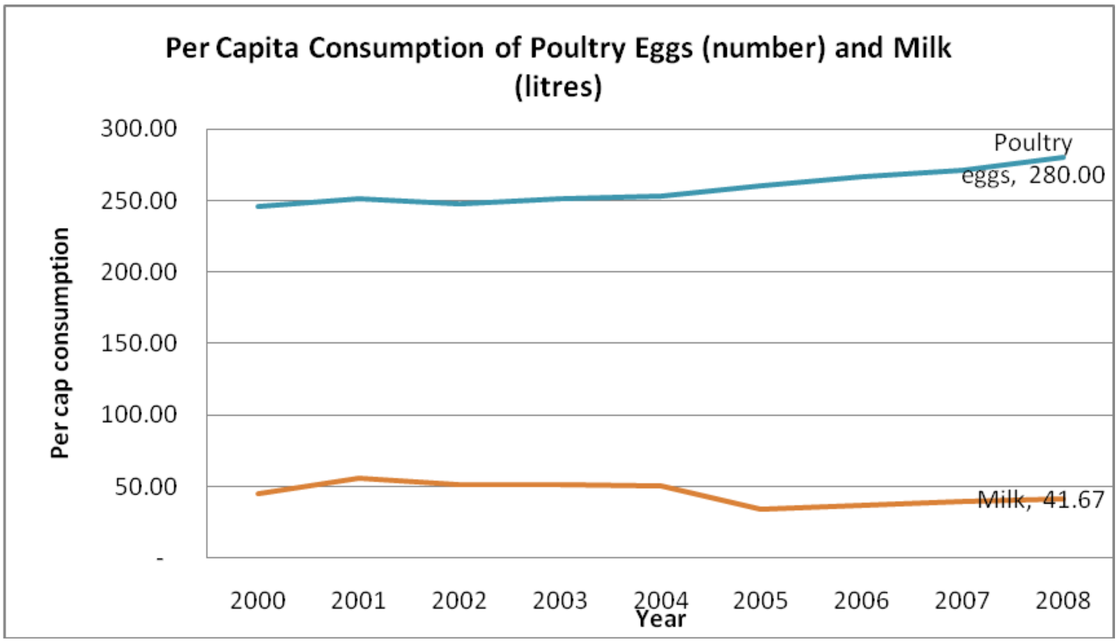


Figure 3.9: Per Capita Consumption of Poultry Eggs (number) and Milk (litres)
Source: DVS (2010)

In many countries of the South, the consumption of meat, milk and eggs is closely linked to the income level of the general populace. After decades of tremendous economic growth, though punctuated by major economic crises of 1987-1988 and 2008-2009, many Asian countries have seen improvement in the income levels of their populace. Although the consumption pattern for meat, milk and eggs varies from country to country, there is a clear indication of increasing consumption with rising incomes. This is exemplified by the rising consumption of chicken meat in most countries of Asia.

China has averaged 6.7 percent of economic growth annually for the past decade. With it the per capita consumption of animal products has increased. However, various government policies and initiatives have provided a domestic production environment that produces enough for domestic consumption without the need to import. Promotion in the use of straw in beef production has allowed the cattle population to increase to 125 million heads since 1980. China is second only to USA as the largest producer of beef in the world.

Global meat production has increased fivefold since 1950. Total meat supply in developing countries has tripled from 47 million tons in 1980 to 258 million tons in 2004. Rapid increase in meat production has accompanied strong economic growth in these countries, with China accounting for 57 percent of the increase in meat supply. Milk supply has also been on the increase in the developing countries registering 122 percent expansion between 1980 to 2002, with 40 percent of the increase, has come from India.

India remains as the world's leader in milk production with an annual production exceeding 80 million tonnes. Some 75,000 dairy cooperatives with over 10 million members contributed much of the milk volume produced in the country. Although milk yield per cow is low, opportunities abound to increase productivity through improvement in dairy genetics and feeding management.

As reiterated earlier the consumption of milk, meat and eggs in the developing countries is closely linked with income. More effluent consumers would move away from cereals to a richer diet that includes increased amounts of animal products, fruits and vegetables. This is in contrast with the trend in the developed countries where consumption of animal products is stagnating. Consumers there worry about the health risks of increased intake of red meat, animal fats and eggs. The link between higher consumption of animal products with raising levels of cardio-vascular diseases and cancers has also curtailed the consumption of animal products in the developed economies.

Countries with traditional herding occupation (Somalia, Ethiopia) have high meat consumption compared to Middle Eastern countries. Meat consumption is below average in India but above average in China. Japan and Scandinavian countries consume less meat but fish consumption is high. France, Germany and the USA have traditionally high meat consumption.

FAO projects the world aggregate demand for meat to grow at 1.7 percent per annum in the period to 2030, declining from 2.9 percent in the preceding 30 years. The reduction is expected to be more drastic in the developing countries as the aggregate demand for meat is reduced from 5.3 to 2.4 percent. Except for the traditional meat producing countries of Brazil, Argentina and Uruguay and the emerging economy of China, the trend in per capita consumption of meat in most developing countries is at a middling level around 17.2 kg.

Poultry meat has been the preferred meat of choice in many of these countries. The economic prospects of most African countries suggest that little growth in per capita meat consumption is likely. In industrial countries the average per capita consumption of meat of 88 kg is likely to be maintained, thus reaching a near-saturation level of overall food consumption and meat consumption has modest scope for further increase.

Indonesia's beef production has been on an upward trend over the past decade. Between the period 1993 to 2000 beef production share to total meat output was 20.7 to 27.9 percent compared to 58 percent for poultry meat. The beef industry relies heavily on cattle imports from Australia to meet the demand of beef cattle feedlot operators. Although faced with the economic set-back in 1997 when cattle imports reduced to low level, the beef industry has rebounded and is expected to expand.

Beef has been an important commodity in the exports of Australia and its two primary markets are the USA and Japan. The market for beef imports from Australia in the USA is limited by import quota, and health issue has been a persistent non-tariff barrier exercised by the Japanese market. Therefore, Australia has been looking into other markets for its beef and cattle. Its two traditional markets for live cattle are Philippines and Indonesia where smallholder production still accounts for a greater share of beef production. The expansion prospects of the beef industry in these two countries are severely constrained by low productivity of the breeding herds and inadequate supply of feed resources of moderate to high quality.

While the populations of chickens and pigs have remained high to attain current level of productivity, the cattle and goat populations have experienced modest growth in Malaysia (Figure 3.10). The cattle population has seen an upward trend since 2005 with 20 percent increase in cattle number over 2000. In 2006 there were 794,510 heads of cattle, with 49 percent of the cattle distributed in the states of Kelantan, Terengganu and Pahang. Buffalo and sheep have seen a declining trend in population - due to the lesser emphasis accorded to these two indigenous genetic resources. Lacking in low maintenance grazing areas and low supply of competitively priced feedstuffs are often quoted as the two major impediments to the expansion of ruminant population in this country.

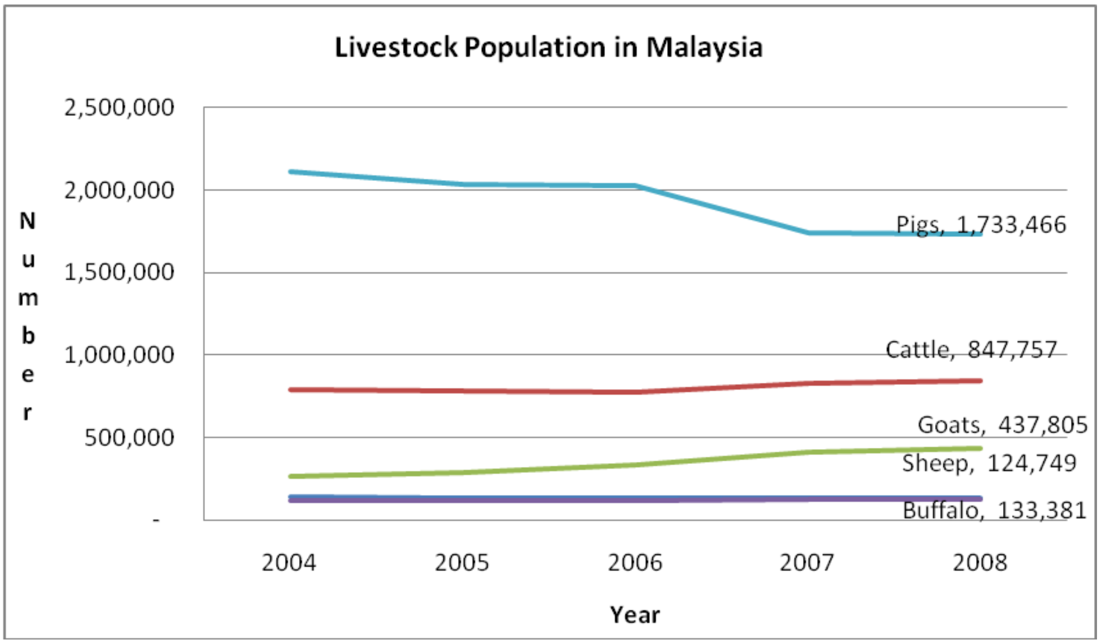


Figure 3.10: Livestock Population in Malaysia
Source: DVS (2007, 2010)

The trend in increasing consumption of beef, mutton and dairy products in this country has not been matched by domestic supply. For example, self sufficiency level for beef has declined from 40 percent in 1975 to 25 percent in 2007. Although there are a number of initiatives by both public sector agencies and private enterprises which were planned and implemented to further develop the ruminant industry in the last few years, their contribution to domestic output would only be realized in the middle term. Among these initiatives are large importations of cattle breeding stock from Indonesia and Myanmar and setting up of a National Beef Feedlot Centre in Gemas, Negeri Sembilan and a National Beef Cattle Breeding Centre in Muadzam Shah, Pahang under the ECER initiative.

Several factors have been cited as the probable constraints to the low output of local ruminant animals - among them are a paucity of suitable grazing land to maintain a large population of breeding beef cows and does, inadequate supply of feedstuffs of high nutritive value and absence of an efficient marketing system in the value chain from production inputs to final produce. Their un-doings would require a new thinking in ruminant production in this country. Taking cue from the poultry industry, the ruminant industry has to facilitate the ready supply of breeding and production stock, ensure the supply of reasonably priced feed and set up an efficient marketing network.

Supply of quality feeds is crucial to the profitability of an animal production business. While the cow-calf operators could rely on the undergrowths under the tree crops as feeds to maintain the cow population, the feedlot operators and dairy producers have to depend much on palm kernel cake (PKC), a by-product of the palm kernel oil extraction process, and other agro-industrial by-products and fodder crops to grow and produce meat and milk from their cattle. In 2007, the production of palm kernel cake in the country amounted to 2.38 million tonnes. Being a high source of protein in cattle feed, 86 percent of the PKC produced in 2007 was exported to European Union countries, South Korea and Australia: 64 percent were exported to EU, 11.2 percent to South Korea and 10.8 percent to Australia. Export value of PKC was RM762 million for 2007. The price of PKC is very much tied to the price of crude palm oil which has remained at high levels in the past several years. There is a real need to explore alternative feeds for the ruminant industry in order to ensure its sustainability in this country. Local by-products from the palm oil, rice and sago industries offer vast opportunities for the industrial feed manufacturing sector together with the application of appropriate technologies in improving their nutritive values and feed intake efficiency.

The integrated production system (Figure 3.11) combining the business of oil palm with cattle is an example of a production system that efficiently uses the available resources. Malaysia is the second largest producer of palm oil, after Indonesia. In 2007 the area under oil palm covers 4.3 million ha - an increase of 3.4 percent over 2006. Sabah makes up 30 percent of the total area cultivated with oil palm. Close to 2.0 million ha of the land under oil palm are suitable for beef production using the integrated system. Innovations along the value chain are very much needed to increase the efficiency of the integrated system, especially in ensuring the efficiency of resource use and increasing efficiency in feed conversion.

The poultry industry has seen very active participation by the private sector. Currently ten companies with their core business in production and retailing of poultry products are listed on the Kuala Lumpur Bourse. Many of these companies act as integrators supplying grow-out chicks, feeds and veterinary and transportation services to contract farmers. The establishment of breeder farms to produce parent stock and presence of an efficient feed milling industry have enabled the poultry industry to expand beyond domestic self-sufficiency .

Figure 3.11: Livestock Integration with oil palm farm

Thailand has prospered in the poultry sector by adopting technologies of evaporative cooling housing and contract farming . This has led the poultry sector to become more industrialized and vertically integrated. The processing of poultry meat into numerous food products is an important component of the poultry industry there. In 2008, Thailand earned RM 3 billion from its exports of frozen chicken products. However, the outbreak of highly pathogenic avian influenza in recent years has adversely affected exports of poultry products from Thailand with import bans by many countries.

The large increase in demand for animal products has largely been met by intensive production systems, especially in poultry. Intensive or industrial livestock production, also known as factory farming, is fast getting acceptance among livestock producers (FAO, 2009). Industrial livestock farming facilitates the integration of many facets of the production process, production of uniform finished products, ease of use of modern technologies, risk sharing between integrators and contract farms. Globally, 74 percent of poultry products, 50 percent of all pork, 43 percent of beef and 68 percent of eggs are produced in industrial systems.

ii) Science, Technology and Innovation Contribution

Unlike the green revolution happening in many parts of Asia as triggered by the introduction of new improved varieties of rice, the livestock sector in Malaysia has seen unequal development with the poultry and pig industries making much headway in meeting market demands but less can be said with cattle, buffalo, goats and sheep raised for their meat and milk.

Increased exposure to inevitable globalization and the realm of new supply chains have necessitated livestock producers to continuously innovate to remain competitive in order to be able to meet the ever changing market demands. A paradigm shift is warranted to not only concentrate the R&D efforts on increasing yield or productivity but be concerned about reducing the usage of water and energy and risk of transmitting zoonotic diseases, improving product quality and ensuring that the environment remains clean. New biotechnological sciences and genomics are available to assist the producers’ entry into market-driven supply chain of agricultural produce.

It must be realized that the purview of churning out technological innovations in food animal agriculture does not lie solely with the government (national research institutes, public universities) alone; the contribution of the private organizations and access to global repository of technical information are necessary complement to the national effort to transform animal agriculture into a more vibrant and modern high-income industry. Private sector spending on R&D in the food animal sector has been small and direct importation of foreign technology is a much preferred route in the adoption of modern livestock technology. The non-ruminant sector (poultry and pigs) has adopted well many of the modern technologies: much improved breeds of broiler and layer chickens and pigs, maize-soybean diets, close house system and further processing of chicken meat. Owing to these efforts the poultry and pig industries have progressed tremendously – meeting the domestic requirement and expanding into the export markets.

Productivity of food animals is determined by the genetic make-up of the animal breeds, the environmental management and possibly the interaction between the influence of the genetic and environmental factors. Many strides in livestock improvement in the past have shown that the goodness of breeds of animals developed in temperate countries has not adopted well when similar breeds of animals were relocated in countries within the tropical belt. Many attempts in the recent past to produce animal breeds best suited to the sub-tropical and tropical regions have resulted in varied success. It is often taken as a fallacy that a good breed is all it takes to produce the desired commodity. The emphasis on non-genetic factors such as nutrition, health and management of the animal is equally important in achieving high productivity in livestock production.

Past research in improving the efficiency of feed conversion in livestock species has led to a significant reduction in the amount of feed required to produce a kilogram of meat. Improvement in the nutrition of the animals as well as their genetics has allowed such a progress. Non-ruminant species are efficient convertors of feed to meat with a feed conversion ratio (FCR) of less than 1.8 for chicken and 3.0 for pigs. However, ruminants such as beef cattle and goats have FCR above 6.50 due to their diets containing more indigestible carbohydrates. In broiler poultry production the time taken to produce birds to market has greatly reduced to a current practice of less than 42 days for a 1.6 to 2.0-kg bird .

Feeds constitute more than 70 percent of the current cost of animal protein production from cattle, goats, poultry and pigs. Sources of energy and protein for optimum growth and production mainly come from imported materials such as maize and soy bean meal for the poultry and pig sub-sectors. The feeding regime for commercial broiler and layer chickens raised in this country is similar to that of the temperate climes, with an adjustment to cater for a slightly greater requirement for animals located in the hot environment in combating heat loss. R&D efforts must target to explore new sources of energy and protein feeds for both the non-ruminant and ruminant sub-sectors. Cereals such as rice, sorghum and millet, tubers such as sweet potatoes and yams and vegetable oil based feeds could further be examined for livestock feeding.

Much of the milk produced in many developed countries come from Holstein-Friesian breed of dairy cattle. Many developing countries in the South have followed a similar path in their dairy development with varying success. Crossbreeding research incorporating both the Holstein-Friesian or Jersey and the local indicus cattle has generated new breed composites such as Friesian-Sahiwal and Friesian-Zebu which produce higher volume of milk than the local purebred Zebu or indicus cattle. However no on-going herd replacement programmes for these breed composites are institutionalised so as to ensure the continuous improvement of the composites and ready supply of breeding stock.

iii) Domestic Germplasms

Many indigenous breeds of livestock are in danger of genetic erosion as the industry concentrates on improved breeds for maximising yield and performance. Kedah-Kelantan cattle, Katjang goats, Swamp buffalo and Kampong chickens are examples of indigenous breeds of livestock which have acquired sufficient level of resistance to ecto- and endo-parasites but they are still underexploited as meat-producing animals. These breeds are likely to be more cost effective in producing animal proteins in a sustainable production system. Although many of them lack an economic level of productivity, further R&D efforts are much needed to improve these species using modern genetic and biotechnological tools and recommend a better feeding system for the multiplication and growing-out of animals of these breeds. Besides many wildlife species such as gaur or seladang (*Bos gaurus*), Red Jungle fowl (*Gallus gallus*) and sambar deer (*Cervus unicolor*) remain unexploited as animal protein resources.

Indonesia has about 3 to 5 million Bali cattle and 600,000 of them are found in Bali Island. Although adapted to the ecological and socio-economic environment of Indonesia, Bali cattle are still underexploited as meat producing ruminants. Opportunities abound to create many Bali cattle populations in this country through initial importation of breeder cows and stud bulls and extensive use of AI programme using imported frozen semen. R&D efforts need to strengthen the national capability to enhance and improve on the use of advanced reproductive biotechnologies such as cloning and semen and embryo sexing and capitalize on genomics to create domestic breeds of cattle and goats better suited to the local climatic and feeding situation.

iv) R&D investment

In 2006 the percentage of gross expenditure in research (GERD) to GDP was 0.64 percent against a target of 1.5 percent in the Ninth Malaysia Plan (2006 to 2010) as shown in Figure 3.12. In the preceding 10 years Malaysia has improved steadily from RM 549.2 million in 1996 to RM 3.6 billion in 2006 in R&D investment. The private sector accounted for 84.9 percent of GERD spent with the remaining proportion of 15.1 percent due to public sector involvement. Of the percentage spent by the public sector on GERD, government agencies and research institutes and institutions of higher learning took up 5.6 and 9.9 percent, respectively, of the GERD spent.

In general 45.1 percent of GERD was allotted to Applied Research followed by Experimental Development Research (43.6 percent) and Basic Research (11.3 percent) as shown in Figure 3.12. Agricultural Sciences received 4.6 percent of GERD – the lowest among the six fields of research with the biggest recipient of GERD been Applied Sciences and Technologies (34.7 percent), Engineering Sciences (32.2 percent), Material Sciences (10.0 percent) and Information, Computer and Communication Technologies (5.7 percent). Although the public sector spent 13.3 percent of GERD allotted on Agricultural Sciences as compared to 3.1 percent by the private sector, the amount of GERD was higher (RM94.5 million) in the private sector compared to the public sector (RM73.1 million).

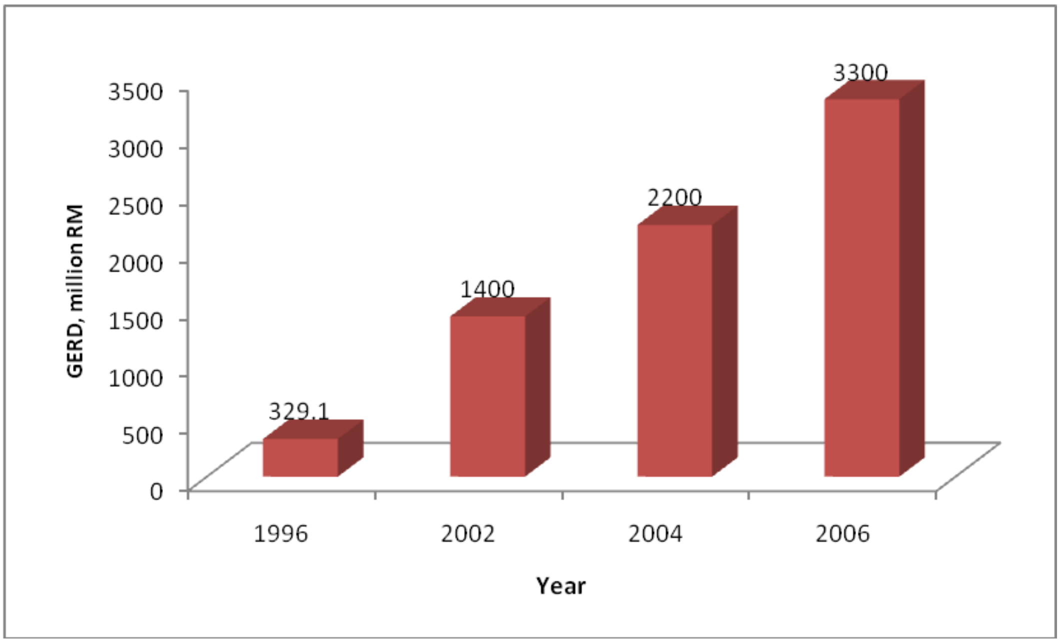


Figure 3.12: Malaysia's Gross Expenditure on R&D (GERD)
Source: MOSTI (2008)

Research in the field of agriculture has been the realm of government agencies and research institutes established to conduct research dedicated to major food and non-food commodities. Of the 36.8 percent of GERD allotted to Agricultural Sciences, Animal Production and Animal Primary Products took up only 8.2 percent of the allocation (Table 3.10).

Table 3.11: Top five Fields of Research (FOR) of General Expenditure on Research and Development (GERD) by Government Agencies and Research Institutes (GRIs), Institutions of Higher Learning (IHLs) and private sector in 2006

GRIs		IHLs		Private sector	
FOR	**Percent GERD**	**FOR**	**Percent GERD**	**FOR**	**Percent GERD**
Agricultural sciences	36.8	**Medical and health sciences**	12.9	**Applied sciences and technologies**	39.5
Forestry sciences	9.3	**Engineering sciences**	12.8	**Engineering sciences**	36.0
Material sciences	7.7	**Applied sciences and technologies**	10.2	**Material sciences**	10.5
Engineering sciences	7.6	**Social sciences**	9.1	**ICT***	5.5
Biotechnology	7.0	**Chemical sciences**	8.0	**Agricultural sciences**	3.0

v) Future Trend in Livestock Industry

Forecasting what the future scenario for the livestock industry will be prospective in nature and leads to presenting a number of different scenarios (USM, 2010). For the purpose of this report, a foresight analysis was used and two possible scenarios among many likely scenarios were selected. The first scenario maintains the current development strategy of being self-sufficient in poultry meat and eggs and pork and increasing organically the sufficiency level of beef, mutton and milk. The second scenario ventures into a future environment where self-sufficiency in poultry meat and egg is maintained, the national production capacity for beef, mutton, milk and pork is capped at a reasonable level dictated by limiting input supply and the shortfall in the supply of beef, mutton and milk will be strategically sourced from outside the country. Attendant to the identification of these future scenarios are the probable questions on what are needed in terms of short-term and long-term strategies necessary for such a scenario. Both the government and the private sector are mandated to participate actively to make Malaysia economically sufficient in her food supply to ensure some acceptable level of food security while adhering closely to a sound environmental management of her natural resources. Opportunities for non-commersial animal for food and recreation should be explored.

Imrpoved genetics and nutrition in improving production efficiency in broiler chickens

The role of commercial breeder companies in providing the most efficient breeds of chickens is well recognized in the development of the Malaysian poultry industry. Breeder stock of broiler and layer chickens of Arbor Acres, Ross and Hubbards brands have been transferred from the breeder farms in the North to countries in the developing world in the South. Though these breeds were selected in the temperate environment, the use of modern close-houses with better ventilation and cooling has reduced the interaction effect between breeds and the environment. Furthermore diets based on maize-soy bean mixture are easily supplied with a ready supply of these feedstuffs – although the supply of maize and soy bean are highly critical of the fluctuation in their prices in the world market. Much progress has also been chalked in breeding improved breeds of broiler chicken. In 1945 it took 12 weeks to produce a 2.0 kg broiler chicken as compared to 6.5 weeks in 1995.

3.4.v.1 Poultry

The poultry sector is an important component of Malaysian agriculture today and will continue to be in the future. Compared to other livestock commodities the poultry sector has grown rapidly in consumption and trade. Demand driven by economy of scale, global access to better poultry genetic materials and availability of high-energy and high-protein maize-soy bean diets has evolved the poultry sector into an efficient and highly industrialized system (Figure 3.13) that spans the whole width of value chains from farm to plate in many countries, including Malaysia (ACCCIM, 2006) . The production of poultry meat and eggs is highly industrialized with many integrators involved. These integrators import highly improved breeding stock and supply day-old chicks. This trend is in tandem with the development of the poultry industry in Thailand where nearly 90 percent of the poultry producers are linked to integrators.

In many countries poultry meat and eggs have enjoyed buoyant growth in the past several decades. Among the factors that have assisted the rapid growth of the poultry sector are the greater biological efficiency of current breeds of poultry, economies of scale that justifies big capital expenditure, vertical integration which allows the use of more efficient biotechnologies, assurance of high quality inputs, specialization in the production of specific products and concentration of production closer to feed supply and markets. Around Asia the annual production growth rate has exceeded 6 percent which allows poultry meat to remain competitive by being the cheapest source of animal protein compared to beef and mutton.

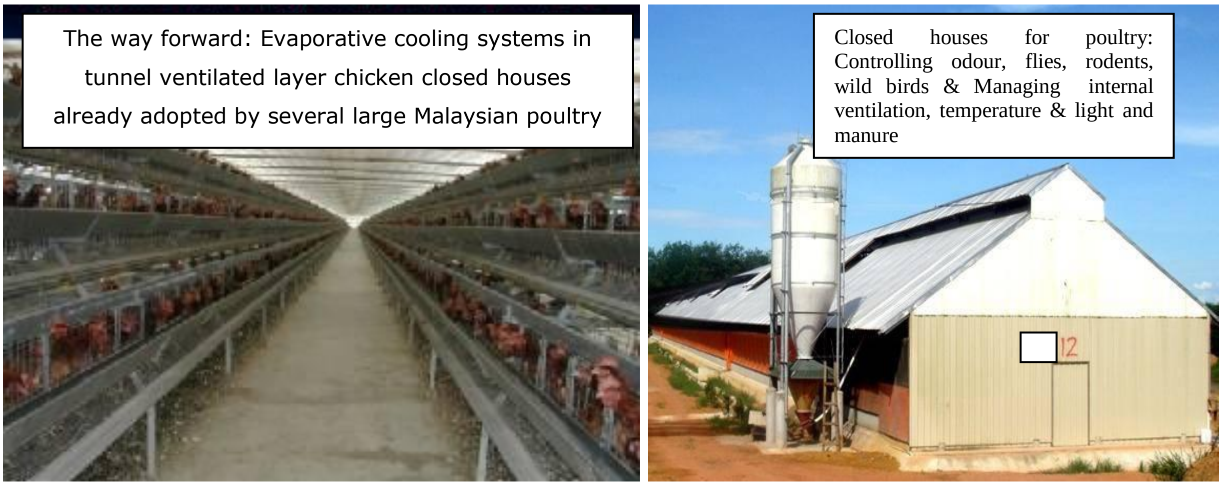


Figure 3.13: Closed houses for poultry

A Malaysian poultry industry board should be set-up to represent the interest of producers, breeders and processors. Many issues on use of antibiotics and other drugs, product safety, Halal slaughtering, processed products and animal welfare could be addressed by the poultry board so as to enlighten consumers on how poultry meat and eggs are being produced and communicate with the government on issues affecting the industry. In an industrialized poultry industry receptive to technologies from many parts of the world, R&D efforts should be geared toward tropical animal health, product safety, products' quality and product convenience. The processing of poultry meat into processed food items provides scope for expansion of the poultry sector. Together with a certified Halal scheme and product safety quality assurance system processed poultry products could enter many markets in many regions of the world.

The poultry sector faces many challenges including the highly pathogenic avian influenza, water shortages, rising feed cost, rising animal welfare concerns and competition for maize for biodiesel production. To contain highly pathogenic avian influenza and reduce its impact on the poultry industry, it is suggested that greater division and differentiation among the production systems and value chains. There is a movement towards compartmentalization in which the whole or part of the value chain is managed separately to have a different health status with its own set of biosecurity practices in place. Here traceability is important so that a built-in tracking system will allow the identification of source from where a particular breach of protocols has been compromised.

Swine

The swine sector in Malaysia is faced with many challenges that may enlighten it to embark on new strategies to stay profiTable and remain eco-friendly. The surplus production of pork over domestic demand has been achieved at the expense of a cleaner environment and a higher standard of farm hygiene which gives rise to potential risks of newly emerging diseases. The designated pig farming areas planned to be established in several states have yet to be operational fully, despite concerted awareness campaigns by DVS of its safety and non-polluting characteristics. A new version of an improved pig management plan known as modern pig farming has been suggested. The management of pig farms needs to undergo further upgrading especially in the aspects of waste handling and animal welfare.

Aware that the current production of pork entails many shortcomings in environmental management, it is wise that Malaysia concentrates on producing less than 60 percent of current demand of pork for the Malaysian market. The balance of 40 percent would have to be sourced strategically from abroad or imported from within the common economic union of ASEAN.

The establishment of specialized farms as envisaged in the modern pig farming plan should halve the number of pig farms in the country. Fewer farms are producing more pigs, as in New Zealand where herds of over 1,000 head of pigs now account for 56 percent of total pig population (Ministry of Agriculture New Zealand, 2010). An industry board specially devoted to the pig sector should be established to promote the pig sector on many issues of interest to the general public, assist in upgrading the marketing system and expansion of markets, fund R&D programmes on animal welfare and waste management, institutionalize quality assurance schemes and advise the government on issues affecting the stakeholders in the pig industry (ACCCIM, 2006).

3.4.v.2 Beef and Mutton

Considering the limitation in input resources, namely feedstuffs and breeding stock, and gearing towards an efficient beef and mutton production in this country it is prudent that the sufficiency level for beef and mutton be capped at less than 40 percent. The integrated cattle

– oil palm production system is recommended for the cow-calf production phase of beef production and the intensive feeding system for the growing-fattening phase to produce cattle ready for slaughter.

Lacking in natural grasslands as found in many beef producing countries such as the USA, Argentina and Australia, the Malaysian beef sector has to rely on the vast oil palm area as the production area to produce beef for the country. Oil palm crop covers an area of 4.5 million ha in Malaysia. Using less than 50 percent of the total area under oil palm to stock breeding populations of beef cattle is a viable and sustainable approach to beef production. It is envisaged that beef production, specifically the breeding component, will continue to be concentrated in the oil palm plantation, especially in those oil palm holdings owned by smallholders or managed by government agencies and state farmers' associations. The growing and fattening phase of beef production will be more intensified in feedlots located closer to the source of feed stuffs. There is still controversy about damage to oil palm due to complaian and other issues that needs to be resolved. Waste management of animal manure is a primary consideration in the management of intensive beef production system and technologies are very much needed to assure animal manure are contributing less to green house gas emissions and deterioration of water and environmental quality.

The beef industry needs a common platform for producers, breeders, feed suppliers and processors connected with the beef industry to champion their cause. A beef industry board that promotes, educates and markets the interest and products of the industry is worth considering to further develop the beef sector. Producers and consumers need to be exposed to modern technologies to improve the efficiency of production and enhance product value for safety and quality.

Strategic sourcing for beef to meet domestic demand should focus on producing more than half of our beef requirement from Australia and the neighbouring countries, either through imports of live cattle for slaughter and fattening or owning farms in those countries (DVS, 2010). Frozen buffalo meat from India would still provide us with a choice of cheaper beef.

Mutton production from goats is still to be derived from the breeding and growing of local Katjang/Kacang goats and crosses as well as offspring of imported Boer and Jamnapari goats.

Initial high capital expenditure on purchase of breeding stock of Boer and Jamnapari does would have been recovered when kids are produced, fattened and marketed as slaughter animals when many of these goat farms attained production maturity in the next several years. Current semi-intensive production system of goats will further be improved with better feeding and improved genetic materials. Reproductive biotechnologies such as embryo transfer, semen and embryo sexing and marker assisted selection will become routine procedures in future management of goats in this country. Goats could also act as bioreactors for the production of specific pharmaceuticals through the use of molecular genetic methodologies.

To promote the industry a goat industry board is suggested to be set up in line with the other livestock sectors. As there are many private investors in the goat industry, a goat industry board would band those involved in the goat industry and act in unison to further promote the causes of the industry to the government and the general public.

Swamp buffaloes are valuable animal genetic resource often neglected in favour of cattle. Specialized production areas suited to the natural behaviour of swamp buffaloes could provide with another source of beef. Research to identify new buffalo beef production system utilizing local feed resources could be included in future research areas for animal production.

Dairy cattle improvement through genetic and management tools

Many countries have attempted through crossbreeding to produce dairy cattle synthetic breeds such as Friesian-Sahiwal and Australian Milking Zebus as a development strategy in dairy development. The alternative route of selecting within an existing population of indigenous dairy cattle such as the Sahiwal, Tharparker, Cholistani and Local Indian Dairy is rarely chosen due to its demand for a long term strategy of 4 to 5 generations in order to realize any meaningful benefit. Another approach is to import purebred Holstein-Friesians and Jerseys and raised them under the local environment. While genetic – environment interaction has been observed to be important, purebred Holstein-Friesian and Jersey cattle could perform reasonably well in the tropics with milk yield above 5,000 litres per lactation if efforts were extended to ensure optimum feeding and proper environmental management are

3.4.v.3 Dairy

The rapid holsteinization of the dairy cattle industry globally means that it is easier for the dairy producers to raise Holstein cattle for milk than any other breeds because of the ready supply of breeding and replacement stock, semen and embryos available from many breeding centres located in many countries. Besides Holstein breed, Jersey is another viable option in breed choice for milk production. Many attempts at producing composite breeds involving the crossing of Holstein or Jersey with the local Zebu cattle have resulted in mediocre performance of the resultant composites and suffer from inadequate supply of replacement stock, discontinuous selection programme and variable quality of replacement stock. The solution to arrive at an adaptable dairy cattle breed is to explore the possibility of creating a tropicalised Holstein and Jersey breed as has been attempted in Thailand. Following the adoption of evaporative cooling system in close houses in the poultry sector, a dairy cattle production system could further be intensified when Holstein or Jersey cattle are reared in these climate-controlled barns.

Of utmost importance is to find ways to produce adequate supply of high quality fodder and feed concentrates for dairy cattle as well as for other ruminant species. Technologies in the conservation of forages are needed to provide a year-round feed supply. Livestock feed companies could undertake to produce and market fodder based feeds to cattle and goat farms. Constraints by shortage of supply of tropicalized Holstein dairy cattle and high quality feeds it si prudent that the target for milk production in this country be capped at less than 20% of the current demand for milk and milk products.

The adoption of intensive dairy production system in many developing countries has given rise to the excess animal waste being produced and warrants a better management of animal waste so that it is a no risk to pollute the environment (Delgado et al., 1999; Farm Foundation, 2006; Dourmud et al., 2008; FAO, 2009). Alternative uses of animal manure, better efficiency in feed utilization and reduced water discharge from dairy farms are among the thrust areas of future dairy cattle research as dairy herds get bigger in size in the coming decades, fewer producers will produce most of the milk for the populace. Smallholder-type dairy producers will continue to be in the industry when they are tied up with the big producers. Dairy cooperatives with members of producers, feed millers and processors when set up would promote more forcefully the interest and concerns of the dairy cattle sector.

3.5 Fishery and Aquaculture

The total sea area (exclusive economic zone, EEZ) surrounding Malaysia is about 126 percent the land area of about 330,000 square kilometres. To enhance wealth creation for the nation the seas will and should play a vital role over the next forty years to 2050. Malaysia with a coastline of 4,780 kilometres is an important fish producing country. In 2009, Malaysia's capture fisheries production ranked 17th globally with a production of about 1.4 million tonnes valued at 5 billion ringgit while the aquaculture production for the same year was 212,000 tonnes, valued at 1.3 billion ringgit ranking 20th globally. Together, capture fisheries and aquaculture account for some 15 percent of the total agriculture gross domestic product of about 40 billion ringgit in 2006. Malaysians are also great seafood consumers. In year 2009, the per capita consumption was 57.7 kg, way above the world's average of 15.8 kg. Malaysia, however, faces many challenges in its management of the fisheries. To meet these challenges of the future, Malaysia will have to make optimum use of all the new technologies and latest tools- and high on the list of these technologies and tools are selective breeding techniques, stock management, pollution control, feed development, data, information, knowledge and knowledge management and development of institutions, policies and technologies for resource management.

Recent and on-going trends in global fish production, consumption and trade reflect several fundamental changes in the structure of the supply of and demand for fish and seafood commodities. Fish is no longer just the subsistence diet of poor, coastal people, although some fisheries items still play this role in many countries. The fisheries sector has emerged as a major part of the economies of many developing countries with one of the highest growth rates of all sectors in those countries. World per capita consumption of seafood increased substantially, reaching an all time high of 15.8 kg in 2009 from about 6 kg in the 1950's. Significant realignment of fisheries production in favour of developing countries, and growing South-North and South-South trade in fisheries commodities has linked distant production centres with diverse markets and changed the structure of supply. The noticeable features of changes in fisheries sector include the following:

The creation of Exclusive Economic Zones (EEZ) and implementation of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) established the fishing rights of coastal states over the larger areas of world fishery resources formerly controlled by developed country fishing vessels.

Availability of new technology has encouraged a significant expansion of fishing effort by developing countries. The share of fishery production by developing countries rose from 20 percent in the 1950s to 60percent in recent years.

Success in fish breeding and fish farming technologies paved the way for aquaculture to become the fastest growing agricultural practice in many developing countries including Malaysia. The supply of certain fish species has shifted from capture to aquaculture. For example, more than 30 percent of salmon and 20 percent of shrimp are currently supplied from farmed sources.

Globalization and expansion of markets has promoted global sourcing of fish purchases by large commercial companies, diversified use of fish, and increased inter-regional trade. Nearly 40 percent of global fish production is traded internationally. Thailand, China, Indonesia and India are world leaders in fishery exports.

Changes in the institutional arrangements and legal instruments governing local, national and international fisheries have had different implications for future management of fisheries resources. Decentralization of management to local authorities, communities and citizens' groups has increased local roles in making decisions about resource management. Various conventions, such as the Convention on the Biological Diversity (CBD), the Convention on International Trade of Endangered Species (CITES), and Conventions on management of shared stocks like Tuna, have provided stronger national rights over living aquatic resources and increased national responsibility.

The response of fishing states to UNCLOS has been very rapid. It saw new ownerships and/or access in most fishing areas by coastal states, rapid expansion of national fishing capacity and application of modern fishing techniques. Opening of markets and growing consumer demand has encouraged harvesting of desirable species with increased use of efficient and specialized techniques. Smaller nations, particularly small island developing states with limited fleet expansion capacity, have made arrangements with foreign fishing vessels to earn an income from their share of the ocean's resources.

Both production and real prices of fish increased over the past three decades. Rapidly increasing aquaculture output (11.8 percent per year during 1984-1996), has helped in the continued growth of fish production, despite stagnation in the capture fisheries. Continued high demand and high prices encourage a greater investment in fishing effort. This however has led to the overexploitation of natural fish stocks and insufficient attention to problem of fish stock depletion

3.6 Agroforestry

The rapid population growth has a direct impact on increasing pressure to clear forests for agricultural purposes, as demand for food, feed and wood increased. For instance, in 1957, Malaysia had a population of about 7.4 million. Its population has since grown rapidly, such that by 2005 the country had some 26.8 million people and, on current estimates, is by 2010 to nearly 29 million (Zainal and Bhattasali 2008). Rapid population growth might have initiated the conflict between agriculture production and forestry development in Malaysia and other developing countries in the tropical belt. In fact, agriculture has contributed to the loss of more than 90 percent of forest cover in the tropics. However, when the total value of the forest is considered in agricultural production, the activity then seems to be more profitable than forestry. Agriculture, therefore, displaces forestry in land use decision making. As a result, large tract of productive natural forest have been replaced with agricultural mono-cropping systems of industrial crops such cacao, oil palm, rubber, and pineapple.

Agroforestry practices encompass an entire spectrum of land use systems in which woody perennials are intentionally combined with agricultural crops and/or animals with spatial or temporal arrangement. Advocates have contended that soil conservation is one of its primary benefits. The presence of woody perennials in agroforestry systems may affect several biophysical and bio-chemical processes that determine the health of the soil substrate. The less disputed of the effects of trees on soil include: amelioration of erosion, primarily through surface litter cover and under story vegetation; maintenance or increase of organic matter and diversity, through continuous degeneration of roots and decomposition of litter; nitrogen fixation; enhancement of physical properties such as soil structure, porosity, and moisture retention due to the extensive root system and the canopy cover; and enhanced efficiency of nutrient use because the-tree-root system can intercept, absorb and recycle nutrients in the soil that would otherwise be lost through leaching.

Recently, the Malaysian Government has allocated US $3.08 billion under the 9th Malaysian Plan (2006-2010) to transform the agriculture sector into a modern, dynamic and competitive sector. The Government aims to increase agricultural production through measures such as new land development, replanting, and land consolidation and rehabilitation. This will be implemented through intensification of land use by introducing integrated agriculture with main emphasis in agroforestry, rehabilitation of marginal land and proper soil and water conservation. Efforts are now also geared toward improving the fertility of the soil by promoting organic and integrated farming practices.

Agroforestry in Malaysian context is unique and slightly different from the definition proposed by ICRAF, as it involves among others, integration of agricultural crops such as rubber, oil palm, fruit trees and short term crops and/or domesticated animals with selected timber and non-timber forest species. Agroforestry in Malaysia has been practiced since time immemorial, although as a scientific discipline it is very recent. In fact, it is a major mode of production of traditional agricultural systems. The classic examples of these traditional agricultural practices include shifting cultivation (slash and burn farming), (Figure 3.14) multi-purpose tree production systems and home gardens.

i) Traditional Agroforestry Practices

These practices have been developed and accumulated over many generations. They are popular with farmers living near or in the forests. In other words, traditional agroforestry systems were developed by local farmers. There are several traditional agroforestry practices which still have been practiced in Malaysia. Shifting cultivation can be considered the oldest practice where food crops and forest species are sequentially arranged in time. Under the most basic forms of agriculture, where land availability allows a relatively low labour strategy to work effectively, shifting cultivators alternate cropping with fallow periods in which tree cover is allowed to regenerate and restore soil fertility. As land pressure increases, forcing a move toward continuous cultivation, various forms of intercropping develop. The cultivation system would only workable under a low population pressure with a long fallow period (cycle). It can cause massive deforestation when the fallow period is shortened, under increase population pressure. Shifting cultivation continues to be the mainstay of traditional land-use systems over very large areas in remote areas in Sabah and Sarawak. Shortening fallow periods and widespread burning to control weeds and pests further contribute to soil degradation. Soils on steep slopes have commonly completely lost their productivity due to soil erosion.

As a solution to shifting cultivation, taungya system had been introduced by D. Brandis, a British forester in 1850s. In Malaysia, this agroforestry system has been employed to establish Pines (*Pinus caribaea*), Meranti (*Shorea* spp.), Yemane (*Gmelina arborea*) and teak (*Tectona grandis*) plantations in Negeri Sembilan, Pahang, Perak and Perlis . Under this system, farmers were temporarily allotted land which they can cultivate with short term cash crops or food crops of their choice for a period of 1-3 years. The farmer cleared the land, grew annual or short-term food crops, and planted tree seedlings between the food crops. As the trees grew larger, the space for food crops became limited, and the farmer was given a new piece of plot to cultivate and establish forest trees.

Multi-purpose tree production system is where forest tree species are regenerated and managed for their ability to produce not only wood, but leaves and/or fruits that are suitable for food and/or medicines. In rural areas, suitable wild tree species are commonly domesticated for both wood and fruits. *Fruit Garden*, a traditional land-use system is found nearby to villages or setlement areas. It often comprises from 3 to 4 main vegetation layers. The upper/top storey includes large and light preferred trees such as durians, keranji, coconuts, mangoes, jackfruits, sentang etc. The middle and lower layers includes fruit trees such as bamboo clumps, mangosteens, starfruits and guava. The bottom layer could include medicinal plants and vegetables.

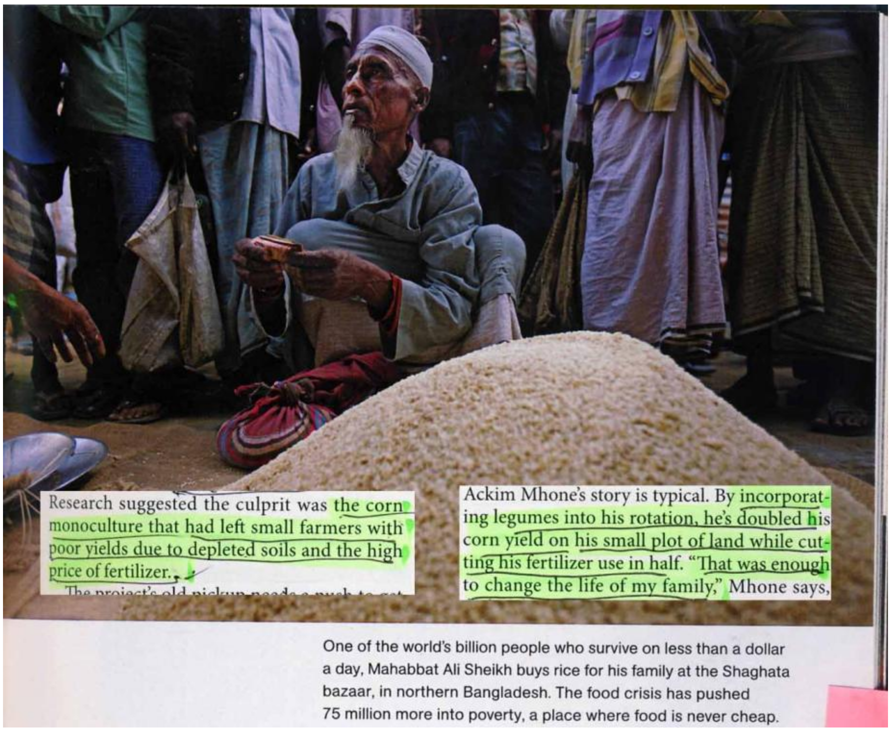


Figure 3.14: Implication to Agriculture

ii) Conventional Agroforestry Practices

The main agroforestry systems being practiced in Malaysia include:

- Agri-silvicultural system
- Silvipastoral system
- Agrosilvipastoral system
- Forest farming
- Community forestry
- Others (linear tree planting, windbreak, buffer strip planting, silvofishery, apiculture, etc.)

The predominance of multispecies systems in lowlands and areas with high agricultural potential at one end of the ecological continuum, and extensive silvopastoral practices at the other end, with various systems located in between, indicates that the ecological potential of a locality is the important factor that determines the distribution and extent of adoption of specific agroforestry systems.

3.6.ii.1 Agrisilviculture

This is an agroforestry system where agronomic crops are combined with woody plants (shrubs/trees) on the same unit of land for greater or better-sustained production of annual crops, fruits and wood. Agrisilviculture is the most common agroforestry system in Malaysia. There are various types of agrisilvicultural options practiced, both in time and space. Intercropping of cash crops with perennial tree crops is commonly practiced to utilize empty space during the immaturity phase of tree crop establishment. The selected short term crops are mostly shade intolerance and planted in the inter row space. As there is no effort made to modify or change the planting design of tree crops, the effective period of intercropping is rather short, prior to canopy closure of the overstorey trees. In tree plantations such as rubber , acacia and teak, cash crops such as bananas, bamboo , chilies, coffee, dry paddy, groundnuts, limau purut , maize, mengkudu (Hasan et al. 2006, Abdul Karim et al 2006), misai kucing, sugarcane , tobacco, sweet potatoes and vegetables are commonly planted in the inter row space during first 2-3 years of establishment. For bamboo plantations, intercropping with suitable crops such as lemon grass and Pandan wangi can improve the cashflow of the agroforestry system., Planting of sugarcane in immature oil pam plantation has been found to give a lucrative return from the harvesting of canes, a gross profit of RM18,209 per hectare.

As the light availability decreases due to canopy closure of overhead trees, the inter row zone is left uncultivated, as not many crops can be grown under low light condition. However, there are shade tolerant plants that can be intercropped after canopy closure. Hashim et al. (2008) reported that *Licuala spinosa*, a dwarf palm species, can be grown successfully in mature rubber plantation for production of shoots. The shoots are used in food wrapping of 'ketupat', a local delicacy served during the Muslim festivals of Aidul Fitri and Aidul Adha. A common medicinal plant known as 'Kacip Fatimah' can also be grown under shady under storey condition of mature oil palm plantations.

If the over storey species are palms such as coconut and oil palm trees, intercropping can be done twice, that is prior to the canopy closure and after the trees have reach a certain height where the light condition becomes favourable to the understorey crops. Species such as cacao, pineapples, Tongkat Ali can be planted under the coconut. Nevertheless, for a longer period of intercropping, planting design of main crops need to be adjusted or modified, creating wide alley between the tree rows. In rubber plantation, hedgerow planting design with wide inter row provides ample space cultivation. However, planting design with a wide alley or corridor space would reduce tree density, and might be suiTable for timber species but not practical for rubber or oil palm.

The contour hedgerows technique is a type of alley farming method being practiced in neighbouring countries (Indonesia, Philippines, Thailand, and Vietnam) for hilly areas (Figure 3.15). In the Philippines it is often known as SALT (Sloping Agricultural Land Technology). Field and permanent crops are grown in 4-5 m bands between contoured rows of nitrogen-fixing trees and shrubs, which are densely planted in double rows to form hedgerows. Examples of hedgerow species are leguminous trees such as Flemingia macrophylla, Desmodium rensonii, Calliandra calothyrsus, Leucaena diversifolia, L. leucocephala, Gliricidia sepium and Sesbania sesban. Other leguminous trees and shrubs can be used, depending on locality and availability. Rows of permanent crops such as coffee, cacao, citrus and banana are dispersed throughout the cultivated area. The alleys not occupied by permanent crops are planted on a rotational basis with short term food crops (e.g. maize, upland rice) or other crops (e.g. sweet potato, melon, pineapple) and legumes (e.g. mungbean, soybean, peanuts). This rotational cropping helps in maintaining soil fertility and provides the farmer with several harvests throughout the year. When a hedge is 1.5 to 2 m tall, it is trimmed and the cut branches are placed in the bands between the alleys, to serve as mulch for conserving moisture and as organic fertilizer. The basic benefits of this alley farming method are: erosion control (Table 1), improvement of soil nutrient availability, weed suppression, and enhanced wood and fodder availability. However, SALT is not a miracle or a panacea as SALT system requires systematic work and discipline. It should be remembered that none of agroforestry systems can bring depleted, degraded and eroded soils back into production in a short period of time.

Figure 3.15: (a) Alley cropping (b) Silvipasture

3.6.ii.2 Silvipastoral

Silvopastoral systems are designed to produce a high-value timber, while providing short-term cash flow from the livestock. The interactions among timber forage and livestock are managed intensively to simultaneously produce timber commodities, a high quality forage resource and efficient livestock production. In silvipastoral system, tree, forage and animals are combined and managed as a single integrated entity. It should be noted that an animal rearing system can only be considered a silvipastoral system when the forage crops are intentionally introduced or enhanced in a tree production system, or woody crops are deliberately introduced or enhanced in a forage production system. Grazing animals on silvipasture has been shown to reduce the cost of tree crop maintenance in oil palm and rubber. Grazing can reduce competition from the understorey vegetation by recycling nutrients 'locked up' in the biomass.

Any attempt to combine two or more crops together, and particularly to grow one (forages) beneath the shading canopy of another (trees), requires knowledge of the environmental factors involved and the nature of competition. Major factors affecting the growth of forage species under tree canopy are the amount of light, available soil moisture and nutrients, and the magnitude of competition between the forage plants and the trees. As far as animal production is concerned, the provision of shade and thus lower heat loads on animals is likely to have a favourable effect on animal productivity. The nutritive quality of forages grown in partially shaded environments such as old coconuts is comparable to those grown in full sun . However, under mature tree crops such as rubber and oil palm, the forage yield is decreasing with tree age due to decreasing of light availability.

Reports have indicated that models used in the forest farming in Peninsular Malaysia in the attempt to rehabilitate degraded forest due to encroachment are highly profiTable, with B/C ratio of 2.43 – 3.80 and IRR of 58 – 88 percent. Opportunity exists for raising potted landscape plants under the shade of mature oil palm plantations located within the town limit and are readily accessible. Plantations ages 5-6 years are suiTable for raising containerized plants meant for interior landscapes. Elsewhere, thinned timber plantations were under planted with shade tolerant commercial crops. For example, an 8 year *Acacia mangium* plantation thinned to remove 2/3 of trees (60 percent light) gave the second highest ginger (*Zingiber officinale*) yield next to open planting. The potential forest farming should be explored and innovatively exploited to help smallholder timber tree growers to improve the cash flow.

Silvofishery involves the establishment of small-scale aquaculture systems or pens constructed within or adjacent to existing or rehabilitated mangrove area or tree groove. The idea is to not adversely affect the existing mangroves, but to enhance them via a sustainably managed aquaculture activity. Proper management of the silvofishery pens and the restoration and/or conservation of the mangroves can go hand in hand. Various forms of silvofishery have been practiced in Malaysia, involving the culture of crabs, shrimps, fish, mollusks, seaweeds, etc. Raihan (2001) described an integrated fodder fish system in Malaysia where fish (grass carp and tilapia) is fed with duckweed, napier grass (*Pennisetum purpureum*), cassava (*Manihot esculenta*) and leaves of *Leucaena leucocephala* and supplemented with rice bran, corn, chopped sago, etc. In Sarawak, Marina *et al.* (2006) reported that farmers participated in a community forest in Kapit, rear fish in ponds built within the natural water way and using water from natural water springs. Indigenous freshwater fish species such as semah, tengadak, empurau, keli and baung were successfully domesticated.

Similarly, it was reported that forage biomass change with plantation age; the amount of forage biomass under a 7 year old oil palm was 1,230 kg/ha dry matter, while under a 17 year-old oil palm, the quantity reduced to 411 kg/ha dry matter. Furthermore, the productivity of native pasture has been estimated to reduce from 3,000 kg/ha/year at establishment, to 435 kg/ha/year in the mature phase. The composition of forage species also varies with plantation age. There are about 60 - 70 plant species growing under the young plantation and the number declined to 20 to 30 species under older trees. Out of these, only about 70 percent of these species are palatable and can contribute as forage for livestock production .In conventional oil palm plantation, grazing livestock can be released at 18 - 20 months after field establishment when the young shoots are beyond the reach of the animals. Grazing management under plantation requires a systematic and flexible system to equate animals stocking rate with forage availability. In young oil palm, 3 steers/ha of Kedah-Kelantan breed can be kept for two years and gave an average daily gain of 320 g/head. Subsequently the stocking rate could be adjusted to 2 and 1 cattle/ha for a period of 2 years when the canopy is closed. Lower carrying capacity of 0.3 to 0.4 Kedah-Kelantan cattle/ha may be adjusted on native pasture depending on season, soil type, age of oil palm and plantation management. Low forage availability has been reported to lower conception rate (52 percent) of Kedah-Kelantan cows grazing on native forages in 10 to 15 years old oil palm plantation. Currently, successful integrated farms use low stocking rate of 0.25 to 0.5 animal per ha under mature plantation trees.

Sheep had also been successfully integrated with oil palm plantations. The stocking rate depends on the availability of native forages under the palms. The recommended stocking rate for 2 to 6 years old palms is 6 to 10 sheep/ha. In terms of animal productivity, sheep of local breed grazing under oil palm attained weight of 22.2 kg in nine months compared with 17.9 kg at one year of age under rubber . A study by Chong *et al.* (1990) showed that the initial high level of native forage production under immature rubber (3 years old) of about 2200 kg/ha could support a high stocking rate of 17 sheep/ha with animal productivity of about 400 kg/ha/year. However, stocking rate had to be reduced as forage yield decrease under maturing rubber trees. In mature rubber (7 years old), native forage availability was less than 600 kg/ha and this forage could only support 2 - 3 sheep/ha with lower animal productivity of 72 kg/ha/year. According to Tajuddin and Chong (1988), the recommended stocking rate is 6 - 8 sheep/ha for immature rubber trees and 3 - 5 sheep/ha for mature trees, in accordance with forage availability.

The cluster-based agro-industrial development as identified in the Second Industrial Master Plan (IMP2), 1996-2005, seeks to strengthen both inter and intra-sectoral linkages including the development and expansion of intermediate and supporting industries. Through this approach, agricultural production will be more specialized to meet the needs of various domestic and global market segments. This will encourage the production of high quality and high value produce, facilitate product differentiation and increase value-added agriculture.

In the Third National Agricultural Policy (NAP3), the Malaysian agriculture sector has become an engine of economic growth, whereby agriculture has been employed as the main economic driver for Malaysian rural communities. During the Ninth Malaysian Plan period (2006-2010), the agriculture sector has achieved a higher rate of growth than targeted and contributed towards economic growth and export earnings, in which there was increased involvement of the private sector in large-scale commercial food production and agro-based industry. The Ministry of Agriculture of Malaysia needs to implement more target specific policies and strategies to expedite the transformation of the agriculture sector by taking serious consideration on the sustainability and long term productivity.

The success of modern agricultural and forestry production can be largely attributed to monoculture systems using a few selected species. In the drive for maximizing yield and profit, the age-old tradition of using mixed farming systems was essentially rejected and in many cases this intensive agricultural system has resulted in environmental and ecological degradations. During the last three decades, however, the benefits of agroforestry have been increasingly recognized. Combining trees and crops or animals in spatial or temporal arrangements has been shown to improve food security and mitigate environmental degradation, offering a sustainable alternative to monoculture production. By providing supportive and complimentary functions with an adapTable approach, agroforestry can offer specific social and environmental benefits across a range of landscapes and economies. However, more research and efforts is needed to obtain the full potential of agroforestry applications and to increase the awareness. As the plethora of benefits of agroforestry are realized, modern land-use systems are evolving towards a more sustainable and holistic approach to land management.

Agroforestry systems would be superior to other land-uses at the global, regional, landscape, and farm level because they provide synergy between increased food production, poverty alleviation and environmental conservation. The best measure of the success of new or improved technologies is the readiness with which farmers accept them. If innovations do not take account of the social context in which smallholders operate, then the potential of such innovations will not be recognized.

3.7 Precision Farming

Sustainable agriculture refers to agricultural production that can be maintained without harming the environment. It is an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- Satisfy human food and fibre needs;
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- Make the most of efficient use of non renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- Sustain the economic viability of farm operations; and
- Enhance the quality of life for farmers and society as a whole.

Precision Farming (PF), Precision Agriculture (PA), Smart Farming (SF) or Site Specific Management (SSM) on the other hand is a management technique for sustainability in production agriculture to apply the right input in the right place at the right time and in the right amount. Information technology is used in precision farming to suit soil, water and crop management to match varying field conditions such as soil texture, nutrients and moisture status, pest and disease distribution, etc.

Precision Farming (PF) is a management strategy which utilizes precise information and information gathering technology to increase profit and decrease environmental impact. It is based on an innovative and comprehensive systems approach, which depends on a combination of technologies. Some of these are geospatial information systems (GIS), global navigation satellite systems (GNSS), computer modelling, multispectral and hyper spectral ground based, airborne and satellite remote sensing system, variable rate technology and advanced information processing for timely in-season crop management as shown in Figure 3.16. PF strives to achieve the following goals and outcomes: increased profitability and sustainability, improved product quality, effective and efficient pest and nutrient management, energy, water and soil conservation, and surface and ground water protection. The figure shows the five systems (5S) or five main technologies involved in precision farming. All or some of the components can be adopted in the practice of precision farming.

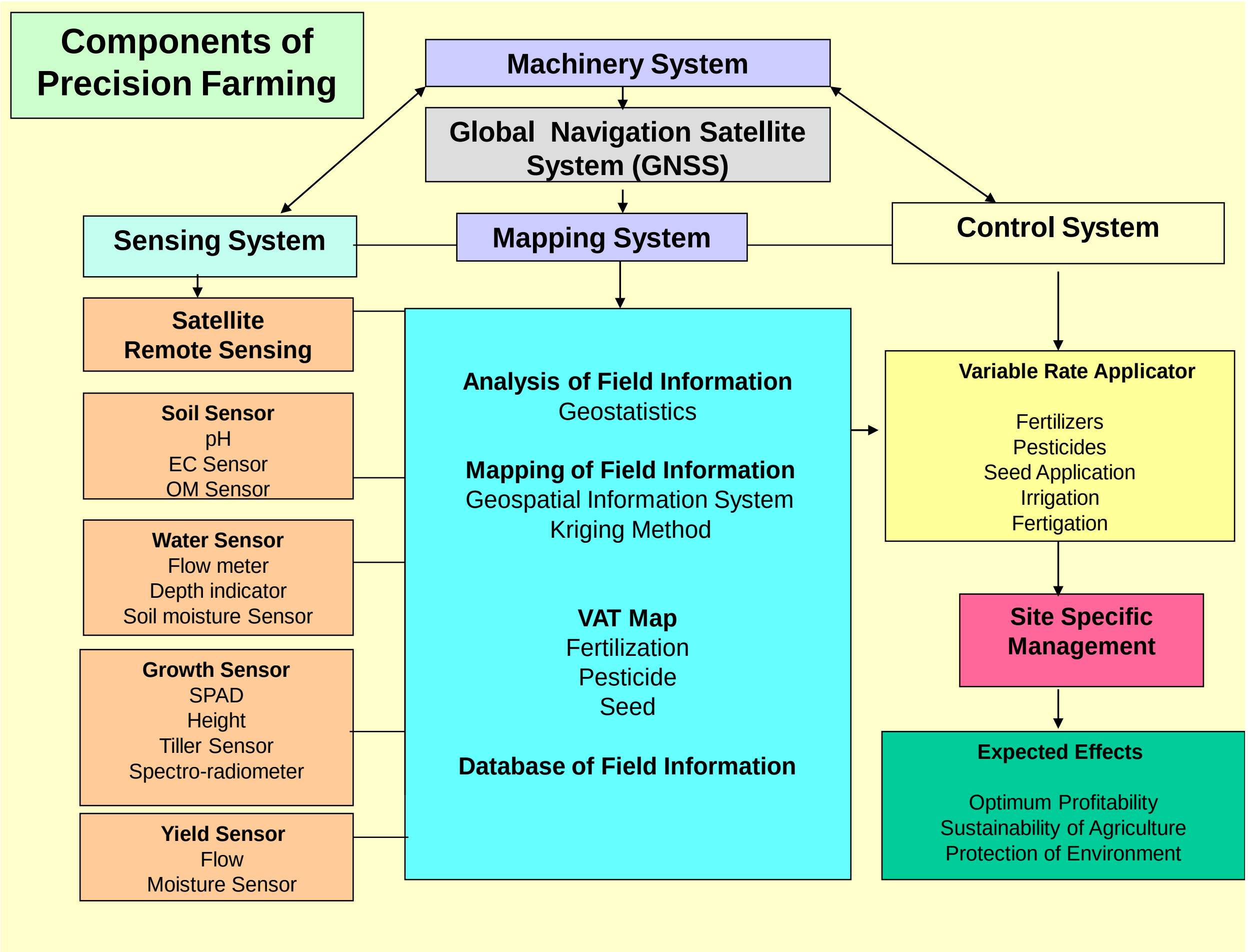


Figure 3.16: Precision farming components for site-specific management of soil, water and crop.
(Adapted from Woo-pung Park, 2003)

PF has been practiced in advanced countries since 1990s and it has since then also generated interest locally (Amin et al., 2004). PF is useful for Malaysia's important crops like oil palm and rice as well as some field crops and horticultural crops. For all these crops, yield mapping is the first step to be carried out in order to determine the yield variability within a field, the location of the highest and lowest yielding areas of the field. The factors causing yield variation are then analyzed and remedial actions are taken precisely to increase yields, but with minimum inputs in order to maximize profits. Testing of precision farming technology locally is a step forward in exploiting information technology to reduce inputs and maximize returns from an agricultural enterprise. Using micro irrigation system with fertigation, which applies water only in the crop root zone, is also an example of precision farming. It saves water and nutrients for upland crop production or in a protected controlled environment and rain shelters.

3.8 Food and nutrition situation

i) Socio-demographic changes

Malaysia, like other developing countries, is undergoing nutritional changes which are characterised by manifestations of the dual burden of malnutrition. While macronutrient and micronutrient deficiencies persist resulting in poor nutritional status and morbidity, the prevalence of overweight and obesity has been on the rise in urban and rural areas in many countries.

Malaysia typifies a rapidly developing country which has undergone major demographic and socioeconomic changes since attaining independence in 1957. Notably, fertility rates decline substantially from 6.94 in 1995 to 2.94 in 2005, while life expectancy at birth markedly increased from 48.5 years to 73.1 years during the same period. Urbanisation growth rate at 3 percent in recent years has resulted in 62 percent of the present population, which is estimated as 25.35 million in 2005, living in urban areas. The country has also experienced an epidemiological transition from a situation with the predominance of infectious diseases to one distinguished by the growing prevalence of chronic and degenerative diseases. In recent years, coronary heart disease, cancer and stroke constitute the leading causes of mortality, accounting for more than 40 percent of medically certified deaths.

ii) Data on nutritional status of population groups

Data on nutritional status of various communities have been available in the country since the early part of the century. These were relatively small scale studies, on specific population groups, reported mostly by the Institute for Medical Research. From the 1980s, data were also reported by various research groups, mainly from several local universities.

The largest data on nutritional status of Malaysians is from the National Health and Morbidity Surveys (NHMS) which have been conducted over the past three decades. The first was in 1986, a subsequent one in 1996 and the third were carried out in 2006. These are nationwide surveys of various aspects of health, carried out on representatively sampled subjects from all parts of the country. These are massive surveys, involving large sample sizes. For example, in the 2006 survey, over 56,000 subjects were interviewed. The efforts of these surveys are indeed commendable as they have made available data that is useful in determining the national health burden. Such data is absolutely essential in health policy and programme planning. Repeated surveys over the years now enable us to understand the trend of various disease prevalence. The NHMS III report was released in early 2008.

iii) Nutritional status of children

The principal outcomes of under nutrition affecting young growing children are underweight and stunting. According to the Ministry of Health/UNICEF Survey that was undertaken nationwide in 1998-2000 among children less than six years, 19.2 percent were underweight (<-2SD weight-for-age) and 16.7 percent stunted (<-2SD height-for-age) (MOH-UNICEF, 2000). Based on the surveillance data of the Ministry of Health (MOH), the overall prevalence of underweight among children aged below five years was 17.3 percent in 2004 compared to 25 percent in 1990. In contrast, research studies often report prevalence of underweight and stunting in children of similar ages from poor households exceeding 25 percent and 30 percent respectively.

The prevalence of overweight in Malaysia children is markedly lower than that in adults. The MOH surveillance data showed that in 2004, 4.1 percent of children aged below five years were overweight. The MOH/UNICEF survey (1998-2000) recorded 2.9 percent male and 2.20/0 female children below six years as overweight, with higher prevalence in metropolitan (3 percent) and large urban areas (2.8 percent) than in rural areas (1.8 percent) . The proportion of overweight children in poor rural communities remains relatively low, below 1 percent generally.

More recent data are obtained from the NHMS III survey (Table 3.13) (IPH, 2008a). Findings showed that the national prevalence of underweight children was 13.2percent, the level being higher in boys (14.5 percent) compared to girls (12 percent). The report also showed that more children in rural areas (16 percent) were underweight compared to those in urban areas (11.4 percent). Stunting is another common malnutrition problem and implies long term under nutrition and poor health.

In the NHMS III study, stunting was the most important under nutrition problem encountered. The prevalence of stunting was found in 15.8 percent of the children, with a slightly higher prevalence among boys (16.6 percent) than girls (15.0 percent). The percentage of children who were stunted in the rural areas (19.4 percent) was clearly higher than children in urban areas (13.6 percent).

Wasting is the third form of under nutrition commonly encountered and suggests recent or continuing current weight loss. The prevalence of wasting was found in 10.4 percent of the children, with a similar prevalence among boys (10.6 percent) and girls (10.2 percent). The prevalence of wasting was slightly higher in urban compared with rural areas at 11.0percent and 9.5 percent respectively.

Table 3.12: Summary of prevalence of undernutrition and overweight amongst children (0-18 years) (n=21,249)

Status	National	Gender		Location	
		Boys	Girls	Rural	Urban
Underweight	13.2	14.5	12.0	16.0	11.4
Stunted	15.8	16.6	15.0	19.4	13.6
Wasted	10.4	10.6	10.2	11.0	9.5
Overweight	5.4	6.0	4.7	4.0	6.3

Source: National Health and Morbidity Survey III, 2006 (IPH, 2008a)
Note: Figures indicate percent of children

Examining more closely the data indicates which age groups are most affected (Figure 3.17). For the problem of underweight, the highest prevalence was found amongst those one to three years old (19.8 percent). The next highest group was found in children four to six years old (16.4 percent). Infants, on the other hand, had the lowest prevalence (7.1 percent).

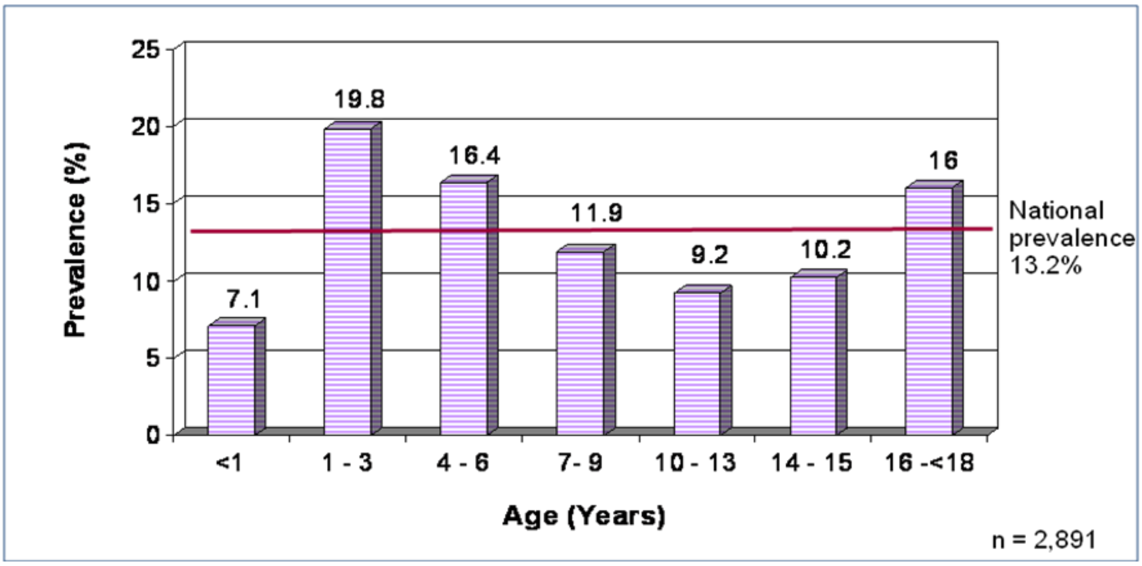


Figure 3.17: Prevalence of underweight according to age group
Source: National Health and Morbidity Survey III, 2006

In the case of stunting, the group most affected was those in the 16-18 years group (23.7 percent). This is followed by young children, ie those one to three years (17.2 percent) and four to six years (16.7 percent). Again, infants were the least affected (9.0 percent). Wasting was found to be most common amongst infants (15.2 percent) and those in the one to three years old group (15.1 percent). Children in the 10-13 years group were the least affected (4.5 percent).

On the other extreme of the malnutrition scale is over nutrition. The NHMS III found that 5.4 percent of the children were overweight, with a slightly higher prevalence among boys at 6.0 percent than girls at 4.7 percent. The proportion of overweight children was higher in urban areas at 6.3 percent than in rural areas at 4.0 percent (Table 3.13).

As for the problem of overweight, younger children were again most affected (Figure 3.18). Findings showed that 6.8 percent of children in the seven to nine years old group were overweight, followed by 6.4 percent in the four to six years old group. The children least affected by overweight were those in the one to three years group (3.2 percent).

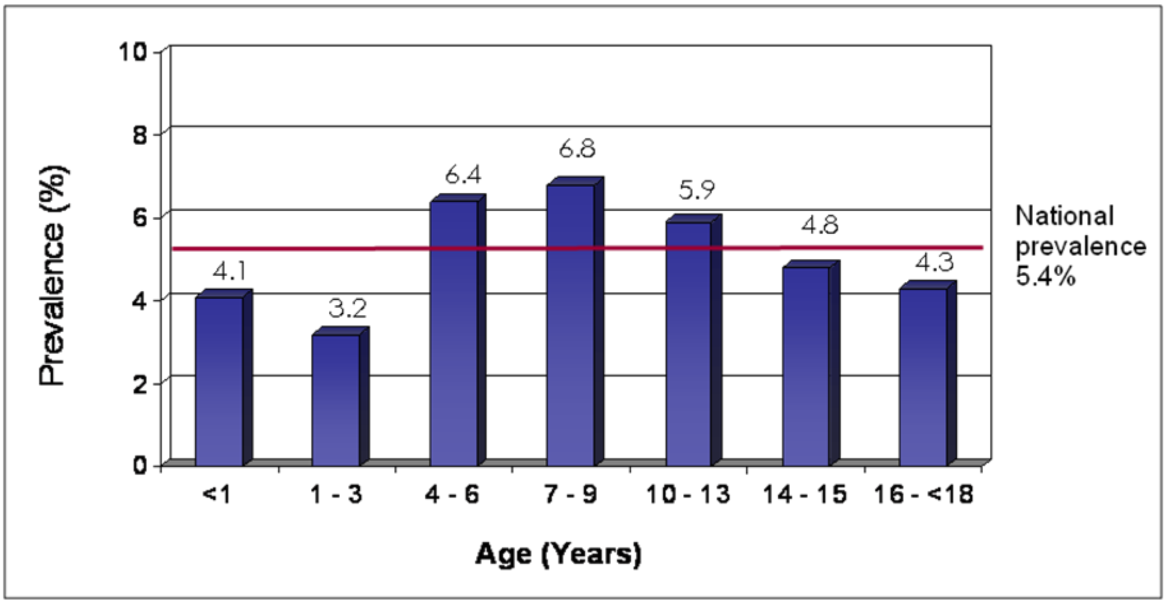


Figure 3.18: Prevalence of overweight according to age group
(Source: National Health and Morbidity Survey III, 2006)

It is quite clear that younger children, particularly those in the one to six years old group were the most affected with nutritional problems, both under nutrition and over nutrition. This is not surprising at all as these are the most vulnerable groups where growth and development are rapid.

The NHMS III findings showed that the great majority (over 80 percent) of Malaysian children have satisfactory nutritional status. Nonetheless, a significant proportion of the children were found to be undernourished as about 15 percent of them were found to be underweight, stunted or wasted.

Stunting appeared to be the most important under nutrition problem. These are average figures for the whole country. One can expect significant differences in percentage of undernourished children in different parts of the country. Just as an illustration of this difference according to location, the survey findings clearly showed that the three types of under nutrition reported were more prevalent in rural areas. These findings are as expected as socio-economic conditions of rural groups may be a handicap for optimal growth achievement.

On the other hand, the problem of overweight was of a lower magnitude, as it affected only 5 percent of the children studied. This is a significant figure and must not be overlooked. Other studies in the country, amongst various age groups in selected parts of the country, have indicated higher prevalence. In the case of overweight, the reverse is true; more urban children are affected, compared to those in rural areas. This finding is in line with the commonly accepted understanding that overweight is very much influenced by the environment. Urban children are generally less physical active and at the same time, have a higher food intake.

It can also be noted that there are gender differences in these parameters of malnutrition. Findings showed that there are more malnourished boys than girls in all the three parameters discussed. While only marginally more boys were wasted, it is clear that more boys were stunted and underweight.

All these findings, including differences in geographical locations, between gender, different socio-economic groups and ethnicity are extremely important and useful in formulating intervention programmes.

iv) Nutritional status of adults

Numerous studies have reported on the nutritional status of various population groups. It would be too extensive to report on all these studies. Only selected findings from the 1980s and 1990s are highlighted, followed by the large scale findings of the NHMS II (1996) and NHMS III (2006).

As in the case of children, both underweight and overweight problems are encountered in the community. Data obtained from selected communities for the late 1980's and early 1990's show a wide range of prevalence of overweight and obesity from 18 to 39 percent and 2.7 to 20 percent respectively. The overall prevalence for overweight amongst urban communities is probably about 29 percent and that for obesity, 12 percent. The combined prevalence of overweight plus obesity ranged from 26 to 53 percent, with an overall mean of 39 percent. The problem appears to be also prevalent among lower income urban adults. Even among rural communities, the problem of overweight appears to be on the increase (Table 3.12 and

3.13). Although the sample size of some of these studies are rather small, these findings do indicate some cause for concern and the need for more serious studies and interventions. An emerging paradox is the overweight burden on the poor, especially among women, as revealed by studies that identified one-third to half of women from poor households as being overweight and obese.

Table 3.13: Prevalence of underweight, overweight and obesity among rural communities (males)

Males	**Poverty villages (Chong *et al.,* 1984)**	**Bagan Datoh (Ng *et al.,* 1995)**	**Rural villages (Khor *et al.,* 1999)**
N	522	190	1854
Percent underweight	45.0	24.5	13.2
Percent desirable wt	50.0	52.0	62.8
Percent overwt +obese	5.0	23.5	24.0
Mean BMI ± SD	20.5 ± 2.8	22.6 ± 4.3	22.5

Table 3.14: Prevalence of underweight, overweight and obesity among rural communities (females)

Females	**Poverty villages (Chong *et al.,* 1984)**	**Bagan Datoh (Ng *et al.,* 1995)**	**Rural villages (Khor *et al.,* 1999)**
N	965	237	2751
Percent underweight	31.0	14.0	12.4
Percent desirable wt	54.0	40.0	48.5
Percent overwt + obese	15.0	46.0	39.1
Mean BMI ± SD	20.9 ± 3.4	24.3 ± 4.4	23.8

The Ministry of Health Second National Health and Morbidity Survey of 1996 (n=33,386, >18 years of age) reported an overall national prevalence of overweight of 20.7 percent, obesity, 5.8 percent and combined overweight and obesity of 26.5 percent (IPH, 2008a). Since then, several studies have reported rising prevalence of overweight and obesity in men and women from both urban and rural areas. The preliminary result of the first Malaysia Adult Nutrition Survey conducted in 2002 and 2003 showed that 26.7 percent of Malaysian adults aged 18 to 59 years are overweight and 12.2 percent were obese.

Ten years later, the NHMS III data in2006 reported a marked increase in overweight and obesity among Malaysians as compared with findings in NHMS II in 1996 as follows:

- 26.5 percent combined overweight + obesity in 1996 NHMS II, 43.1 percent in 2006 NHMS III; increase of 1.6 times
- 20.7 percent overweight in 1996; 29.1 percent in 2006; increase of 1.4 times
- 5.8 percent obesity in 1996; 14.0 percent in 2006; increase of 2.4 times

These are dramatic changes over a decade and a serious cause for concern. In the mean time, the problem of underweight decreased from 12.7 percent in 1996 to 8.5 percent in2006. Details of the comparison are given in Tables 3.14 and 3.15.

Table 3.15: Prevalence of underweight, overweight and obesity in 1996 and 2006 according to gender

Gender	Percent Underwt BMI <18.5		Percent Overwt BMI 25-29.9		Percent Obese BMI ≥30.0	
	NHMS 2	NHMS 3	NHMS 2	NHMS 3	NHMS 2	NHMS 3
All	12.7	8.5	20.7	29.1	5.8	14.0
Men	11.5	8.3	20.1	29.7	4.0	10.0
Women	14.1	8.7	21.4	28.6	7.6	17.4

National Health and Morbidity Survey 1996; N=28,737; >20 years (Lim et al., 2000)
National Health and Morbidity Survey 2006; N=33,055; >18 years (IPH, 2008a

Table 3.16: Prevalence of underweight, overweight and obesity in 1996 and 2006 according to ethnic groups

Race	Percent Underwt BMI <18.5		Percent Overwt BMI 25-29.9		Percent Obese BMI ≥30.0	
	NHMS 2	NHMS 3	NHMS 2	NHMS 3	NHMS 2	NHMS 3
Malay	13.4	8.5	22.0	29.8	7.0	16.6
Chinese	11.1	8.4	21.6	28.5	5.0	8.7
Indian	11.4	7.6	24.9	33.2	6.8	17.7
Others	14.0	8.6	17.9	20.8	4.5	8.1
Other Bumis	-	9.5	-	27.3	-	11.2

National Health and Morbidity Survey 1996; N=28,737; >20 years (Lim et al., 2000)
National Health and Morbidity Survey 2006; N=33,055; >18 years (IPH, 2008a)

v) Micronutrient deficiencies

Under nutrition not only brings about energy deficits affecting growth and physical performance, but also results in the "hidden hunger" problem of micronutrient deficiency. An important micronutrient deficiency in Malaysia over the decades is anaemia, affecting chiefly young children, women of childbearing age and the elderly. Based on the MOH/UNICEF survey in 1998-2000, the prevalence of anaemia in children below six years of age was 17.7 percent for boys and 20.5 percent for girls . Research studies have also recorded anaemia prevalence levels of 20 to 25 percent in children, adults and the elderly from poor communities. The prevalence is appreciably higher among pregnant women, often exceeding 25 percent.

Another micronutrient deficiency that has been monitored for many years is Iodine Deficiency Disorders (IDD) especially in Sarawak and Sabah. Through legislation on universal salt iodisation, which was fully implemented in 2000, the gravity of 100 has abated to a large extent in Sabah. Since 2002, the median urinary iodine levels of children aged 8 to 10 years in Sabah has been within the normal range. Continued monitoring efforts, however, are needed in Sarawak and some endemic districts in the peninsula to further reduce the prevalence of IDD in the areas.

Prior to the 1960s, vitamin A deficiency accompanied by clinical symptoms used to be encountered among young undernourished children from poor communities. However, the situation has improved significantly over the years. The finding of the MOH/UNICEF survey in 1998·2000, in which 2.5 percent of boys and 4.5 percent of girls less than five years of age had blood retinol level ≤ 0.7 μmol/L, indicated that vitamin A deficiency prevalence in Malaysia is at a mild sub-clinical level .

As for other nutrient deficiency, there is a dearth of data. Recent research interests have emerged but tend to be limited to a few nutrients such as calcium, vitamin D, zinc and folate. More studies should be supported to establish intake levels and deficiency prevalence of nutrients for which data is lacking among Malaysians, including the nutrients mentioned above as well as selenium, vitamins K and B12.

vi) Infant and young child feeding pattern

In relation to nutrition of infants and young children, the subject of breastfeeding practices in Malaysia has been the focus of numerous studies over the decades. The overall prevalence of ever breastfed remains high at 88.6 percent according to the Second National Health and Morbidity Survey (NHMS II) in 1996, compared to the Malaysian Family Life Survey (MFLS) prevalence of 85 percent in 1998 . However, the median duration of breastfeeding appears to have declined from 6 months (MFLS) to 4.5 months (NHMS II). NHMS II also noted that the prevalence of exclusive breastfeeding through the first four to six months was low at 29 percent and bottle-feeding was high at 86 percent among children aged below 2 years.

NHMS III (2006) provided more recent data on infant and child feeding pattern. The overall prevalence of ever breastfed among children aged less than 2 years was high, at 94.7 percent. The overall prevalence of exclusive breastfeeding below 4 months was 19.3 percent and below 6 months was 14.5 percent. This prevalence was much lower than those ten years ago reported in NHMS II.

Predominant breast-feeding below 4 months and 6 months were 19.7 percent and 16.9 percent respectively. Breast feeding was initiated within one hour of birth in 63.7 percent infants and the national prevalence of continued breastfeeding up to two years was 37.4 percent.67.9 percent of children below 12 months received any food or drink from a bottle and the prevalence of pacifier use was 32.9 percent.

In terms of complementary feeding, 41.5 percent of infants had received timely complementary feeding. However, complementary foods were given as early as two months of age especially in breastfed children. Most children were given a variety of foods but that the percentage of children consuming iron rich foods ie. meat and fish was low noticeably among children in the younger age groups. Less than 40 percent of infants below six months consumed these food items at least once a week. Meal frequency of most children aged 6 to 8 months followed the WHO recommendations. However, only 55.9 percent of children aged 9-23 months received the appropriate number of meals (at least 3 meals per day) .

The results of the NHMS III survey suggest that breastfeeding and complementary feeding practices in the country were not optimal. More efforts are needed to improve exclusive breastfeeding especially in educating the public on the practice of giving plain water to breastfeeding infants, improving support for working mothers as well as guidance on appropriate complementary feeding practices.

vii) Changes in food consumption pattern

An analysis of food availability in the past five decades has indicated that dietary patterns of Malaysians have changed markedly. These changes include increasing amounts of food available as well as changes in the composition of the diet. Although these data should not be equated with consumption levels, food balance sheet data are useful in indicating probable trends in food consumption patterns. In the absence of regular nationwide food consumption surveys, these data do provide some useful information, within the recognized limitations of such data.

Figure 3.19 gives some data extracted from food balance sheet data for Malaysia, taken from reports of the Food and Agriculture Organization. Over the period of 46 years, from 1961 to 2007, there was a trend of increasing per capita availability of the major macronutrients calories, fat and protein, particularly the former two nutrients.

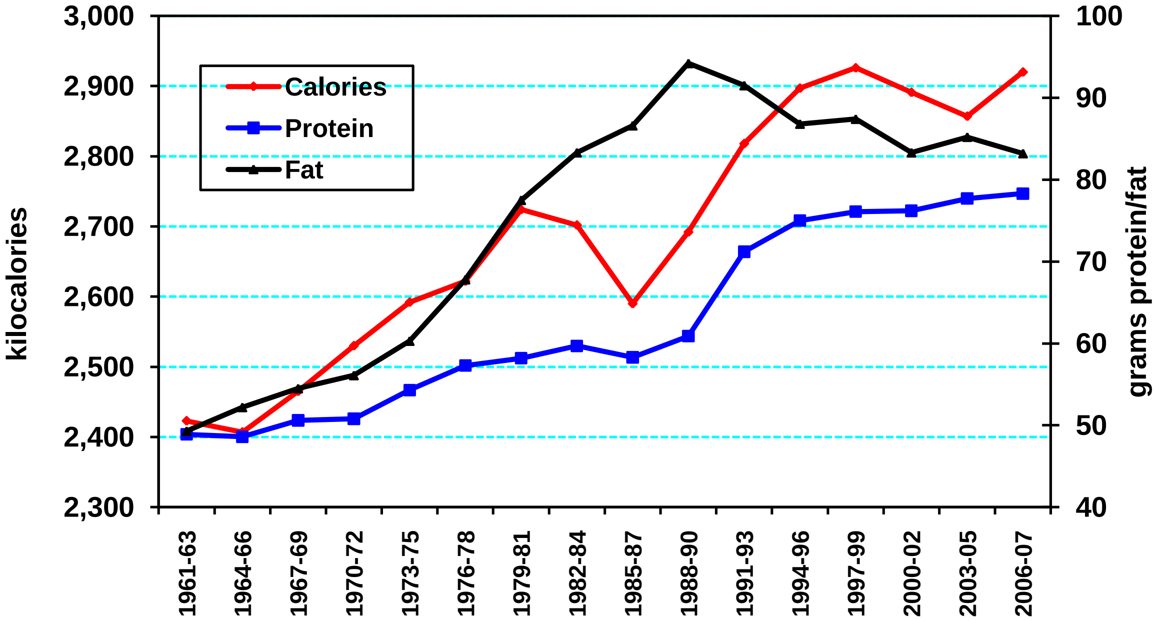


Figure 3.19: Increases in nutrient availability (1960s – 2000s)
Source: Re-plotted from Tee (1999) and FAO balance sheet data

Besides changes in amounts of calories, protein and fat, there has been marked changes in the contribution of various food items to the calorie and protein intake of the population.

Figure 3.20 shows the changes in the contribution of various food groups to available calories over the four decades. The contribution of calories from meat, fish and egg increased significantly over the years. Commencing with 6.2 percent of total calories from these three food groups in the early 1960s, this percentage rose steadily over the years and reached 15 percent in the early 1990s and remained at around this level in the late 2000s.

There have been marginal changes in contribution of milk to total calorie intake over 5 decades as obtained from food balance sheet data (Figure 3.21). The contribution of milk to total calories varied around 3-4 percent over the years.

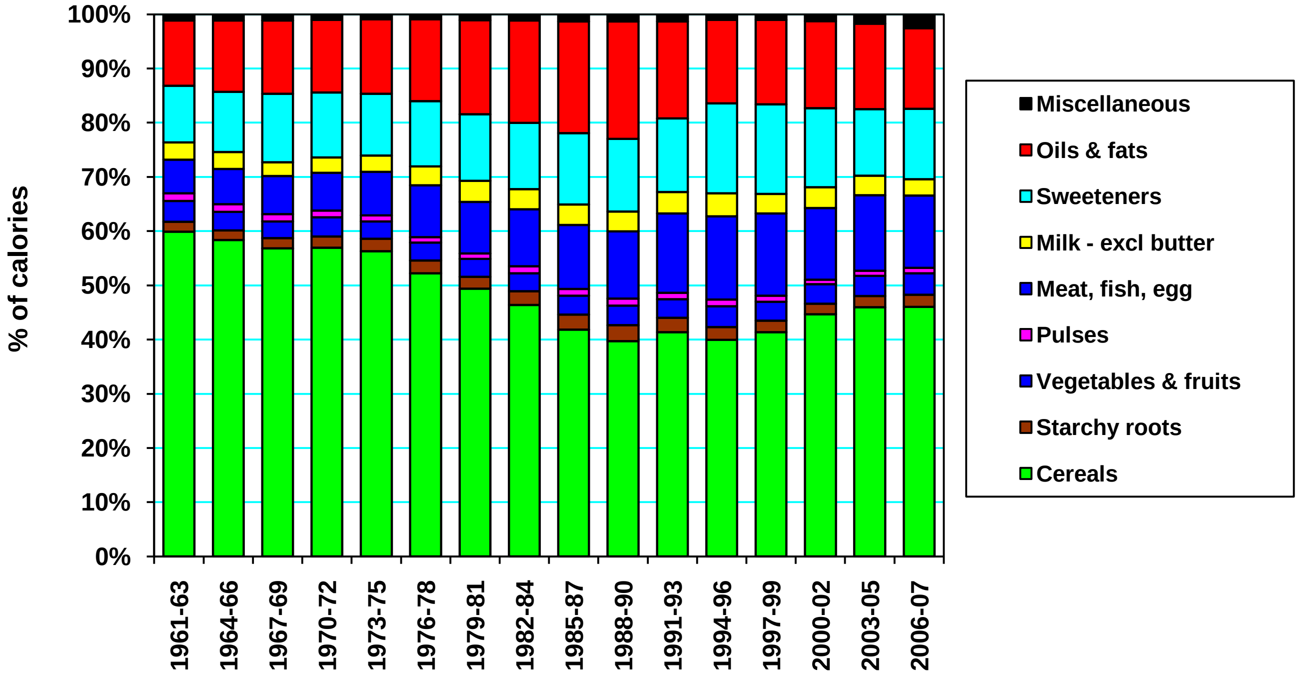


Figure 3.20: Changes in food sources of calories (1960s – 2000s)
Source: Re-plotted from Tee (1999) and FAO balance sheet data

The contribution of oils and fat and sweeteners to total energy intake also increased significantly over the years. On the converse, a steady decline in calories from complex carbohydrates, notably cereals, can be observed, from 60 percent in the 1960's to 45 percent in 2000's. The percent contribution of cereals to total calorie appeared to have stabilized at this level in the early 2000s.

The availability of other fibre-rich foods, such as fruits and vegetables, has not increased over the years. There was a concomitant increase in the proportion of calories from oils and fats, sugars, and meat, fish and eggs over the last three decades. These increases appeared to have stopped during the late 1990s.

A similar trend in percent contribution of various food groups to total protein intake is observed over the four decades (Figure 3.22). The most dramatic changes are the steady marked increase in protein intake from meat, fish and egg from the 1960s to 1980s.

Concomitantly, there was a steady marked decline in protein contribution from cereals over the same time period. These changes in proportions of protein from cereals and that from meat, fish and egg appeared to have levelled off in the late 1990's.

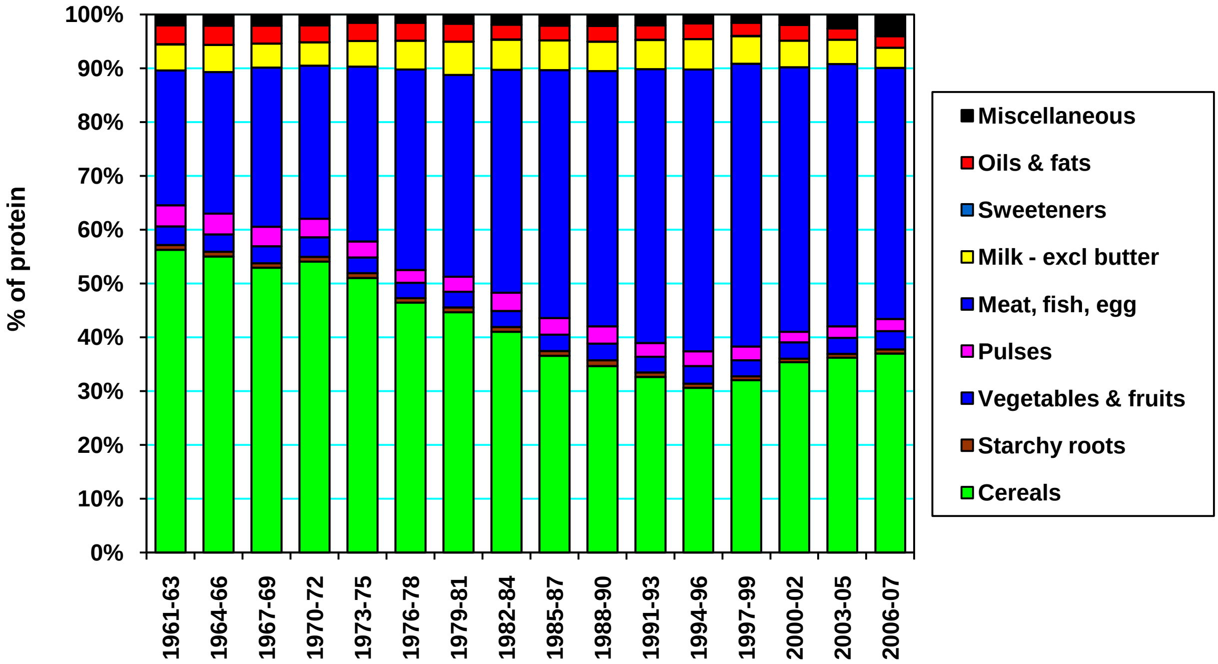


Figure 3.21: Changes in food sources of protein (1960s – 2000s)
Source: Reported from Tee (1999) and FAO balance sheet data

Analysing the percentage contribution of the three main nutrients carbohydrates, fat and protein to the total available energy over the past three decades, it can be seen that there was a definite decline in the proportion of energy from carbohydrates, from about 74 percent in the 1960's to about 62 percent in the 2000's. At the same time, the percentage contribution of fat was observed to have increased from 18 percent to 25 percent over the 3 decades (Figure 3.22). From the late 1990's, however, the proportion of energy from carbohydrate and fat appeared to have remained unchanged. No major change in the proportion of energy supplied by proteins was observed over the years.

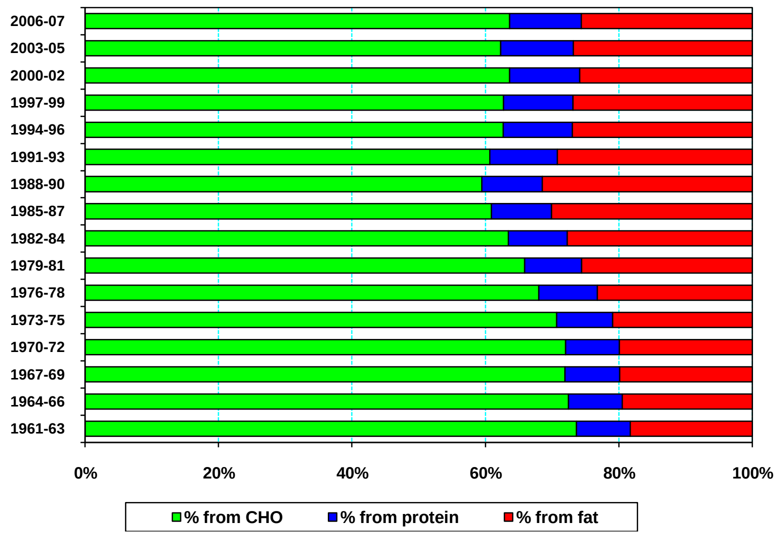


Figure 3.22: Changes in contribution of major nutrients to calorie intake (1960s – 2000s)

Source: replotted from Tee (1999) and FAO balance sheet data

These changes in food availability in Malaysia are consistent with the generally observed patterns for nations with increased national wealth. It has been shown that the main components of the diet tend to be related to a nation's relative affluence (WHO, 1990). As gross national product (GNP) increases, there is a shift towards an "affluent" diet that is characterised by an excess of energy-dense foods rich in fat, particularly animal fats, and a parallel decline in complex carbohydrate foods. Free sugars, particularly sucrose and glucose syrups, also form a much higher proportion of the total dietary carbohydrates in very affluent communities.

The shift towards to the "westernised" dietary pattern has brought about a new nutrition scenario in many developing countries. These countries are now faced with the twin problems of malnutrition, i.e. under nutrition among some segments of the communities and the problems of obesity and associated disorders in other groups. These disorders, frequently termed the diet-related chronic non-communicable diseases include coronary heart disease, cardiovascular disease, various cancers, diabetes, dental caries and osteoporosis. Such diseases will pose a great stress on the health services of less affluent and developing communities which can ill afford such expenditures.

viii) Non-communicable diseases related to lifestyle

As a result of the rapid pace in socioeconomic development and increased affluence in Malaysia, there has been a definite change in the lifestyle of communities. These include marked increase in sedentary lifestyle and changes in food consumption pattern, as summarized above. These changes brought about marked changes in the nutritional problems in the country. The population is now faced with the other facet of the malnutrition problem, namely chronic diseases associated with excessive consumption of various nutrients (e.g. fat) on the one hand and low levels of intake of other nutrients (e.g. complex carbohydrates and fibre) on the other, such as hypertension, coronary heart disease and certain types of cancers, as evident from mortality data and epidemiologic data.

Mortality data for Malaysia have shown that deaths due to diseases of the circulatory system and neoplasm have been on the rise since the 1960's. On the other hand, deaths due to infectious and parasitic diseases, and conditions in the prenatal period reduced in number, reflecting the improved health care facilities in the country over the past three decades. Within the category of "diseases of the circulatory system" the two main causes of death are ischemic heart disease, cardiovascular disease and acute myocardial infarction. Available mortality statistics in the country showed that for the past 25 years, the diseases of the circulatory system has topped the list of ten leading causes of death in the country. The second cause of death has been those due to accidents and poisoning. Ranking third in the list is deaths due to neoplasm.

Studies into these diet-related chronic diseases are relatively recent undertakings in the country, commencing in the 1960's. The prevalence of obesity, an important risk factor in CHD, has been studied for various population groups, including various rural groups. This has been described earlier in this report.

Several epidemiological studies on risk factors of coronary heart disease have shown that hypercholesterolemia was a problem amongst the more affluent segments of the population whereas the rural population has lower levels of serum cholesterol. The aborigines were reported to have the lowest levels of serum cholesterol of about 150 mg/dl, whereas levels of 180-200 mg/dl have been reported for the rural communities. Urban Malaysians were found to have the highest serum cholesterol levels of 210-230 mg/dl. The prevalence of hyperlipidemia amongst this group is almost 30percent.

The prevalence of several other risk factors such as hypertension, high blood glucose and smoking is also a cause for concern. From the nationwide Second National Health and Morbidity Survey (NHMS2) conducted by the Ministry of Health in 1996 on 22,984 subjects greater than 30 years of age, the prevalence of total hypertension was 29.9percent (self-reported, 14.0percent and undiagnosed, 15.9percent). Ten year later, the NHMS3 reported a prevalence of total hypertension of 42.6percent (n=24,796; >30 years), an increase of 42percent (IPH, 2008c).

Diabetes mellitus also showed a marked increase over the last 3 decades. In the NHMS 1 in 1986, the prevalence was reported to be 6.3percent. Ten years later, NHMS 2 reported a prevalence of 8.3percent, an increase of 32percent. Another decade later in 2006 in NHMS3, diabetes mellitus was reported in 11percent of the subjects. This was a further increase of 32 percent over the 1996 figure.

4 CHALLENGES POSED BY MEGATRENDS

Megatrends which are discussed below pose challenges to the initiative to make agriculture sustainable and inclusive for Malaysia. Increased population, diminishing arable land, climate change, scarcity of water, farming systems, loss of biodiversity, changing energy sources and greater awareness and concern for health and depleting resources (nitrogenous and phosphoric fertilisers) are challenges that will shape the future of Malaysian agriculture. These challenges are further aggravated by the many shifts and magnified in the coming decades in the roles of agriculture for food, feed, fruit, fibre furniture and industrial uses.

4.1 Population Increase

Population increase is the single challenge that urgently calls for impact of science, technology and innovation to produce food to meet the needs over the years. From the current 29 million people in 2010, Malaysia's population is projected to increase to 35 million in 2020. The pressure on food production will be unabated and the national burden to feed the population will become more urgent with population increase to 70 million by 2050. It is expected that the competition for land for other purposes than agriculture will result in less arable land available for agriculture.

4.2 Diminishing Arable Land

More than a century ago, when the nation's population was small, the environmental degradation and concerns brought about by shifting cultivation activities was not greatly felt. Even though it has been practised for generations it is how considered destructible and unsustainable. Shifting cultivation has to be discontinued and land space has to be utilized judiciously and optimized for varied purposes. But now, that has to change because the population has grown exponentially, land for agriculture has become scarce and only marginalized land is available.

The utilization of land for agriculture has to compete equally with important needs for industries, human dwellings, and environmental conservation. The unabated conversion of the inexpensive, agricultural land parcels for other purposes will continue as rural-urban migration continues. The cost per square meter of land has become too expensive for low economic activity to give poor return on investment (ROI) as in conventional farming. Creative ways have to be developed to optimise the layers of space utilization of the cubic meter space, rather than the square meter area only. If the square area of land can be stacked vertically like that of a multi-storey building (Vertical Farming shown in Figure 4.1) then the cost per square meters of land is correspondingly reduced by the number of storeys. It is the equivalent of many folds of the same square meter area being spread vertically instead of horizontally, from the same dimension of cubic meters of space. Hence, it would be cost-effective or profitable for investment on agriculture through vertical farming in cities – (Urban Agriculture). Urban agriculture is considered sustainable because, socially and environmentally, it creates jobs for city folks (vertical farmer) and the cooling effects of the green vegetation or the CO_2 and O_2 exchanged are desired therefore urban agriculture should be promoted in the cities. It also uses less energy in transportation then reducing the carbon footprint.

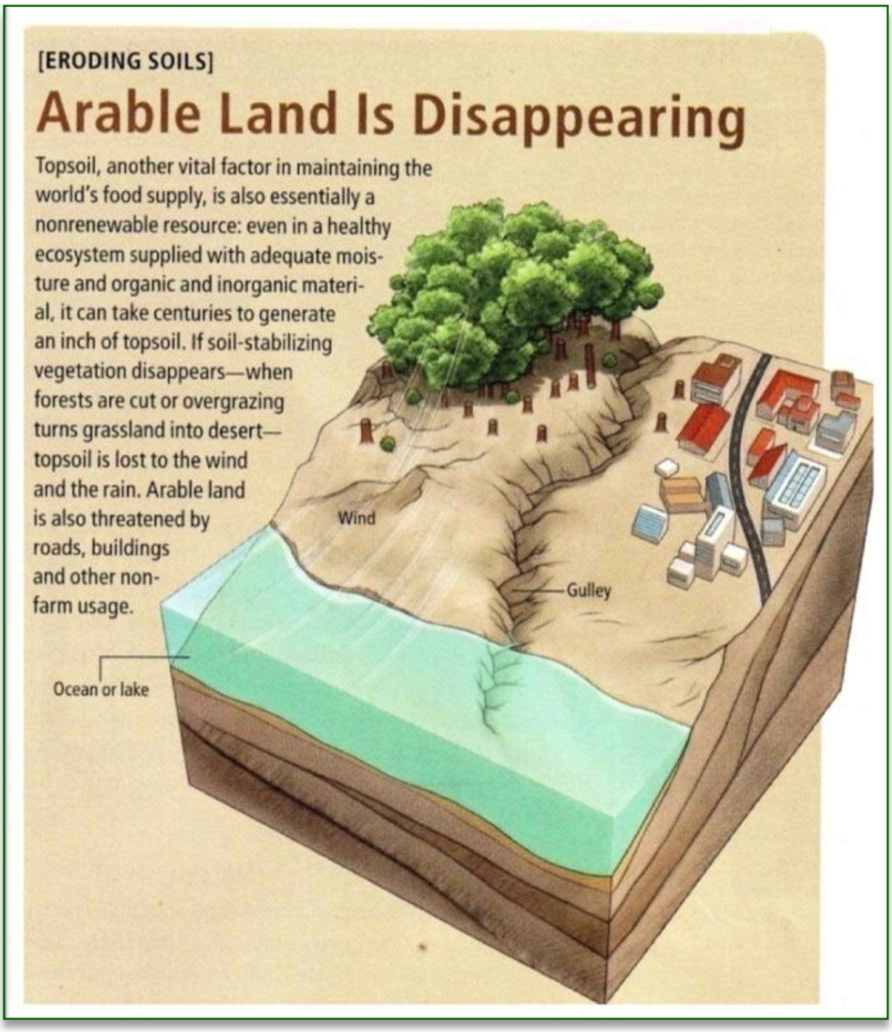


Figure 4.1: Arable land is disappearing

Land ownership: The practice of land ownership via farming since the last ten thousand years has enabled the domestication and breeding of crops and livestock for greater productivity, thereby, reducing risks of yield uncertainty from farming as compared to hunting-gathering. Opening of new land for agriculture became vigorous since the commercial planting of tree crops, especially in the clearing tracts of virgin jungle for oil palm plantations in Sabah and Sarawak. This has become a contentious issue to the global community, particularly the environmentalists, because the destruction of the rainforest has been caused for loss of species biodiversity and ecosystem niches to the chagrin of the conservationists and indigenous people.

Agglomeration of Fragmented Lands: Since land is so precious a capital to agriculture, properties and industries, the tussle for its use is being regulated by the Land Act. In Malaysia, when land tracts are gazetted as land use for agriculture, it means it is one of the most inexpensive land when compared to other classes of land. The land use code has protected much agricultural land from being converted for other industries or purposes. Since land is a state-government-matter, the federal government has little to assert on policy matters for the conversion of agricultural land to other uses. It is not in the immediate future that this issue will be overcome. The goal of agglomerating fragmented arable land holdings of the smallholders by FELCRA in the countryside to seek an economic critical-mass and sustainable size of land holdings for agriculture has been elusive for years. The crux of the problem is centred on the people, especially associated with the system of inheritance and legacy of the Malay community. It is expected that the agglomeration of fragmented holding lands (FELCRA initiatives) for agriculture will not progress much because of logistics and complex ownership problems and unsustainable critical-mass. Related to certain footprints other means of securing arable space of land for agriculture for the future has to be endeavoured. In general, most of the fragmented land areas belong to the two types of small holders. One type of smallholders is the aging rural folks who are poor farmers. The other is the investment of dynamic, capital intensive farming activities who are touted to be the future farmers who are educated, enterprising and capable to change. We deem the land for horticulture, vegeTables, aquaculture and livestock husbandry are the ones that require small-hectareage of land. This would be a megatrend of intensive-land utilization by small holders in Malaysia. Contract farming would be an appropriate solution for this problem.

4.3 Depleting Resources

According to Jonathan Foley (in special report on Managing Earth’s Future, Scientific American April 2010), extensive spreading of industrial fertilizers has upset the chemistry of the planet earth. He estimates that the use of fertilizer has more than doubled the flows of nitrogenous and phosphorus. Fertilisers used at the rate of 133 million tons of nitrogen and 10 million tonnes of phosphorus per year and caused widespread water pollution, degradation of numerous lakes and rivers and disruption of coastal oceans by creating dead zones. The estuarine aquatic life is adversely affected. Several articles on this subject have lately emerged to argued farmers to reduce the dependence on inorganic fertilisers, which are petroleum-based fertilizer from fossil fuels. Some of the recommended ameliorating strategies are to reduce the use of inorganic fertilizers, reutilizes animal waste as organic fertilizer and to process human wastes.

4.4 Climate Change

The world's agriculture in 2050 would be mix and varied in terms of what would be because of the pronounced and wider roles of agriculture in food, feed, fuel, furniture and fibre The defining elements or factors that will shape agriculture include biodiversity loss, nitrogen and phosphorus cycles, climate change, land use for agriculture, ocean acidification, freshwater use and stratospheric ozone depletion. Although there are many and diverse elements and factors but we surmised that Climate Change, Water, Energy, Health and Biodiversity and their interactions will impact greatly on agriculture towards 2050.

Climate change brings the gamut of tumultuous and unpredictable weather extremes, but with the certainty of increase in global atmospheric temperature (Figure 4.2). Some of the predicted consequence of Climate Change that can adversely affect agriculture would be delayed monsoons, increase salinity of coastal arable lands, loss of coastal arable land due to increase sea level, increase frequency of floods and extensive droughts to cause crop failures, (hence flowering and fruiting seasons and seasonal abundance of wildlife in the lower food chains).

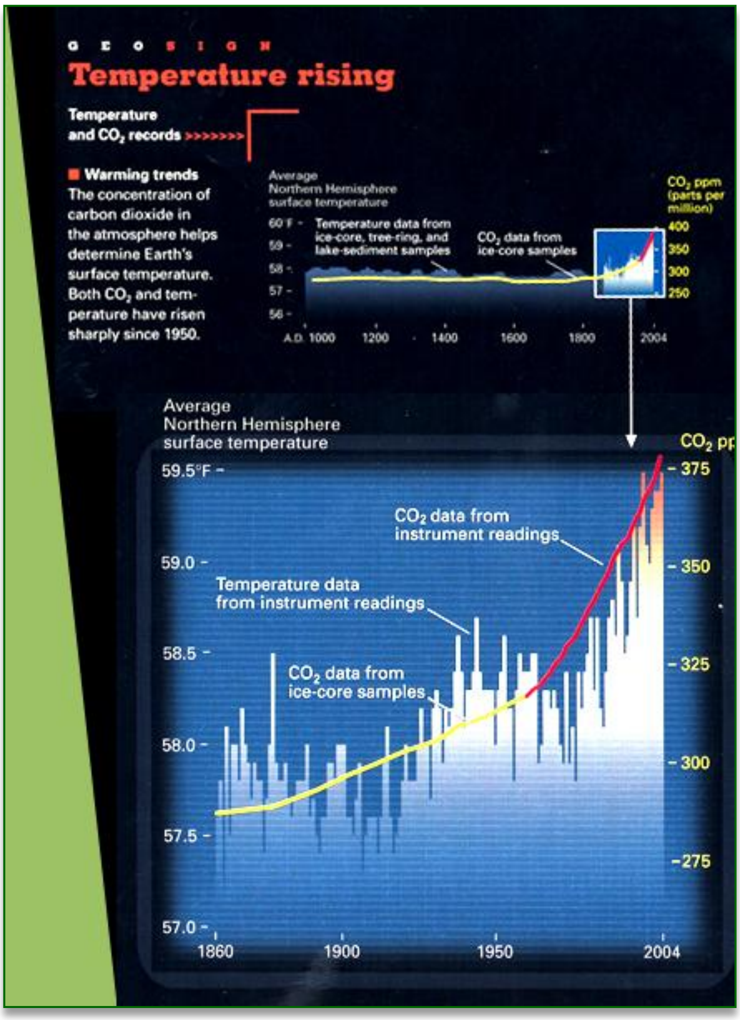


Figure 4.2: Temperature rising

Farmers worldwide are facing the brunt of disastrous droughts in many other parts of the world after reduce agricultural productivity. The world had experienced many foretastes of the global Climate Change that caused droughts, for example, the recent prolonged and unprecedented droughts to cause crop failures and farmers been displaced in the Murray Darling basin of Australia and the recent migration of 300 000 people to the cities in Syria due to crop failures too. Apart from crop failures, Climate Change will see higher sea level that will probably render coastal arable land to be under water and become non-arable.

4.5 Loss of Connectedness of the Ecoweb

Chain effects of altered weather, temporarily altered seasons, disrupt pollination efficacy, reduced fruit sets and yield, altered species abundance and distribution and altered homeostatic balance of the rainforest ecosystem, hence causing disruption to the agroecosystem, eventuating to crop loss and unpredictable yield, and affects the agriculture commodity market (Figure 4.3). The spectre and chains of consequences triggered by Climate Change is definitely emerging as one of the most impactful element that shapes and defines our agriculture towards 2050. If the protracted global atmospheric temperature increases by 2 Celsius it would be disastrous to the total homeostatic balance of the rainforest ecosystem, consequently the agroecosystem too. As it is, the species-diversity and huge biomass of rainforest ecosystem contribute to the stochastic stability of the homeostatic balance of the rainforest that the profound impacts of Climate Change will definitely alter and deeply dishevell the biorhythm of the rainforest, specifically the loss of connectedness of keystone species and resulting in the loss of connected order of ecoweb in the food chains in both the rainforest and the agroecosystem. Hastened and increased species extinction rate will unravel the ecoweb of connectivity between species and alter the stochastic balance of the rainforest's homeostasis. It is predicted that Climate change will cause delayed monsoons triggering a chain of stochastic events of synchronous flowering season and reduce fauna species abundance that may serve as keystone species of pollinators that sustain the rainforest biodiversity. Delayed monsoons will cause delayed flowering season to cause delayed and reduced fruit sets that unable to provide sufficient food source for the diversity of the rainforest species. Delayed monsoon means delayed fruiting season and it also means delay in the seasonal abundance of pollinators that provide pollination services and decline in wildlife that depend for food from wild fruits. The migratory seasons of bees, especially the pollination activities of the carpenter bees and honey bee species like *Apis dorsata*, *A. cerana*, *A. andreformis* . will be affected too. Therefore, there would be total eschewed fruiting seasons and the abundance of wildlife and conservation strategies will be affected.

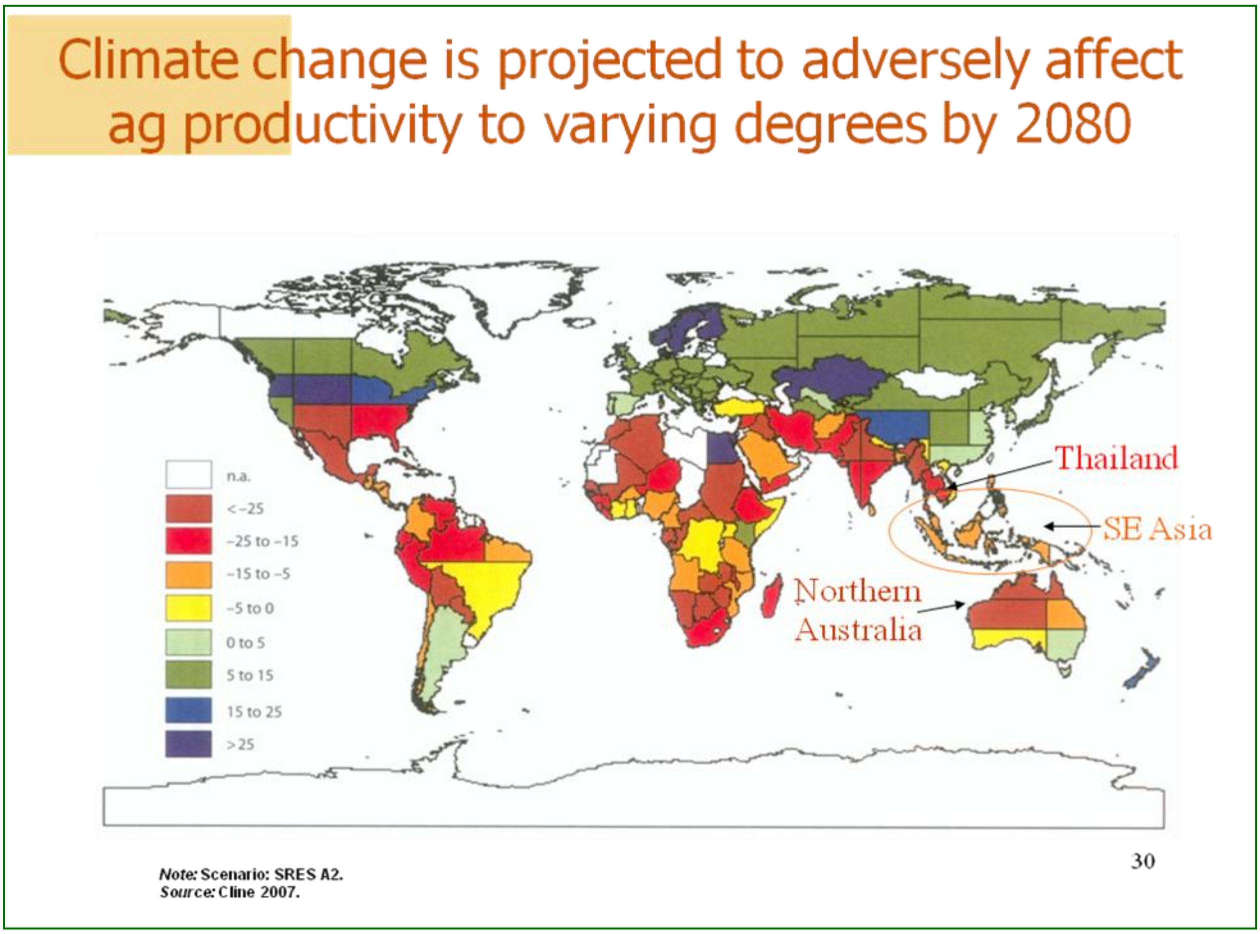


Figure 4.3: Climate change is projected to adversely affect agriculture productivity to varying degree by 2080

Yield of fruit and orchard crops affected: The damage to the fruit yields of many tropical crops and orchards of the Malaysian agriculture industry would result in pollination and fruit set failures, delayed monsoons resulting in loss of synchrony between the flowering seasons and forest-fauna abundance, altered biological rhythm of the flora and fauna species to the altered forest biomass, and crop losses due to floods and droughts (Figure 4.4). Fruit yield of oil palm, cacao, coffee and many tropical fruits like Durians, Rambutan, Mangoesteen. will definitely be affected by floods and droughts. An atmospheric temperature increase by 1 degree Celsius will cause a 15 percent drop in crop yield, especially rice. The range of temperature extremes and unpredictable weather poses great problems to the false onset of flowering seasons and thereby wrecking the synchrony and bio-rhythm of the flora and seasonality of the wildlife in the forest. The seasonal abundance of insect pollinators like bees in the orchards and *Elaedobius* weevils in the oil palm plantations will equally be affected by the temporal shift and synchrony change of the flowering and the fruiting season. Seasonality of durian will change to become a seasonal but will also lead to loss of biodiversity, just like the other fruits and flowers in the forest. Logistics and price of the crop commodity will change too. The abundance and distribution of pollinators ranging from birds, bats, bees, butterflies and weevils would affect pollination efficacy to oil palm (cantharophily – weevil pollinated), durians (chiropterophily – bat-pollinated) and other fruit crops like starfruit, mango. will invariably show changes. Delayed in monsoons by 10-15 days are expected and that will lead to an equally delayed blooming period for Malaysian fruit crops like durians, mangoes, rambutans, langsat, mangosteen, star fruit, etc. and as a consequence, will change or disrupt the logistics arrangement for the transportation and marketing of fruits.

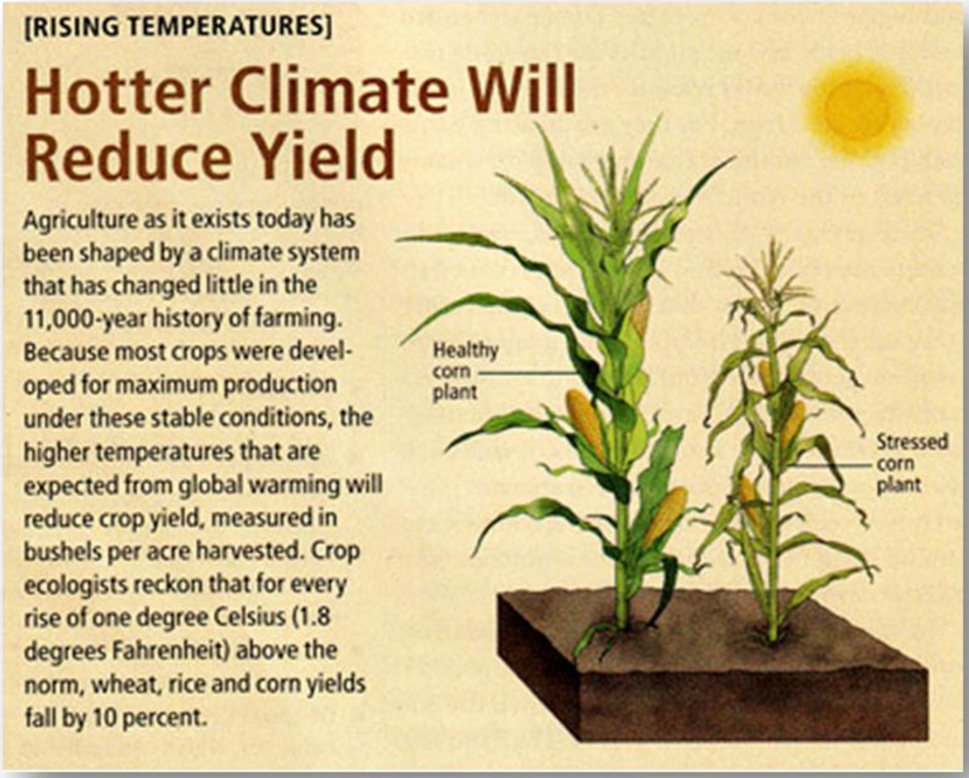


Figure 4.4: Hotter climate will reduce yield

Corollaries of the Climate-Change Kind: Under the circumstances of Climate Change and exponential population increase, it is indeed a daunting task for the world's agriculture to meet the world's food needs in the coming decades of the mid-century in 2050 (Figure 4.5). It would be doubly difficult with the intertwined problems of growing population coupled with relentless impacts of Climate Change on the world's food production system to produce food, feed, fuel, furniture, fibre and raw materials for the human populace with further marginalised arable land for agriculture. The human race, and especifically the agriculture scientific community, must rise to the challenge and resort to radical changes in the way we practice our agriculture for sustainable growth. The quest for sustainable development requires us to be inclusive in that we have to take account of the spin-offs, wastes, fate of chemical residues and excesses that are beyond the capacity of the homeostatic environment to cope with.

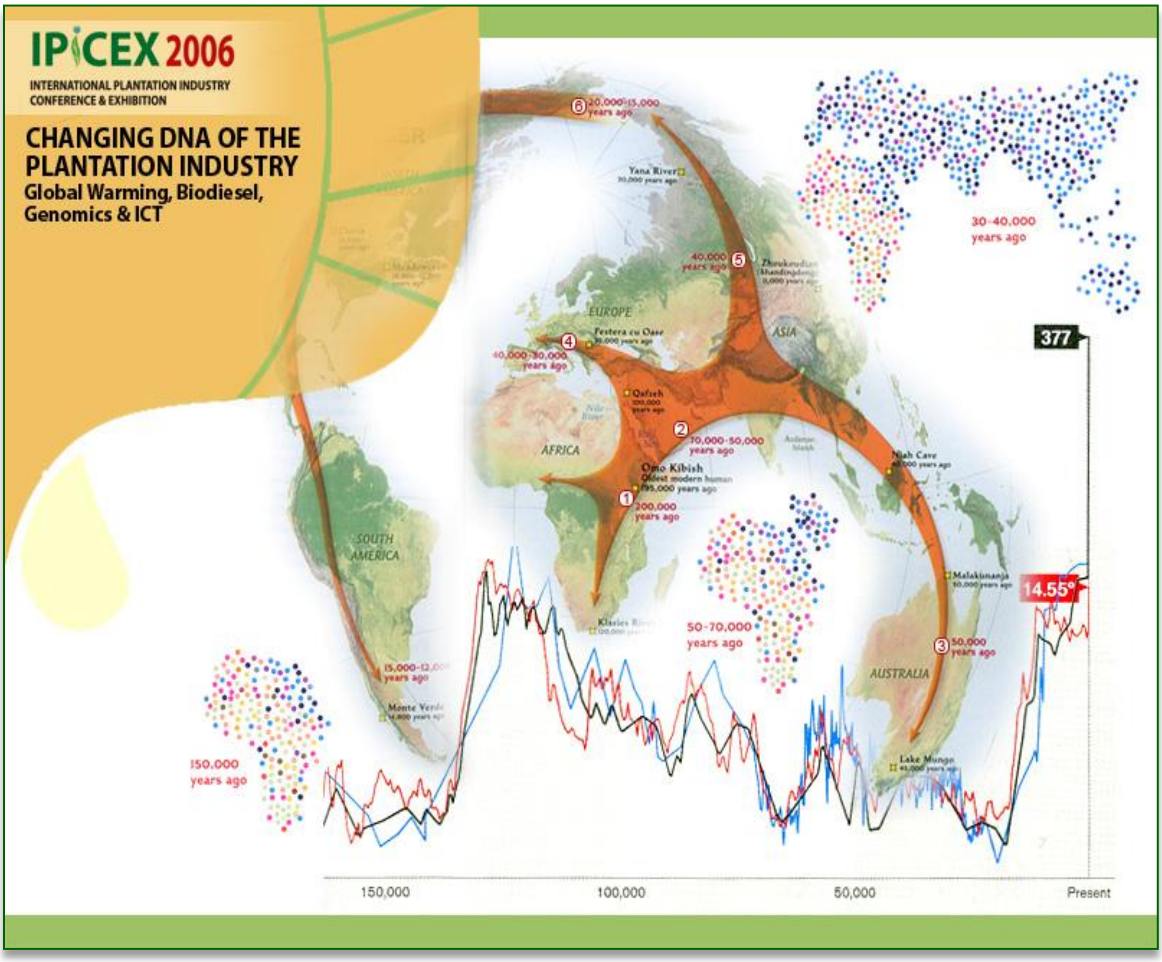
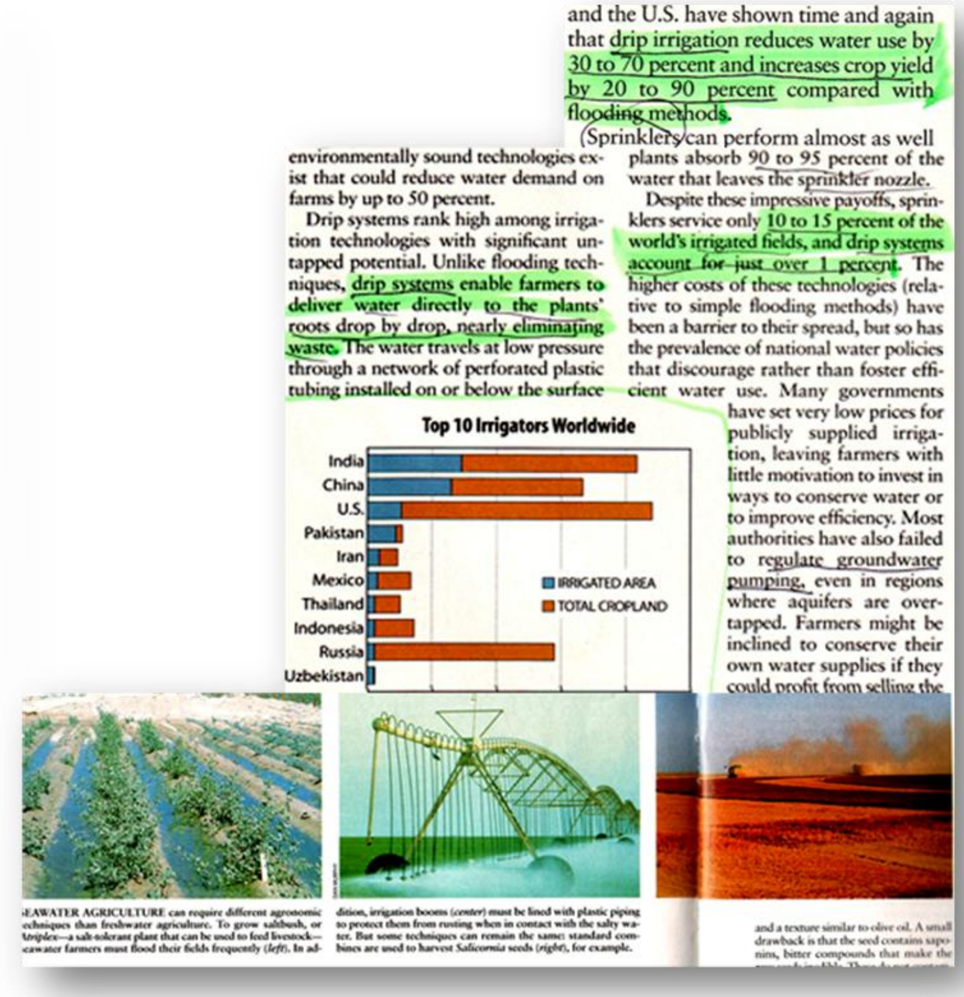


Figure 4.5: Changing DNA of the plantation industry

Carbon Emissions: Agriculture is both emitting as well as sequestrating carbon from the atmosphere. The world is increasingly mindful of the carbon footprint. According to the Wetland International, the world's wetlands usually become man-induced carbon emissions from bogs, mires, marshes, swamps and fens which amount to an estimated 1.3 billion tons per year The world's wetlands are big sources of greenhouse gases Climate Change, through human activity of exposing them into oxidative process of the atmosphere via drainage, fire, dried-up bogs. It emits about 6percent of the man-made CO_2 emissions. According to the estimates of the Economicst magazine, both Malaysia and Indonesia are in the top 10 countries in the world that contribute to the man-made carbon emissions from the wetlands through deforestation or turning swampy peat land into oil palm plantations. There is a growing international pressure to curb the expansionary clearing of swampy peat land into oil palm plantation and there will be closer global monitoring of this incidence by labelling and traceability system using satellite imagery and other ICT complements. The Guido van der Werf of the Free University of Amsterdam reckons that tree-felling or clearing for plantation accounts between 12-20percent of man-made carbon emissions to the atmosphere.

4.6 Water

Water is the essence of plant and animal life on earth and hence agriculture. We look for traces and indicators on the presence of water on other planets in the search for earth-like life-forms in outer space. Human searched for fossils records of farming along great rivers of the world (Nile, Danube, Tigris and Euphrates, Yangtze) where water is critical to agricultural activities and as a major means of transportation in rural areas. Water is a constrained and scarce resource that we have to rethink and radically change in the way we procure and utilize them by 2050. More than 70percent of freshwater is locked in ice and more than two-thirds of available water is being used for agriculture. When the polar ice caps (north and South) melt, triggered by Climate Change, that equation of the global freshwater and availability and sea level will definitely change. Every year there will be about another 83 million mouths to feed and water supply is running short. It is expected that more than 1.8 billion people will live in regions of severe water scarcity in the next 15 years. The future of water availability and quality in the coming decades look grim (Figure 4.6). The current conventional practice of agriculture utilizes lots of water, especially in the growing of paddy, need to change how water is made available with increated timeliness. With the expected paucity of rains in some areas and the arrives of unprecedented floods, water for agriculture need to be regulated and conserved in terms of its use in agriculture.



and the U.S. have shown time and again that drip irrigation reduces water use by 30 to 70 percent and increases crop yield by 20 to 90 percent compared with flooding methods.

Sprinklers can perform almost as well

environmentally sound technologies exist that could reduce water demand on farms by up to 50 percent.

Drip systems rank high among irrigation technologies with significant untapped potential. Unlike flooding techniques, drip systems enable farmers to deliver water directly to the plants' roots drop by drop, nearly eliminating waste. The water travels at low pressure through a network of perforated plastic tubing installed on or below the surface

plants absorb 90 to 95 percent of the water that leaves the sprinkler nozzle.

Despite these impressive payoffs, sprinklers service only 10 to 15 percent of the world's irrigated fields, and drip systems account for just over 1 percent. The higher costs of these technologies (relative to simple flooding methods) have been a barrier to their spread, but so has the prevalence of national water policies that discourage rather than foster efficient water use. Many governments have set very low prices for publicly supplied irrigation, leaving farmers with little motivation to invest in ways to conserve water or to improve efficiency. Most authorities have also failed to regulate groundwater pumping, even in regions where aquifers are overtapped. Farmers might be inclined to conserve their own water supplies if they could profit from selling the

SEAWATER AGRICULTURE can require different agronomic techniques than freshwater agriculture. To grow saltbush, or *Atriplex*—a salt-tolerant plant that can be used to feed livestock—seawater farmers must flood their fields frequently (*left*). In addition, irrigation booms (*center*) must be lined with plastic piping to protect them from rusting when in contact with the salty water. But some techniques can remain the same: standard combines are used to harvest *Salicornia* seeds (*right*), for example.

and a texture similar to olive oil. A small drawback is that the seed contains saponins, bitter compounds that make the

Figure 4.6: Top 10 irrigators worldwide

Reduced water wastage: Malaysia experiences high rainfall (> 2000 mm of rainfall/year) and hence water overflows the riverbanks to cause floods that bring alluvial soils along riverbanks for agriculture to take a foothold. Agriculture, especially paddy-growing, utilizes a lot of water but about 50% of the water supplied is wasted away. Some of this excess water are redirected for drainage, but some are dammed and channeled into canals for irrigating paddyareas in MADA, KEMUBU. and more often water is being drained from water-logged areas. Other sources of freshwater from aquifer and underground water can be made available but reduced wastage will be ensured by the use of improved water technologies. The current excessive and wasteful use of water by the agriculture sector will change towards more prudent and efficient use of water where water distribution and delivery to the plants will be calibrated through various technologies, ranging from inundation/flooding via irrigation and draining water via drainage canals, overhead sprinkler, fertigation, time-lapse sprinkler, sensor-controlled devices, drip irrigation, pumps, water desalination and purification technologies, and other methods to ensure the optimal use of water will be adopted for agriculture. For example, paddy-growers in the MADA, KEMUBU and other paddy-growing areas can follow the footsteps of rice-growers in Madagascar, where they have figured out ways to increase yield with less usage of water. Rice seedlings are transplanted weeks earlier than is customary, space the plants farther apart, and keep the paddies unflooded during most of the growing season. That means they have to weed more, but also it increases yields fourfold to sixfold. Now that practice is fully adopted by more than 20 000 farmers in the country,. In the coming years of Climate Change era, we will have to be more efficient in the utilization of water with greater calibration and regulation in order to conserve water. Perhaps, apart from dam irrigation, groundwater irrigation is needed to complement the sustainable and continuous availability of water source for paddy-growing from the dam. This will ensure water supply to avert crop losses from droughts in the Muda and Kemubu area.

Irrigation Modernization: Modernization of irrigation system is a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms, if required, with the objective to improve resource utilization (labour, water, economics, and environment) and water delivery service to farms (FAO, 1999).

Modernization implies changes that may occur at all operational levels of irrigation schemes from rainfall harvesting and capturing of the water supply, to its conveyance and to the final distribution at the farm level. This "integrated" definition is a major step forward and a departure from previous modernization approaches executed along disciplinary lines of actions, with disregard of other much needed complementary players. Thus, unless irrigation modernization is perceived and executed under such a multi-disciplinary approach it is bound to fail. Agricultural drainage is an integral component of irrigation.

Cosgrove and Rijsberman (2000) summarized the role that irrigated agriculture play as: "The more food we produce with the same amount of water, the less the need for infrastructure development, the less the competition for water, the greater the local food security, and the more water remains for household and industrial uses. And the more that remains in nature." Clearly, it is possible to produce more food while securing water resources sustainability if we introduce new technologies and approaches to both water and irrigation management. This includes, among others, a more efficient water reuse, improved water delivery in quantity, quality and timing, supplementary irrigation costs reductions, and development of new water sources at lower economical, social and environmental costs. The practice of precision farming will ensure high water productivity in irrigated agriculture.

To boost up agricultural production, good water management practices are essential in all paddy granaries and other crop growing areas. Each system is unique, both in terms of its physical and managerial structures. Irrigation professionals and crop growers need to be familiar with the advanced technologies which are appropriate for their situation. Farmers' participation in irrigation water management will be enhanced through the water user groups based on tertiary canals. Modern and new perspectives for planning and design of irrigation and agricultural drainage systems involve new theories, concepts, technologies, methodologies, computer models and research findings. More investments are expected in instrumentation for data collection and monitoring irrigation water use and disposal. In addition, professionalism needs to be instilled at all levels of planning, designing, implementing and operating an irrigation and drainage system.

Innovations in rice production, which have been demonstrated in over 40 countries, include increased yield (50-100% or more), a reduction in required seed (up to 90%) and water savings (50% or more). The System Of Rice Intensification (SRI) -- *le Systéme de Riziculture Intensive* in French and *la Sistema Intensivo de Cultivo Arrocero* (SICA) in Spanish -- is a methodology for increasing the productivity of irrigated rice by changing the management of plants, soil, water and nutrients.

SRI, which originated in Madagascar, leads to healthier soil and plants supported by greater root growth and the nurturing of soil microbial abundance and diversity. In its simplest form, SRI involves carefully planting single, young seedlings (8-12 days old) at a wide spacing (25 cm or more), keeping soil moist but well-drained and aerated, adding compost or other organic material to the soil when possible.

The agroecological principles that contribute to SRI effectiveness have good scientific bases. SRI concepts and methods have been successfully adapted to upland unirrigated rice, and they are now being extrapolated to other crops like millet, wheat and sugar cane. Many SRI users also report a reduction in pests, diseases, grain shattering, unfilled grains and lodging. Additional environmental benefits stem from the reduction of agricultural chemicals, water use and methane emissions that contribute to global warming. SRI *does not require* the purchase of new seeds or the use of new high-yielding varieties. Although the highest yields with SRI have been obtained from improved varieties, most traditional or local varieties of rice respond well to SRI practices and command a higher market price. And while chemical fertilizer and agrochemicals can be applied with SRI, their use is not required as organic materials (compost, manure or any decomposed vegetation) can give good or even better results at low cost. Farmers report that when SRI methods are used correctly, rice plants are better able to resist damage from pests and diseases, reducing or eliminating need for agrochemical protection.

Because plant populations are greatly reduced with SRI, seed costs are cut by 80-90%, and because paddy fields are not kept continuously flooded, there are water savings of 25 to 50%, a major benefit in many places. However, cessation of flooding means that increased weeding is required. If this is done with soil-aerating implements like a rotating hoe, this cost has a benefit of enhanced crop production.

SRI *does require* skilful management of the factors of production and, at least initially, more labour, particularly for careful transplanting and for weeding. Since yield increases are usually 50 to 100%, and possibly several times present levels, the returns to labour can be very great. The profitability of rice production can be greatly increased when yield goes up with a reduction in the costs of production. As farmers gain skill and confidence in SRI methods, their labour input in fact decreases, and over time SRI can even become labour saving compared with conventional rice-growing methods.

SRI is a work in progress, with improvements continually being made, including better implements and techniques that further reduce labour requirements. Farmers are encouraged to make their own improvements in SRI methods and to share experience within the farming community. Yield is the most evident (and controversial) feature of SRI, but many other considerations are also driving its spread around the world. Additional benefits of SRI are resistance to drought and storm damage, shorter time to maturity, and more milled rice resulting when SRI paddy is processed.

i) SRI Management Practices

SRI increases rice production and raises the productivity of land, labor, water and capital through different practices for managing:

Rice plants - Seedlings are transplanted *very young* -- usually just 8-12 days old, with just two small leaves; *carefully and quickly* to have minimum trauma to the roots; *singly*, only one per hill instead of 3-4 together to avoid root competition; *widely spaced* to encourage greater root and canopy growth; *in a square grid pattern*, 25x25 cm or wider -- 30x30 cm or 40x40 cm, even up to 50x50 cm with the best quality soil.

Soil - This is kept moist but well-drained and aerated, with good structure and enough organic matter to support increased biological activity. The quality and health of the soil is the key to best production.

Water - Only a minimum of water is applied during the vegetative growth period, and then only a thin layer of water is maintained on the field during the flowering and grain filling stage. Alternatively, to save labor time, some farmers flood and drain (dry) their fields in 3-5 day cycles with good results. Best water management practices depend on soil type, labor availability and other factors, so farmers should experiment on how best to apply the principle of having moist but well-drained soil while their rice plants are growing.

Nutrients - Soil nutrient supplies should be augmented, preferably with compost, made from any available biomass. Better quality compost such as with manure can give additional yield advantages. Chemical fertilizer can be used and gives better results than with no nutrient amendments, but it contributes less to good soil structure and active microbial communities in the rhizosphere than does organic matter. At least initially, nutrient amendments may not be necessary to achieve higher yields with the other SRI practices, but it is desirable to build up soil fertility over time. Rice-root exudation, greater with SRI, enhances soil fertility.

Weeds - Since weeds become a problem in fields that are not kept flooded, weeding is necessary at least once or twice, starting 10-12 days after transplanting, and preferably 3 or 4 times before the canopy closes. Using a rotary hoe -- a simple, inexpensive, mechanical push-weeder has the advantage of aerating the soil at the same time that weeds are eliminated. (They are left in the soil to decompose so their nutrients are not lost.) Additional weedings beyond two increases yield more than enough under most conditions to justify the added labor costs.

The reported and validated benefits and contribution to resilience and climate change adaptability of SRI is shown in Table 4.1 below. (Adapted from: Africare, Oxfam America, WWF-ICRISAT Project (2010). More Rice for People, More Water for the Planet. WWF-ICRISAT Project, Hyderabad, India.)

Table 4.1: Contribution to Resilience and Climate Change Adaptability and benefits of SRI Management Practices

Reported and Validated Benefits	Contribution to Resilience and Climate Change Adaptability
Higher yields per unit of land, labor and capital invested	Grain yields are increased on average by 20-50%, but often more. This not only generates more food, but releases some land and labor for other productive activities. Higher productivity per unit of land reduces pressure to expand cultivated area at the expense of other ecosystems.
Lightened workload for women	Women farmers widely report that SRI methods save them time and reduce the drudgery of rice cultivation, due to less time for nursery management and transplanting, ease of working with smaller seedlings, and less time laboring in standing water. It frees their time for activities of their choice (such as vegetable growing for profit or improved family diet) and enables other family members to seek non-farm employment, thereby diversifying household income.
Reduced requirements for irrigation water	With SRI, irrigation water use is generally reduced by 25-50%, as water is managed to maintain mostly aerobic soil conditions. Farmers can continue to cultivate rice where water is becoming scarcer or rains unpredictable, and can mitigate losses from late monsoons or less rainfall. Less water used at the head of canals means more water is available for farmers at the end. Water can be freed up for other crops and people, and for the maintenance of

Reported and Validated Benefits	Contribution to Resilience and Climate Change Adaptability
	natural ecosystems.
Reduced seed rate	Since farmers need 80-90% fewer seeds for transplanting, they need much less space to sow the seed nurseries. Flooded nurseries are planted with a seed rate of 50-75 kg/ha whereas SRI nurseries are planted with a seed rate of only 5-7 kg/ha, leaving farmers more rice to use for food rather than planting. Smaller nurseries are easier to manage and require a lot less land.
Reduced reliance on chemical fertilizers, herbicides, and pesticides	The high and rising cost of fertilizer and other inputs is one of the main attractions for farmers to use SRI as it allows them to reduce chemical applications without loss of yield. Fewer chemicals around farmsteads have health benefits for people and their livestock. Reduced chemical loads and better soil and water quality has beneficial effects throughout the environment.
Resistance to lodging and storm damage (possibly also cold spells)	Climate change is contributing to more frequent and more severe storms, which cause rice plants to fall over or lodge. This can be devastating to farmers. A fallen crop is vulnerable to rotting and also more difficult to harvest. SRI practices produce stronger straw (tillers) and larger, deeper root systems that make rice plants less susceptible to being blown down or pushed over.
Increased resistance to pest damage	Climate change is expected to increase the prevalence and distribution of pest species as temperatures and rainfall patterns change. With SRI management, farmers observe less loss to pests and diseases even though they use fewer agrochemicals
Increased drought tolerance	SRI rice plants exhibit stronger root systems that grow deeper into the soil profile. At greater depth they can access deeper reserves of soil moisture (and nutrients). This is particularly important given the increasing risk of rainfall variation during the growing season.
Shorter growing season	SRI crops can often be harvested 1-2 weeks, even sometimes 3 weeks earlier than the same variety conventionally grown. This has economic and environmental advantages. Farmers can use the same field for a short-season crop like a vegetable, or can plant a following crop sooner to get higher yield. A shorter growing period reduces water needs and the crop's exposure to pests and storms that arrive late in the season.
Fewer seeds and faster time to planting give more flexibility	If a farmer's crop succumbs to adverse weather patterns, farmers can more easily find the seeds and time to replant the nursery and replant the crop since SRI requires only one-tenth of the seeds, and seedlings can be planted within 8-15 days of sowing, rather than 30-45. People who must travel after planting to find paid work can do so much sooner, and if they have to return to replant a failed crop,

Reported and Validated Benefits	Contribution to Resilience and Climate Change Adaptability
	they only have to come home for a short time.
Increased production and marketing potential from traditional varieties keeps them viable	With SRI methods, farmers are able to achieve higher yields from their traditional varieties, most of which are better adapted genetically to a range of climate stresses. These local varieties often command a better price in the market. Rice biodiversity has plummeted since the 1960s; however, studies show many traditional varieties offer higher iron and protein content. Rehabilitation and conservation of landraces and local cultivars can give more genetic diversity for dealing with adverse growing conditions, maintaining robustness in the systems.
Improved farmer knowledge experimentation and innovation	Good SRI extension promotes farmer initiative and evaluation. It encourages farmers to take more responsibility for adaptation and innovation, contributing to human resource development in rural areas and the prospect of farmers being able to identify and exploit other innovations as they emerge.
Diversified cropping systems	With higher yields per unit of paddy land, some farmers convert part of their land to growing more nutritional and more profitable crops such as fruits, vegetables, legumes and small livestock that diversify their diets and raise incomes. Reductions in chemical use make farming systems more compatible with fish, ducks and other non-crop components. More diversification of cropping systems helps to restore biodiversity and sequester carbon in the soil.

Bioremediation and Purification: The cultivation of oil palm, rubber, cacao, paddy, pepper and vegetables and the rearing of pigs, goats, dairy cows, poultry, aquaculture and quails require lots of water and leaves effluents to pollute the environment through the processing factories and production farms. The needs to be prudent and unwasteful in sourcing and using water there would be great probability that agriculture industries will have to treat water, before or after use, so as not to pollute the environment, Water contained in the effluents, pollutants and wastes from these agricultural activities need to be treated and recycled or even be bio-remediated, desalined or purified even up to the level of the water becoming drinkable. Desalination and purification technologies are currently fast becoming important and the demand for compliancy to the environmental standards for water is conceivable in the near future.

Saline water, Water Footprints of Agricultural Produce and Water use under Controlled-Environment Agriculture: More than 80percent of the world's population lives less than 100 miles from water; especially arable coastal land areas. These coastland areas will be affected by increased salinity from increased sea level from Climate Change. It has become a research imperative to breed several cereal crops like rice, wheat, sorghum, etc. that are tolerant to grow in saline conditions and tolerant to withstand water-logged conditions for longer periods of more than 2 weeks.

Water Footprints: Virtual water or water footprints of farm produce is similarly conceptualized by Tony Allan as to educate the public about the amount of water used to create a product. Tony Allan prompts a sense of proportion and sense of comparative judgement by providing an equation of water equivalents to produce or create a product. Put simply, when a pound of beef is served at the dinner Table it has virtually used up about 1,857 gallons of water or a water footprint. We need between 7-15 kg of cereals to produce a kilogram of meat. Apart from that the carbon footprint to produce 1 kilogram of meat is 17-30 kg of carbon. We can compare how much water and carbon footprints (or carbon emission/sequestration) are involved if the matrix Table on the production of all forms of food, feed, fibre, fuel, furniture and other produce. These parameters will increasingly condition the behaviour of people in their preference of food choices. Literally, a human diet that regularly includes meat requires 60percent more water footprints than a diet that is predominantly vegetarian (National Geographic, April 2010). Creating the awareness on the amount of virtual water to create a product it promotes prudence in the use of constrained resource such as water, via the labelling of water footprints (like carbon footprints). Consequently this will promote greater care and prudence on how agriculture will utilize water in the coming decades; away from the current of 70percent use of available water for agriculture. Water is the elixir of life. The future availability of water will have to face the realities that clean unpolluted water will not be easily available. Available water in the surroundings, even though polluted and with effluents and wastes, will be treated, bio-remediated, recycled and purified before and after use in the farming and processing activities in the controlled environment setting. Water would be more efficiently managed for crop and livestock needs under the controlled-environment setting of vertical farming and urban agriculture. In this controlled-environment conditions everything is accounted for and water from crop plant transpiration can be retrieved and piped, purified and even be bottled into a drinkable water. The environmental requirement of urban farming to ensure no foul odour to pollute the city's atmosphere would easily become a situational compliancy requirement in the future.

Water Footprints and Efficient Use of Water for Agriculture

Just like how we become mindful about the carbon footprints we should be equally concerned about the water footprints involved in agriculture production. Climate Change on finite earth is prompting us to be inclusive and sustainable in all our thoughts and deeds. The conspicuous consumption and voluminous use of water amounting to more than two-thirds of the worlds freshwater for agriculture is a major concern. The world's agriculture has to be more efficient in the use of water and proper calibration of water use for agriculture must be changed for effective use. We can expect there would be major positive change in how water is being channelled from dams or irrigation canals into the paddy plots. Now that rains come in unpredictable amount and time, it punctuates into droughts and floods that eventually lead to crop yield losses. Precise regulation and calibration of water for paddy-growing would require improved infrastructers that water can be efficiently managed and conserved. On the overall, fertigation or other economical or efficient utilization of water for agriculture would be pursued in research endeavours. Even more so, efforts on the molecular breeding of crops (transgenic) that tolerate higher salinity, use less water due to increase sea level, would be endeavoured. The success would enable wider arable coastal land will be available for agriculture.

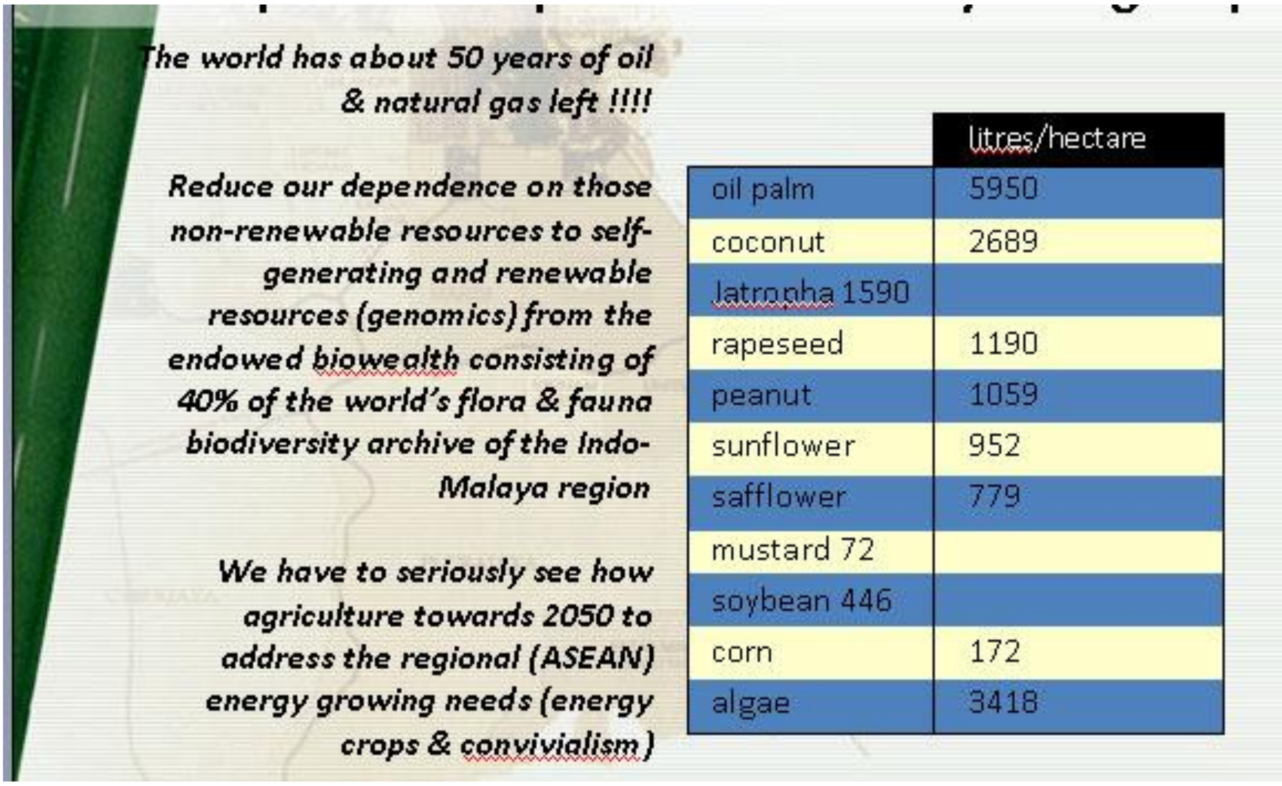
Where necessary water use for agriculture has to be efficiently managed in that there should not be unnecessary disposal of low quality water into the environment. Why use sprinkler when once can sufficiently use fertigation technique? Why channel the whole river stream when you can temporally regulate and irrigate the water from the dam?

According to Peter H. Gleick in his contributing article on Managing Earth's Future (Scientific American, April 2010), he contends that improvement in water-use efficiency are possible in every sector of the economy. More food can be grown with less water (and less water contamination) by shifting from the conventional flood irrigation to drip and precision sprinklers, along with more accurately monitoring and managing soil moisture. Malaysia maybe a country with high rainfall but pollution and contamination of water can render the voluminous water that nature gives us to become unusable, if we do not control how our agriculture uses and dispose it into the waterways.

4.7 Energy

The world's energy supply is fast shifting toward the utilization of a more diversified energy sources including renewable resources like crops. Humans are now diversifying their sources of energy such that agriculture farms in the developed and developing countries would be redefined in terms of its activities and landscape; for example, recycling of wastes into biofuel (Figure 4.7). It is expected that when the economic integration of ASEAN materializes it would be expected that the shift from the dependence on fossil energy to renewable energy will be pursued collectively by ASEAN countries, hence, there will be regional embarkation on energy crops too. This is evident from the independent initiatives of energy policies in the various ASEAN countries. There should be a regional policy cooperation in energy and agriculture (ASEAN), or a regional, mixed energy policy will be pursued. Indeed, this will change the landscape of the agriculture in the ASEAN countries in several decades. Already, Korea and China are going offshore to plant oil palm in Africa and Madagascar for the fuel and food needs. It is even more interesting that Mitsui Engineering of Japan is working with Dong Energy of Denmark to embark on the attempt to convert oil palm into ethanol for green energy program. The small holding ecosystem seems to be the most likely choice for investment in energy crops like Jatropha, etc.

Growing energy crops: Jatropha, a Euphorbiaceae family, is a potential energy crop that is currently being researched by the Rubber Research Institute for possible utilization as alternative energy crop in Malaysia. Jatropha is a non-edible, renewable energy source of energy that can grow well in sandy and marginal soils, especially coastal lands of Terengganu. Conceivably, there are two aspects of the Malaysian agriculture that we think significant contribution will be impacted, in terms of food and fuel. Malaysia has range of choices from her energy portfolio to choose from, for either renewable or non-renewable energy sources viz. oil and gas, coal, solar, wind, biofuel, etc. We believe the newly formed energy commission will probably adopt a mixed energy policy that ties the energy needs to the resources available and chances are there will be some apportionment of policy focus on the use of biofuel from energy crops that can be derived from palm oil, jatropha, Nipah, etc. If the strategy is on diversification of energy from the renewable resources, then palm oil will feature in making the complement of energy sources for the country.



	litres/hectare
oil palm	5950
coconut	2689
Jatropha 1590	
rapeseed	1190
peanut	1059
sunflower	952
safflower	779
mustard 72	
soybean 446	
corn	172
algae	3418

Figure 4.7:Biodiesel production per hectare of oil-yeilding crops

4.8 Health

The concept of sustained well-being cannot be divorced from the fitness or health of humans and agriculture. The quality of food that we eat gives us food nutrients in the form of vitamins, sugar, proteins, salt, etc. A profile study on the top 100 shopping items by Yale University's Quality Index scores foods from 1 to 100, based on nutrients, sugars, vitamins, salt, etc. should similarly be done on the Malaysian food chain bought at the local supermarket, so that the public can use it as a guide in terms of how nutritious these foods are from the supermarket. Herbs, pharmaceuticals and neutraceuticals are great prospect for agriculture with the health industry. The potentials of many locals herbs and plants for medicinal use in commercial scale, for example, Tongkat Ali, Kacip Fatimah, Hempedu Bumi, Misai Kucing. create great opportunities for the growing of the plant species in commercial agriculture scale. It is even more interesting that Vertical Pharming is identified as the potential for future growth areas of job in the future.

4.9 Biodiversity, Genomics and Genome Engineering

Biodiversity wealth and loss of the rainforests: Humankind already commandeers 35% of Earth's land surface for crops and pastures, and expanding agriculture is the prime motivation for clearing new land, thereby destroying natural ecosystems, especially the rainforests. Land development is causing one of the greatest extinctions in Earth's history and Malaysia is one of the major global players in this role in the United Nation's REDD program (Reduced Emissions from Deforestation and Forest Degradation). The enormous wealth of genetic information or biodiversity of the rainforests species of the country serves as a major source of genetic materials for creative and unconventional breeding to improve the genetic make-up of crops and livestock for agriculture. We are well aware that more than 40% of the world's flora and fauna are archived throughout the entire 20,000 islands and niches of the oldest rainforest (more than 100 million years) of the Old World Tropics in South East Asia of Indonesia and Malaysia. Imagine the undeciphered or yet to sequenced DNA genome of many strategic crops and plants with specialized desirable traits that are of interest for molecular breeding. The biowealth or biodiversity of information, residing in the DNA genome of the rainforest flora and fauna species, is there to be sequenced and transgenically inserted the desirable traits into another species. That DNA encrypted of information biowealth, residing in the DNA of the flora and fauna biodiversity, is yet to be sequenced and harnessed into a biowealth for nation-building. For instances, what tremendous potential that can be paved by genome engineering to bring diversity of orchid varieties through genetic engineering and tissue culture experiments. If more than 8000 species, out of the more than 22,000 species of orchids, are found in the Indo-Malaya's rainforest, one can expect the tremendous varieties that can be created via genetic engineering and tissue culture clonings for commercial purposes. The initial headways in inserting the luminous gene to produce luminous orchids in the Biopolis initiative in Singapore depicts the many more potentials that can arise from the biotechnology laboratories in the region and worldwide. Through new sources of genetic materials for either herbs, medicine, food crops and livestocks will be developed in the coming decades. At the current rate of sequencing the DNA genome of crop and livestock, there will probably more than several hundred species of crops and livestock to be sequenced genomically by 2050 and it would be an exciting time to see creative, outlandish and imaginative molecular breeding unveiling in the near future, and the field of agriculture promises that great possibilities.

4.10 Monoculture Farming System

Another challenge towards sustainable and inclusive agriculture is the policy shifts and public interest to enhance the biodiversity of the destroyed biodiversity of the monoculture farming system of the commercial oil palm, rubber and cacao plantation (Figure 4.8).

Monoculture systems in crop cultivation are often regarded as artificial, ecologically dysfunctional and a threat to sustainable agriculture. Monoculture systems may be more productive a the natural or traditional farming, but such advantages occur at the expense of biodiversity and agricultural sustainability, reflected in higher pest vulnerability and environmental degradation. A common resentment to crop monocultures is that they have a very low biodiversity as compared with natural forests. Despite the undeniable benefits offered by monoculture system, there are concerns about the role they should play in sustainable development. It should be noted that maintenance and enhancement of soil fertility is critical for food security and environmental sustainability. The high erosive potential of tropical rains cause progressive deterioration in soil structure and lead to accelerated erosion. Studies have shown that soil erosion in Malaysia could be high in oil palm, cocoa , tea and vegetable area.

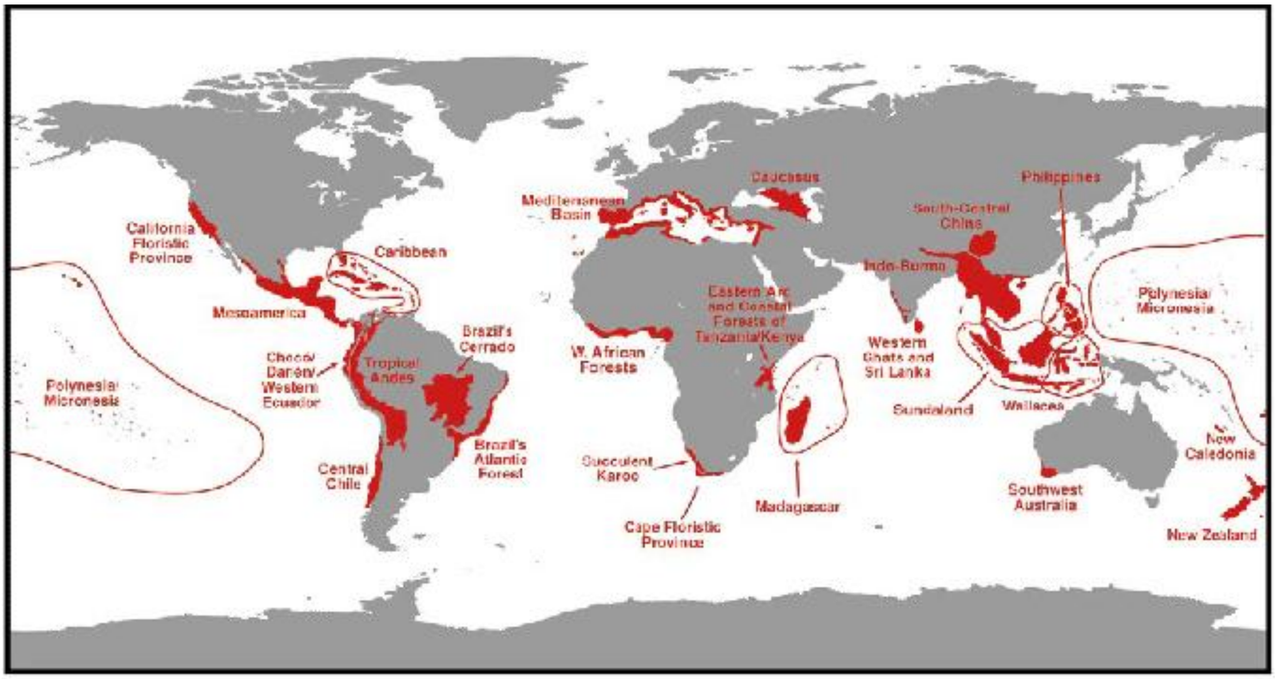


Figure 4.8: Biodiversity Hotspots

In view of increasing the supply of food and timber, agroforestry seems to be the logical approach, as the system can be implemented on either existing agricultural land or forest plantations as well as on idle and degraded forest. Indeed, agroforestry is one of the strategies proposed in the Third National Agricultural Policy (NAP3). Agroforestry approach is considered a potential vehicle to improve agricultural productivity, enhancing risk coverage and diversifying income sources of rural farmers which improving supply of food, fodder, timber and other non-timber produce and other benefits of agroforestry. With vast economic and environmental benefits, agroforestry would promote sustainable alternative livelihood, improves soil quality, empowers rural community particularly vulnerable population groups and promote their participation in productive activities. Thus, it is hope that the revived agroforestry approach incorporated in the NAP3 and future agricultural policies would pave a way for poverty reduction of the rural communities in Malaysia. Moreover, the other benefit of agroforestry in biodiversity conservation is where it helps to connect the urban community to the surrounding rural landscape. This connectivity helps filter water runoff, provides travel corridors for wildlife, creates recreational space, and improves air and water quality for the whole watershed. Cumulatively, these functions contribute to the overall health and sustainability of a community and its neighbours.

5 GROWTH OPPORTUNITIES AND SCIENCE, TECHNOLOGY AND INOVATION NEEDS

This chapter examines the possibilities of engaging appropriate ST&I and meet the challenge. It is stressed that in order to optimize the skilled human resources and limited fund. Malaysia needs to carefully select areas for R&D and commercialization that will have the best chance to succeed.

The major challenges faced by the agriculture sector are and also the opportunities for ST&I development and commercialization. The key challenges will have the greatest influence on what direction agriculture will take in the next 40 years are the population increase and their consumption pattern and climate change. This will impact other challenges, especially demand for fuel and resources such as land, energy, water, and labour in addition to other natural and artificial resources such as fertilizer, pesticides, weedicides, drugs and vaccines. More issues relating to food and nutrition, waste managment and environment, animal welfare, traceability, Halal and liberalization trade will no doubt have to be addressed by integrating the soft and hard sciences to create a more sustainable world.

5.1 Crops

The key challenge that will have the greatest influence on the direction of agricultural development in the next 40 years is population. Malaysia is projected to expand its population from the present 27 to 70 million in 2050. Increase in population would put pressure on the demand for non-renewable resources – fossil fuel, land, water and air. Adequate supplies of nutritious, safe and quality foods would be another challenge. Additional people also means destruction of forests and increase in carbon emission, which cumulatively contribute to global warming with implications to crops, livestocks and outbreak of diseases. Depleting resources such as fuel, water and other inputs escalate the costs of production. These global challenges and their influence on agriculture are discussed in greater details elsewhere in this Report .Some of the opportunities in ST&I for crops are described in the following sections.

i) **Perennial Crops**

Malaysia's crop agriculture will continue to be dominated by perennial/tree species. Currently, oil palm, rubber, fruits, coconuts and cocoa occupy more than 90 percent of the land area under agriculture, This percentage is likely to increase with more suitable land are targeted to be planted with oil palm and this palm crop will dominate the agricultural scenario for the next 40 years and beyond. The crop has many distinct advantages – it is climatically suitable to the rainfall pattern, high temperature and solar radiation of the country, making it the most efficient producer of vegetable oils. Palm oil is highly demanded because of its diverse uses, principally as food and also non-food products. It has a significant biomass that can be utilized for paper and timber products. It has no serious diseases or pests.

Oil palm production is dependent in foreign workers and employing them has its attendant and problems. Labour saving technologies with respect to harvesting and transporting the fruits required urgent attention. Robotic engineering can be explored for that purpose. The breeding and selection programmes that have propelled the productivity of this crop deserves attention of our researchers particularly in developing molecular breeding technique, not only to increase yield and enhance resistance to diseases, but also to improve the quality of its oil with the desired fatty acids and chemical content for health products. Related to the biological improvement, there is also a parallel need for continuous improvement in downstream activities. Bioinformatics and ICT cluster technologies will continue to be upgraded to comprehend the effect of climatic change on the crop. The ST&I needs for oil palm is applicable to the other perennials such as rubber and cocoa.

As mineral soils are limited, oil palm planting is encroaching into peat soil. The development of the peat for agriculture, though not a new phenomenon, is not fully understood in the context of CO_2 emission. Focus on R&D in this area requires attention.

Forests are often called "the lungs of the world", huge carbon sinks absorbing carbon dioxide emitted by the industrialized world, and producing the oxygen that we breathe. At the same time, agriculture is seen as "polluting" since land-clearing and development release greenhouse gases into the atmosphere, contributing to global warming. Environmental organizations such as Greenpeace, Friends of the Earth and Wetlands International as well as their local affiliates take this view further by lobbying for a moratorium on planting oil palm on peat soil and the imposition of greenhouse gas criteria on palm oil exports.

In 2007, Wetlands and the Netherlands-based consultancy Alterra issued a report entitled PEAT-CO2: Assessment of CO2 Emissions from Drained Peat lands in South East Asia alleging the region's peat lands are going up in smoke, emitting tonnes of carbon dioxide and causing global warming. However, Kuching-based Tropical Peat Research Laboratory (TPRL) director Dr Lulie Melling argues that in reality, Sarawak's oil palm plantations have been sequestering carbon dioxide and generating oxygen that goes back into the atmosphere while creating carbon sinks and stocks. She said that people tend to forget that oil palms are trees and that they absorb carbon dioxide in the air, only to release oxygen and in the same process, convert solar energy into biomass. Trees functions the same whether they are part of the forest or plantations.

Since tree plantations are perennial, they are more efficient carbon sequesters than seasonal oilseeds like soy, rapeseed and sunflower. Oil palms can feed on year-round tropical sun and rainfall to create biomass, i.e. carbon stock, without any soil disturbance compared with seasonal oilseeds.

In 2009, Brinkmann Consultancy's recommendation to include greenhouse gas emission from peat land as a criterion for RSPO certification was rejected. TPRL's findings had, in part, showed soil respiration at oil palm estates planted in peat had lower greenhouse gas emissions than that of untouched peat land. Soil research can differentiate facts from mistaken assumptions about planting crops on peat soil. Good soil management, be it peat or mineral-based, is the basis for sustainable food production.

Melling says that many of the current assumptions about tropical peat land were based on the understanding of temperate peat land research. Tropical peat is different from temperate peat. First and foremost, tropical peat is mainly woody material, whereas temperate peat is made up of sphagnum and sedges. The woody nature of tropical peat means there is higher lignin content. Lignin, being a more "recalcitrant" carbon than labile carbon of cellulose materials in temperate peat, highly influences the peat decomposition rate. Furthermore, the acidic condition of tropical peat inhibits microbial population, indirectly slowing the breakdown rate and therefore greenhouse gas emissions. Heavy and frequent rainfall in Sarawak, which helps to maintain moisture content in the peat soil, also decelerates decomposition and carbon dioxide emission. She says that unlike the northern hemisphere where temperate peat land is developed for energy and horticulture, oil palm plantations in the tropical countries only use the peat land as a planting medium.

On current understanding that drainage of peat land for agriculture leads to large carbon losses from oxidation, Melling says peat subsidence is also due to compaction, consolidation and shrinkage. When peat soil is compressed by heavy machinery, oil palm roots are able to take stronger hold of the soil and feed on water and nutrients more efficiently. Water management and soil compaction is a prerequisite to any agriculture development on tropical peat land. Consolidation of the peat increases bulk density and capillary rise, resulting in higher water-filled pore space of the peat. This leads to a more anaerobic condition, which results in a lower decomposition rate and less carbon dioxide emission.

There is a need to find ways to improve the collation and dissemination of scientific data on peat agriculture and greenhouse gas emissions so that everybody can better distinguish facts from false claims. The government needs to allocate more funds for peat soil research in order to fulfil Malaysia's aspiration to become a knowledge-based economy. Through science, farmers are able to carry out sustainable agriculture that satisfies both the economic and environmental needs of food production.

About 70% of Malaysia's peat land is in Sarawak and covers about 1.6 million ha or 13 percent of its land mass. Already some 400,000 ha of peat land in Sarawak has been cultivated with oil palm. The state expected to open up one million hectares for oil palm by 2010 to generate about RM10.8 billion annually for Sarawak. However this potential resources need to be managed sustainably.

As peat land is targeted to be developed for oil palm, an advanced carbon flux study for a deeper underestimating of the carbon dioxide (CO_2) emission under oil palm required immediate attention.

***ii)* Fruit crops**

Malaysia is self sufficient in fruits. We are a net exporter of the commodity. The demand is expected to increase as the people become more health conscious complete with greater awareness of the good health attributes of fruits. The commodity also provides opportunities as they can be processed to juices, minimally processed products, natural food ingredients, functional foods, health and convenient foods, frozen fruits and high fibre food. It is recommended that the types of fruits to be cultivated should be confined to those highly demanded in the domestic market – pineapple, watermelon, papaya, mango, and starfruit and those with potential for export – pineapple, banana, papaya, and starfruit. The highly demanded fruit types, papaya and starfruit, however, are subjected to debilitating pest and disease (the fruit borer in starfruit and viral leaf spot in papaya). Among the measures to be taken to overcome this is to grow starfruit under controlled netted condition. As for papaya, investigations need to be embarked on the effective containment of the disease. Genomic mapping to understand the biochemical constituionts of the unique tropical fruit such as durian, nangka, starfruit, mangosteen is useful for molecular breeding.

***iii)* Vegetables and Herbs**

In the context of climatic change the challenges: Posed by and pollution of the water system, the cultivation of vegetables in the steep slopes of the highlands should be discouraged as soil erosion is serious and the water is polluted with farm chemicals and wastes. The cultivation should be on the lowlands and where appropriate vertical farming should be adopted.

The new crops that offer potential are sweet potato and medicinal herbs, for considerations as spelled out earlier. Besides the nine medicinal herbal species listed earlier (Table 4.9), our rainforests offer many other species that need to be studied in detail. The primary production technologies is still lacking in herbal species such as planting tehniques, agronomic practices, pest and diseases and large scale planting. Coupled to these are the postharvest technologies. The biochemistry of these herbs require a detail study in examining the metabolites and chemical compounds contained in these species, assessing their usefulness as pharmaceutical, neutraceuticals and wellness products, screening as their potential for commercialisation; and the subsequent large scale planting of these selected crops. Genome mapping is important in identifying genes of pharmaceuticals and neutraceuticals significance.

iv) **Ornamentals and Other Plants**

The rich biodiversity of ornamentals and landscape flowering plants such as orchids offer vast potential for their commercialization in the floriculture industry. Considerable progress has been made in the collection and hybridisation of many species whose hybrids have reached the market all over the world. However, molecular breeding offers many opportunities in developing varieties with special and unique attraction. Similarly for genome mapping and molecular breeding will be useful in indentifying and subsequent utilisation of the desired traits for multifarious useful field.

v) **Energy Crops**

Malaysia is blessed with diversity of energy resources available in the country that a mixed or alternative energy policy would be the logical choice. By that measure, it is not too far fetch to expect that there will emerge initiative for the development of energy crops. As it is oil palm, Jatropha and Nipah are the known sources of potential crop plants that can be promoted as energy crops. The dualism of food versus fuel dilemma for oil palm would pose a lot of uncertainties and unpredictable disruptions in market prices that it presents difficulties for the investors in making choices to keep their constancy and purpose of oil palm to either fuel or food. This dilemma should be resolved and guided by astute policy-making to prevent market hesitancy for commitment. When the energy crop issue will emerge to become important it depends on the kind of Energy Policy posture the government will adopt in the coming years

vi) **Agroforestry**

Agroforestry interventions, because of their ability to provide economic and environmental benefits, are considered to be the best measures in making communities adapt and become resilient to the impacts of climate change. The important elements of agroforestry systems that play a significant role in the adaptation to climate change include changes in the microclimate, protection through provision of permanent cover, opportunities for diversification of the agricultural systems, and improving the efficiency of use of soil, water and climatic resources.

Recognizing the ability of agroforestry systems to address multiple problems and deliver multiple benefits, the IPCC Third Assessment Report on Climate Change states that "Agroforestry can both sequester carbon and produce a range of economic, environmental, and socioeconomic benefits. For example, trees in agroforestry farms improve soil fertility through control of erosion, maintenance of soil organic matter and physical properties, increased nitrogen, extraction of nutrients from deep soil horizons, and the promotion of more closed nutrient cycling."

Agroforestry is an integrated agricultural approach of deriving the benefits from suitable combinations of trees, crops and/or livestock (Figure 5.1). Therefore, knowledge on selection of species, plant combination and good management of trees and crops are prerequisite to achieve the maximum production and to realize positive effects of trees while minimizing the negative competitive effects of trees on crops. In a review of 56 agroforestry practices in 21 projects in Central America and the Caribbean, Current and Scherr (1995) found that 75 percent had positive net present values. Nevertheless, agroforestry is not generally recognized as a science or a distinct practice and is rarely featured in development strategies.

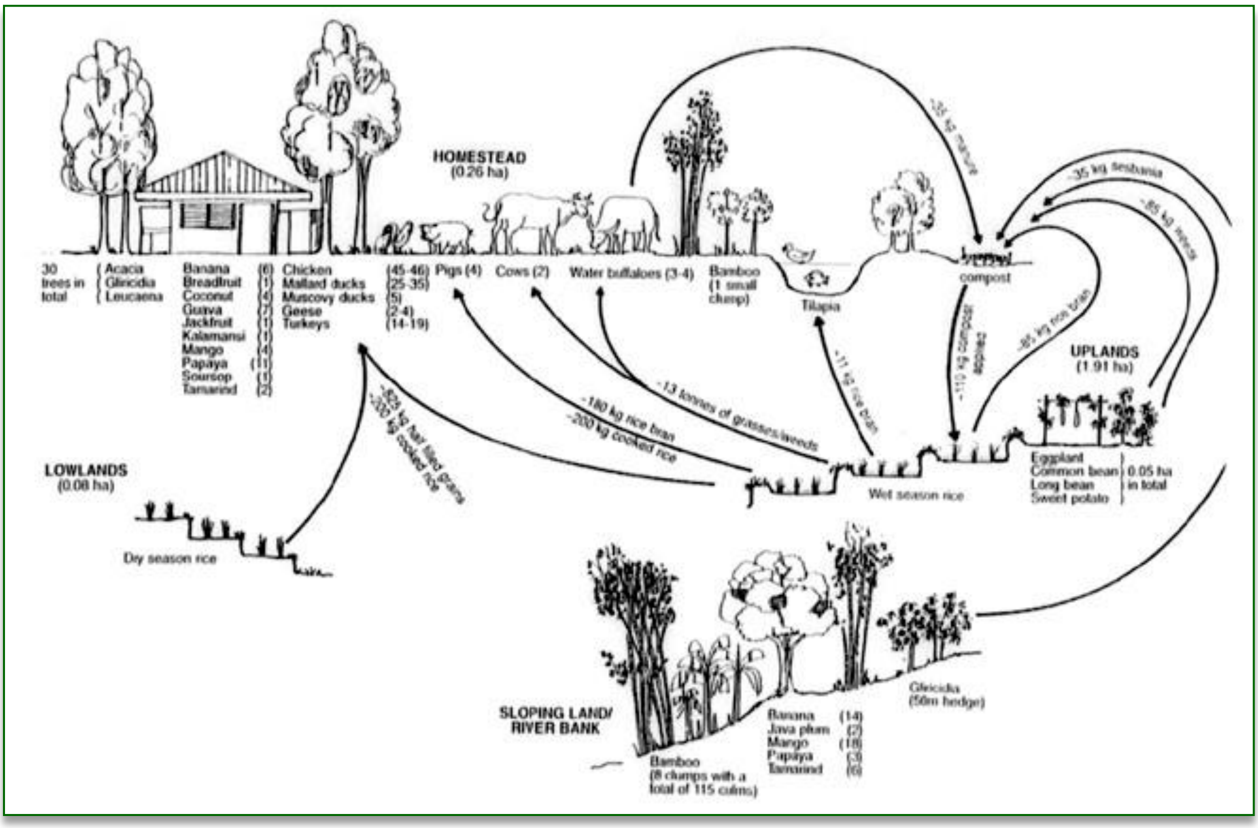


Figure 5.1: Agroforestry is an integer agriculture approach

Several agroforestry systems have been identified and discussed for future use and adoption in Malaysia. The subsistence role of agroforestry system has to be changed by introducing the commercial elements in light of the new market opportunities accompaning globalization. Moreover, determining which practices are most suited to particular groups is another area that warrants serious attention.

vii) Agrisilviculture

Experience of successful agrisilviculture system in Malaysia as well as in the neighbouring countries could be adopted with modification in Malaysia to suit the local socioeconomic and biophysical conditions.

On hilly areas, sloping hillsides are prone to soil erosion, especially when the natural vegetation is cleared for intensive farming practices. In the interior region of Sabah and Sarawak, for instance, with hilly terrain, deforestation caused by shifting cultivation activities has contributed to environmental degradation, increased soil erosion and loss of top soil (Example in Figure 5.2). Top soil which is important for plant growth is easily eroded under humid tropical climate. Increased erosion of nutrient-rich top soil makes the shifting cultivation practice non sustainable, due to decreasing crop yield over a short cultivation period. An agroforestry technology developed in Philippines known as SALT, an acronym of *Sloping Agricultural Land Technology*, could be a solution to sustain crop productivity in hilly areas. It is a package technology for soil conservation and food production, integrating different soil conservation measures. In essence, SALT is a method of growing field and permanent crops in 3 to 5 m wide alley between contoured rows of nitrogen fixing trees. The nitrogen fixing trees are densely planted to make hedgerows. When a hedge is 1.5 to 2 meters tall, it is trimmed to about 75 cm and the cuttings are placed in alley-ways to serve as green fertilizer. SALT is a diversified farming system with rows of permanent tree crops such as coffee, cacao, citrus, guava and other fruit trees, dispersed throughout the farm plot. The strips not occupied by permanent crops, however, are planted alternately to food crops such as maize, upland rice, sorghum or with other crops (sweet potato, melon, pineapple, etc.) and legumes (soybean, mungbean, peanuts, etc.). This cyclical cropping provides the farmer some harvest throughout the year. SALT also includes planting of multipurpose trees for timber and fuelwood on surrounding boundaries. Some of tree species planted along the boundary in SALT are *Paraserianthes falcataria,* mahogany (*Sweitenia macrophylla*), casuarinas (*Casuarina equisetifolia*), ipil-ipil (*Leucaena leucocephala*), yemane (*Gmelina arborea*), bagrass (*Eucalyptus deglupta*), etc.

Figure 5.2: Rice terraces- forest coupled agroforestry system

viii) Silvipastoral

Silvipastoral system is another potential agroforestry practice which can be improved to increase meat and timber production in Malaysia, which in turn could generate downstream economic activities in food processing and woodworking sectors. The mere utilization of natural grasses and broadleaved plants in rubber or oil palm plantations will not permit the long term production period as decreasing light availability under closed tree canopy during maturity phase reduces forage productivity and quality and making it incapable to sustain foraging livestock, such as goats, sheep and cattle. Change in the planting design is required to allow forage plants to thrive and sustain the livestock productivity.

Under the conventional planting designs in rubber and oil palm, both production values and the range of species are severely affected when light availability decrease below 40 or 50 percent. In general herbage/natural forage production and carrying capacity is inversely related to tree density and light availability. Available forage dry matter declines from over 5 tons/ha in young rubber and oil palm plantations to below 1 ton/ha at canopy closure.

Meeting the nutritional requirements of ruminant under declining forage resources in mature plantations is important for livestock management and production. In order to make the silvipastoral system sustainable and attractive to potential investors and smallholders in Malaysia, innovative changes have to be made to this agroforestry system.

First, the tree component needs to be redesigned/ rearranged in a new planting configuration with wide alley. Re-orientation of the planting design will provide a more conducive environment for animal integration in tree plantations. Quality fodder plants of high nutritive can be established in the inter-row alley. Trees of high quality timber species can be planted in a hedge system and along the perimeter of the holdings. Timber trees are preferred because they require minimum management or operational needs and involve low expenses, unlike fruit trees, rubber or oil palm. Thinning and pruning can be prescribed to improved growth and wood quality of timber trees, at scheduled time.

Secondly, for a continuous year–round grazing of local animals on pasture plants established in tropical tree plantation, a more sophisticated system, involving both the pasture and the animal species are specifically selected in the integrated silvipastoral system, taking into consideration the existing characteristics of the tree species, the soil and the climatic condition of the locality. Sheep is the most suitable animals to be integrated with tree plantation. Cattle and goats can cause damage to trees by trampling effects and grazing habit. Sheep can be introduced under immature rubber when the trees are greater than two years old or when the height of the lowest whorl of tree crown is higher than 2 m.

The use of leguminous forage tree species can supplement the low nutritive values of natural forage plants. Species such as leucaena, sesbania, trema, kesinai, and ludai are among the suitable forage trees for silvipastoral system.

The economic viability of silvipastoral system based on improved pastures/forage can be enhanced with a new concept of integrating timber trees using a hedgerow planting system. The trees have a dual role of providing shade for grazing animals while, in the long run, providing timber and/or other non-wood products. Shade of tree canopies could improve livestock productivity by reducing heat stress and extends grazing hours. This concept of the silvipastoral system has been successfully practiced in developed countries such as USA, UK, New Zealand and Australia.

In order to make agroforestry system more productive and producing higher commercial output, it needs to be changed or modified, depending on the locality and socioeconomic conditions of the community. The management, physiography and components of homegarden have to be modified to produce one or more commercial produces, without sacrificing its traditional functions. Near the urban centers, homegarden should be geared to produce greater proportion of fresh food items such as vegetables and fresh fruits, using organic farming techniques, as urban people are very conscious about health food and will pay higher price for freshness. Free ranging chicken can be reared under the shade of tall trees of homegarden to supply high value specialty chicken meat. Seasonal and non-seasonal fruits such as durian, mangoesteen, rambutan, guava and citrus of improved varieties can be profitably grown to generate cash flow. Wood from mature trees (branches and stemwood) can be creatively used in woodworking to produce handicraft items for tourists. On the other hand, homegardens in the remote areas, far from urban areas, should be geared to produce commercial specialty products such as coffee, medicinal plants, mushrooms, fishes and natural honey, which can be further processed in a cottage industry to produce a diverse range of value added products for local or international market.

Other Types of Agroforestry

Linear planting is commonly appeared in the forms of border planting of trees, life fence and windbreak. Multipurpose trees and shrubs have been used for generation as living fence posts around cultivated plots susceptible to damage by livestock; boundary markers demarcating boundaries of land parcels belonging to different owners, between individual plots within a given farm area and wind-breaks or barriers to protect coastal gardens from salt-laden air. Vegetation buffer strip established along the streams and rivers is another form of linear planting, very effective in filtering contaminants from entering the water bodies and affecting the aquatic lives. Buffer zones created by linear planting along the river and streams are usually established adjacent to intensive agricultural activities, such as intensive livestock, high input large scale crops, where neighbouring land has a potential to be adversely affected by the off site impacts from intensive cultivation activities. The effort of Project Lebuhraya Utara Selatan (PLUS) to establish trees of commercial and non-commercial value along the highways can be considered as a type of linear planting. The trees not only yield valuable timber at felling age, but also help in reducing noise and pollutants to the neighbourhood areas.

Apiculture or beekeeping is the rearing of honeybees in forest or tree plantation for the production of natural honey. Beekeeping is an art and science of caring for and manipulating the colonies of honeybees (*Apis* species) so that they will produce and store a quantity of honey above their own requirements. In Malaysia, beekeeping has bright prospects in view of the following factors:

- There are plenty of flowering plants such as forest trees species, fruit trees, plantation crop trees of rubber, coconut, oil palm, coffee, and cacao and other short term crop species that yield nectar and pollens to honey bees
- Availability of a domesticated bee specie *Aphis cerana*.
- Good local markets and potential for import substitution.
- Apiculture provides improved pollination of agricultural, horticultural and tree crops
- Honey provides extra income and a non-perishable food for the farmers and his family
- Apiculture requires small investment in terms of equipments, maintenance and processing.
- Apiculture does not compete for resources with any other agricultural activity.

Demand for honey in Malaysia is increasing. Several plans have been identified by the authority to improve the balance of trade in natural honey such as increasing the honey production and breeding areas. Acacia plantations and oil palm estates have been considered for new breeding areas, where sufficient pollen and nectar is available all year round. With greater number and variety of flowers in agroforestry systems, the quality and yield of honey is expected to improved, in line with efforts to increase domestic honey production. A beekeeper must first make sure there are good sources of nectar on his farm to support the bees. Oil palms can supply good flows of nectar, but since a rubber tree seasonal flowering species, for only about six weeks in March and April, there is a need to provide alternative sources of nectar for honeybees. Farmers can expect up to 35 kg of honey per hive in a season. But this should rise when more suitable plants are available to bees. In Selampit, Sarawak, local community has established about 700 hives of bees and the farmers can obtain a profit of RM3, 000 during a peak season.

Incorporating herbal plants in the farming system is viewed as a good approach to diversify farmer's income and to enhance downstream activities. Currently, herbal industry has been considered as an emerging economic activity in Malaysia. The local herbal industry has contributed an income of RM10 billion in 2008, and is projected to have an economic value of RM 15 billion and 29 billion respectively in the 2015 and 2020. However, the main constraint of this industry is insufficient supply of raw materials from local sources. To solve this problem, cultivation of potential medicinal and herbal plants under suitable agroforestry systems is considered a viable alternative. In deed, several important medicinal plants and herbs have been intercropped with tree crops such as rubber, coconut and oil palm. Johor, Selangor and Pahang are currently the main producers of herbal plants in Malaysia.

ix) Home-garden

Home garden depicts a multi-storey system of agroforestry where the canopies of the component species are arranged to occupy different vertical strata. The physiognomy and composition of home gardens seem to simulate that of tropical rainforest . It is a classic example of a sustainable tree-crop-animal combination system. This agrisilvipastoral system is characterized by a deliberate management of trees in intimate association with trees, annual and perennial agricultural crops and small livestock within the house compounds.

The combination of crops with different production cycles and rhythms is such that an uninterrupted supply of food products is maintained. Depending upon the climate and other environmental characteristics, there may be some peak and low seasons for harvesting various products, but in general, there is something to harvest daily from home gardens. Most of this production is for home consumption, but marketable surplus can provide a safeguard against failure and security for the interval between the harvests of other agricultural crops of the multi-layered home gardens. All these harvesting and other upkeep operations require only a relatively small amount of working time of the members of the family.

This agroforestry system is common traditional village landscape throughout Peninsular Malaysia, Sabah and Sarawak. The biodiversity and structure of home garden improves with age, but varies in accordance with socioeconomic and ecological conditions of the locality. This traditional system can be also considered as the refuge and genetic reservoir of rare and endangered fruit trees and old variety of food crops. Many of these plants are landraces, more genetically heterogeneous than formal modern varieties, and grown from seeds passed down from generation to generation. These landraces offer greater defences against vulnerability in the midst of diseases, pests, droughts, and other stresses.

An important feature of home gardens is a high biomass productivity resulting from an efficient use of sunlight, water, and nutrients. Continuous inputs of organic matter through decaying plant material and farm manure helps in sustaining its ecosystem. Due to inherent structure, soil degradation due to high erosive potential of tropical rain can be minimized. The multitude of tree and crop species in the home garden exemplify years of deliberate selection and breeding for better production and quality. The canopy of trees in home garden is carefully controlled to maintain the balance between light and moisture for understory crops. Apparently, vertical rather than horizontal arrangements of production components that make more effective use of limited area of land in home garden.

The uniqueness of home gardens has attracted many scientists to study them. However, multi-disciplinary biophysical studies, including soil-plant interactions and socioeconomic studies on home gardens, are needed for better understanding and effective use of this ecologically sound agroforestry system.

There are many potential non-timber crops for intercropping in agroforestry system. Rattan is another forest species that can be interplanted in commercial rubber plantations in view of increasing the yield of land and supplementing the income of smallholders/rural farmers . Three rattan species have been found to be suitable for growing under rubber in peninsular Malaysia: *Calamus manan*, *C. scipionum* and *C. palustris*. The age of rubber trees at intercropping and planting densities per hectare are important factors for successful rattan establishment. It was observed that 8 years old rubber trees were the best for intercropping with *C. manan*. Rubber clones (RRIM 600 series) with branch size of 3.6 - 9.7 cm were found to be suitable for intercropping with rattan as rattan plants can easily climb on them . Moreover, to be able to support heavy weight of mature rattan, rubber trees with strong branches is required.

Salak (*Salacca* spp.), another commercial crop, has been successfully integrated in rubber plantation in Terengganu. This domesticated palm is shade tolerant and can be planted under the canopy of rubber, coconut and oil palm. Rubber plantation aged 5 years and above is suitable for Salak, established at 6 m x 3 m. Additional shade is needed for intercropping under coconut plantation , due to high light intensity.

x) Community Forestry and Rare Fruit Reserve

The term community forestry embraces a spectrum of situations ranging from woodlots and other forested land managed for local needs through to the planting of timber and fruit trees at community level and the processing of forest products to the activities of forest dwelling communities. The activities are potentially compatible with all types of land ownership. While providing a partial view of the impact of forestry on rural development, community forestry embraces most of the ways in which forestry and the goods and services of forestry directly affect the livelihood of the rural people

The design of the community forestry model should take into account the need for income generation for communities. Market opportunities exist for planted trees of a number of species (e.g. Acacia, Engkabang, Karas) reflecting the transition from dependency on a natural forest to a planted resource. By selecting appropriate species or ecotypes well adapted to the local environment, which are productive and meet a market demand, communities can benefit financially from tree planting projects. In Malaysia, community forestry can serve as a mean to develop native customary land in Sarawak for the purpose of improving agricultural productivity, food security and sustainable utilization of natural resources. The role of community forests as the source of genetic diversity of rare fruit and other multipurpose trees is already known. Fruits such as green Longan (*Dimocarpus longan* var *malesianus*), Dabai (*Canarium odontophyllum*), Durian Kuning (*Durio graveolens*), Durian Nyekak (*Durio kutejensis*), Terap (*Artocarpus odoratissimus*) and Embawang (*Mangifera pajang*) are derived from community forest. The establishment of community forest in Sarawak will ensure sustainable supply of timber for domestic use, meat and minor forest produces for rural communities indicated that an agroforestry programme initiated in 1987 on area affected by shifting cultivation was fruitful through the participation of surrounding communities. Similarly, Dawend *et al.* (2006) reported another community project at Sabal F.R. organized by the Forestry Department of Sarawak for game production and breeding using deer and bearded pigs, reared in fenced natural forest and Acacia plantation. The project is aimed at uplifting the wellbeing of rural dwellers and farmers by providing a ready source of protein, to increase their income level and for ecotourism purpose. However, the forest area is overgrazed due to high population of animals. In other location of Sarawak, rural farmers for instance, are actively involved in planting of fruit and timber trees, rattans and wild palms for daily uses and food, together with livestock rearing, beekeeping, and fish farming.

Community forestry management activities included planting multipurpose trees on public lands, and establishing community regulations aimed at protecting degraded natural forest areas from destructive impacts and over-exploitation. Native multipurpose trees were planted to enrich degraded forest areas.

xi) Perennial Crops and Biodiversity

Advent of Plantation Crops (rubber, oil palm and cacao) and opportunities to enhance the biodiversity of the agro-ecosystem: The mono-cropping cultivation and industrial-driven approach of the large-scale farming of oil palm, rubber and cacao has totally changed the farming landscape and social fabric of the Malaysian agriculture. This is the polar opposite and a departure from the multi-species (multi-crop), organic, sustainable, indigenously evolved farming practice of the indigenous people of the rainforest, being transformed into a commercial, market driven, industrialized, introduced species, and non-indigenous plantation agriculture done by introduced labourers. There is a huge increase and difference in the productivity between the smallholders sector and the plantation sector due to technology, management and intensive use of petroleum-based inorganic chemicals as in fertilizers, pesticides and weedicides, to improve crop yields. Apart from estate plantations, FELDA land development schemes adopt a similar in approach. That radical shift in Malaysian agriculture development are impacting from the low productivity, low input of the species-rich, sustainable, organic small farming that jives with the rainforest ecosystem of the smallholders into a high productivity, high input of the monocrop, commercial, use of inorganic chemicals in estate holdings of the plantation conglomerates and FELDA land schemes in the country. This approach was unprecedented in the agriculture of the region in the seventies. The openings of vast tracts of rainforest lands and wanton clearings of virgin rainforest land tracts lead to invaluable loss of biodiversity and environmentally hazardous pollutions from the use of biocides. On hindsight, that era of widespread use of chemicals for agriculture was contemporaneous to the admonished dreaded environmental pollution of "Silent-Spring" by Rachel Carlson in the seventies. Therefore, any treatment or recommendation for Malaysian agriculture should be mindful of the detrimental impacts that it can cause to the environment. In the last few decades, the Malaysian plantation sector has begun to make amends and resort to environment-friendly farming practices. The on-going formulation of the Fourth National Agriculture Policy takes cognizance of this issue and promotes the intensification of existing plantation land/estate holdings, rather than opening new virgin lands for plantation crops. Opening of virgin forests for agriculture (oil palm plantation) has now become an untenable policy of oil palm plantation expansion in that the biodiversity in rainforest species is to be conserved, rather than destroyed. The latest round of RSOP standards is incorporating sustainability elements into the negotiations.

5.2 Livestock

Producers of animal products participating in the supply-chain agreement with large retailers need to adapt to the changing demand of consumers. Greater emphasis on product safety and quality is a must to produce animal products in the future. Technologies, which could enhance these attributes, could help producers to continue supplying products that meet consumers' expectation. Furthermore technologies that could further increase efficiency as well as safeguard the environment are crucial in determining the survival of future farms, big and small.

i) Poultry

New Animal Products: As the poultry industry embraces the vertically integrated system of production starting from the breeding and selection of birds and through the growing phase, processing, marketing and retail consumption, safety and quality concerns are integrated too in this process. The goal is to enhance the production of wholesome, high quality, and value-added poultry products.

Consumers coming from different market segments specify what products to produce. Besides having attributes of food safety and quality, animal products are expected to be free of or having minimal level of harmful chemical residues, derived from animals that have been raised in a humane manner and from farms which adopt clean environment principles. Technologies to produce products in the new era of changing consumers' expectation would prepare producers to respond and adapt to changing market demand. Innovations are tweaked from existing technologies to provide solutions to problems faced by the industry.

Labelling of food products helps to inform consumers about product attributes, including food safety, and assist consumers to make informed choice at the market place. Compliance to labelling legislation increases cost to producing animal food products, but producers need to be made aware that producing foods which pose minimum health risks to humans is a win-win responsibility between producers and consumers.

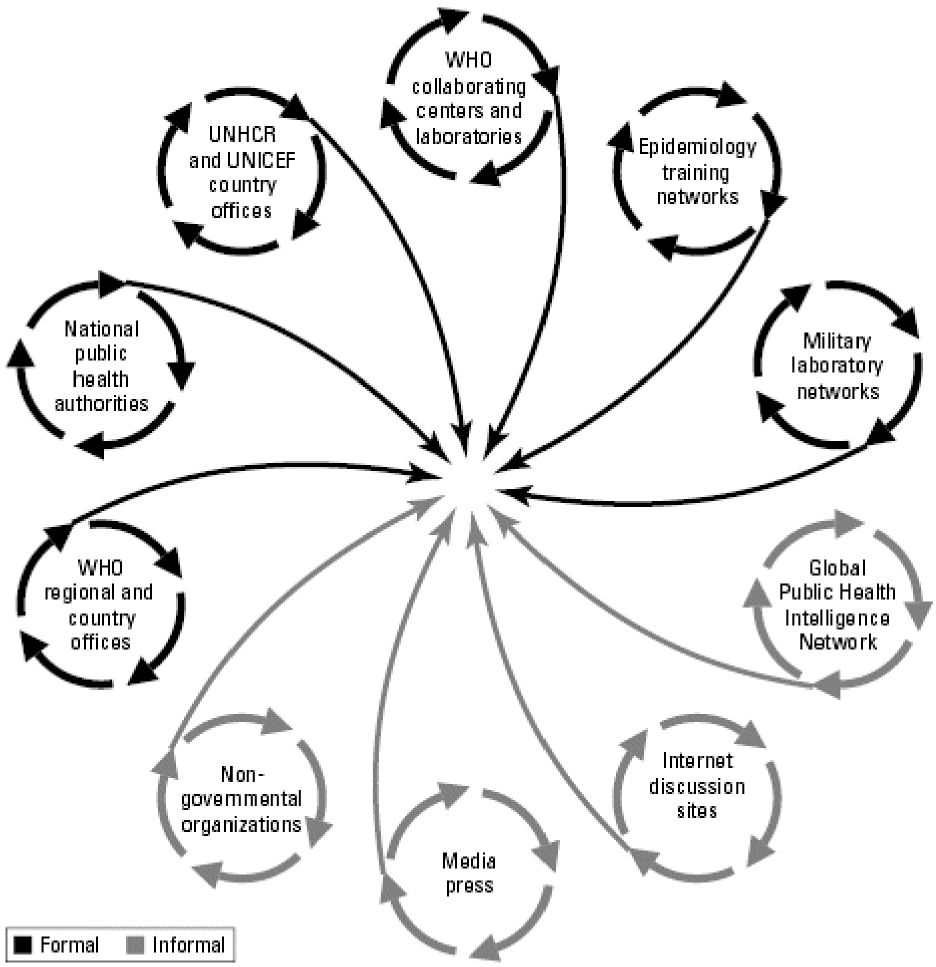
As livestock production begins to adopt more intensive systems the analysis of farm returns and costs has to be relooked since internal products are often recycled or used as raw materials to produce industrial products. This will contribute positively to farm income, hence also farm profitability. Decision whether to recycle farm manure into crop systems as partial replacement to chemical fertilizers or to sell farm manure to manufacturers of industrial products would rest on costs incurred and margins to be made.

Conventional vaccines currently in use are expensive, less effective in conferring protection and have poor delivery. Plant based vaccines may overcome some of the problems associated with conventional vaccines. The allure of reducing cost of vaccine production has always attracted sizeable investment in R&D in plant-based vaccines by both public and private sector research laboratories. Mode of delivery of plant-based vaccines is said to be cheaper when given orally. The issue of slow supply response can easily be overcome when plant based vaccines are accepted by the general consumers. Plant based vaccines are recombinant protein subunit vaccines with antigen of interest derived in plant tissues. In order to confer a high level of protection the antigen must be expressed at a sufficiently high level in the chosen plant species and this will also lead to a more cost-effective vaccine production.

The increasing resistance of certain bacteria to prolonged use of antibiotics has prompted the broiler chicken industry to re-examine the use of antibiotic growth promoters. A number of alternative growth promoters such as a fraction of the Saccharomyces yeast outer cell wall, mannan oligosaccharides (MOS), have been introduced as feed additives for poultry. MOS have at least three distinct modes of action by which broiler performance can be improved by: 1) adsorption of pathogenic bacteria; 2) improved intestinal function or gut health; and 3) immune modulation. Tests with modern strains of broiler chickens fed MOS showed improved live performance compared to unsupplemented feeds. MOS supplement was also comparable to antibiotics in body weight and feed efficiency with significantly lower mortality. Other non-therapeutic alternatives to antibiotics suggested are enzymes, organic acids, probiotics, herbs and immunostimulants.

The public needs to be engaged early in the development of technologies designed to produce animal products of the highest level of food safety and quality. Lack of understanding on the scientific basis of such technologies has often derailed the smooth adoption of technical solutions to industry problems. Though proved to be safe, genetically modified products have found resistance to purchase among many segments of societies. Growth promotants are still questionable products to be used in broiler chickens. The scientific community and government regulators have the responsibility to educate and promote awareness on science and technology solutions to industry problems among members of the general public.

Network of Disease Surveillance and Control:Trans boundary animal diseases are difficult to control without the sharing of information on disease occurrence and diagnostic methods. Avian influenza is the first animal disease that provides the first experience and sharing of information through a network of laboratories set-up in South Asia, South East Asia and East Asia (Mehta and Gambiar, 2008) as show in Figure 5.3. Through the auspices of FAO, information on avian influenza is shared across many countries around the world.



Source: U.S. GAO 2001.

a. UNHCR represents the United Nations High Commissioner for Refugees.

b. UNICEF represents the United Nations Children's Fund.

Figure 5.3: Network of disease surveillance and

Vertical Integration: The participation of small producers in poultry production through contract farming with the big integrators will further facilitate the adoption of close-house technology. Otherwise smallholder poultry production may cease to exist especially having been threatened with the spread of highly pathogenic avian influenza in 2003. Contract farming under the ambit of vertical integration will assure participating producers of high quality breeding stock and feed supply and market for their products. More mechanization and automation as well as cooling and ventilation systems will be introduced in intensive close-house poultry production systems of the future.

Research programmes for the poultry sub-sector planned for the decades leading to 2050 should address the following issues:

- Diversified processed animal products based on poultry meat and eggs that meet global demand and expectation and are certified wholesome and halal.
- Increased understanding in the biology of feed utilization by animals
- Tapping the beneficial attributes of indigenous germplasms of animal species for incorporation into genome of production animals
- Finding products which could enhance the bio-degradability of fibrous feed materials, through microbial fermentation and other means
- Technologies to better manage animals in intensive systems including odour and pest management and alternative uses of animal waste that minimize environmental degradation
- Developing animal and farm management protocols in animal farms to ensure the highest levels of food safety
- Developing environmental friendly plant based animal health protection products

ii) Swine

Intensive rearing of pigs in factory-like settings has created issues in solid manure and waste water handling. Both manure and wastewater have the potential to impact the surrounding water ways and water bodies causing serious degradation in water quality; thus posing public health risks. Improper handling of these wastes from intensive systems has significant environmental implication, including nutrient over-enrichment of surface water and ground water, heavy contamination of public water supplies and deterioration of natural aquatic habitat.

In the USA, animal commercial activities have been identified as a significant source of water pollution, which contributes to the deterioration in water quality of rivers (Farm Foundation, 2006). Nutrients from animal manures usually exceed the uptake potential of crops grown within a region where there is a heavy concentration of confined livestock activities. Manure management would then require looking at the nutrient balance on a whole-farm basis so as to deliver more effectively the manure for optimal crop use while wasting little in water pollutants. If applied to crops in proper conditions, animal manures could be a valuable source of plant nutrients and a good soil conditioner.

The issue of waste handling in animal farms should be looked at from a multi-disciplinary approach as it affects many facets of production and the production environment. A system-based research in waste handling may provide a holistic and long-term solution to animal waste management. Alternative uses of animal waste, better utilization of input resources such as water and ingredient mix and land application of animal waste all help to increase our knowledge in handling animal waste.

Reducing Pathogens: More pathogen reside in stressed and sick animals than in healthy animals. Pathogens found in manure of sick animals pose a higher risk in that food and water will be contaminated. A number of practices such as vaccinations, adequate access to feed and water, appropriate space allowance, temperature and ventilation control, on-farm sanitation, biosecurity measures and good husbandry practices can be adopted to reduce pathogens in animal manure.

Diet selection is a strategy to reduce pathogen levels in animal manure. With the addition of antimicrobials in livestock feed, the discharge of bacterial pathogens can be reduced. Antimicrobials have been used to promote growth and treat certain diseases.

Research programmes for the pig sub-sector planned for the decades leading to 2050 should address the following issues:

- Increased our understanding in the biology of feed utilization by animals so as to reduce waste from animals
- Tapping the beneficial attributes of indigenous germplasms of domestic biodiversity to manage animal waste and develop more disease-resistant animals
- Technologies to better manage animals in intensive systems including odour and pest control
- Developing animal and farm management protocols in animal farms to ensure the highest levels of food safety

iii) Ruminants

Feed conversion efficiency has shown remarkable improvement in poultry and pigs but not in ruminant species. Better feed conversion efficiency means less feed is needed to produce a kilogram of meat or a litre of milk translated to lesser amount of manure generated, hence lesser problem in waste disposal. Animals could be bred to consume less feed but still produce desirable products. Feed technologies may explore combinations of different feed ingredients and nutrient mix to improve feed conversion efficiency.

Research in understanding the bio-chemical pathways in the conversion of feed into different tissues could assist producers to better feed their animals. Bio-processing technologies to degrade fibrous feed materials to release carbohydrate substrates for ready absorption by the animals open up opportunities to increase the inclusion levels of fibrous feed materials in the diets of farm animals. Products which could biodegrade carbon materials are derivatives coming from such bio-processing technologies.

Vaccines are used in the management of farm animals to limit the spread of diseases. Treatment cost would substantially be reduced if vaccination programmes have been carried out successfully. Foot and mouth disease outbreaks in farm animals have largely resulted in reduced mortality among vaccinated animals. Without vaccination affected animals would be less productive by having reduced body weight and reproductive performance. Cheaper vaccines which have a higher rate of delivery efficiency are very much needed to keep animals healthy.

Organic animal products are from farm animals that have been raised on naturally cultivated pastures without any use of chemical fertilizers. Antibiotics, ionospheres, growth implants, feeds from animal sources and chemical fertilizers are not allowed to be used in the production of organic animal products. Organic beef is said to be a sustainable product since only natural resources are used and health enhancing benefits are expected from the consumption of the organic meat. However organic beef, mutton and milk are niche products that are slowly getting popular with certain market segments in the urban areas. Organic animal products are sustainable products but they cannot feed the masses since the cost of producing organic animal products is higher than conventional products.

Developing stress-tolerant livestock breeds is an area of research to provide alternative genetic materials in the event present breeds of livestock may succumb adversely to global warming. Developing strategies to reduce losses in animal biodiversity and animal genetic resources which may occur as a result of increasing adversity in climate conditions could be a long-term objective of the nation’s effort to counter the adverse climate.

Food-borne illness is a public health concern most by affecting consumers. Although we have been blessed with infrequent cases of food-borne diseases due to effective surveillance and monitoring of our food supply we must not let down our guard against potential sources of infection along our food supply chain. It is known that some 200 pathogens are transmitted via food. Beside our food supply may be exposed to contamination of heavy metals from air pollutants, packaging materials or even food preservatives. *Campypylobacter spp., Escherichia coli* O157:H7, *Listeria spp*. and *Cyclospora spp*. are among the pathogens to be given serious attention. We need to understand better how food-borne illness is caused and how the illness is spread. Continuous use of the same antibiotics to treat certain animal diseases may lead to the development of resistance among bacteria. Pathogens evolve over many generations of their lifecycles to adapt in order to suppress the effects of antibiotics. Research must continue to be vigilant in looking at the emergence of previously ignored pathogens and those that have mutated to develop antibiotic resistance.

Farm animals are currently protected against disease pathogens through the use of chemically based veterinary drugs and pesticides. Dosage level for the drug for each category of animals is carefully formulated for farm application and maximum residue level is clearly stated for most drugs sold in the market. This is to ensure food products derived from farm animals are safe to consume. However consumers still have concerns about the safety of animal products derived from animals which have been raised with chemically based animal health protection strategies. Plant based substitutes for veterinary drugs and chemicals are very much needed to allay the concerns of many consumers worried about food safety. The notion here is that a plant based health protection strategy could replace a chemically based product.

The vast inventories of biodiversity in the tropical rain forests contain future solutions for more biologically based remedies to current and emerging diseases. DNA sequencing from genomic studies in many species of animals, plants and humans have revealed many similarities in gene functions among these organisms and this may help to identify innovative methods to combat health related issues of animals and humans. More research is warranted to seek more biotechnological solutions to combat threats of newly emerging diseases.

Foods are predisposed to many risk factors which may affect human health as foods are passed from one point of the production process to another, from farm to plate. Food traceability mechanism tracks the origin of foods along the food supply chain. The International Organization of Standardization (ISO) defines traceability as the ability to trace the history, application or location of that which is under consideration – a purposely stated broad statement because food is a complex product and traceability is a tool for meeting a number of different objectives. A complete information on how animals are raised, fed, vaccinated and location of birth and lineage is an enormous task and expensive to collate and would drive up cost. Producing companies would have to determine the breadth (the amount of information collected), depth (how far back and forward the system tracks the relevant information) and precision (the degree of assurance with which the tracing system can pinpoint a particular food product’s movement) of the traceability system they wish to adopt. Traceability allows companies to improve efficiency with regards to produce, package and distribute products. As technological innovation drives down the cost of electronic coding system, more companies are expected to use the electronic tracking systems in their daily operation. Traceability system helps companies to isolate the source and extent of safety or quality control problems. Research is needed to seek simpler approaches to trace the origin of food products offered in the market place.

Raising large concentrations of animals within small confined areas is a challenge in waste handling. Research focused on improving the efficiency of feed conversion in farm animals would reduce the amount of feed needed to produce a kilogram of body weight gain or a litre of milk, and would decrease the volume of waste discharged. Better utilization of waste into feedstock for renewal energy and industrial raw materials and finished products may reduce the discharge of waste into the soil and waterways and the release of green house gases to the environment.

Food Security: Food security concerns with availability, access and stability of food supply of a state or of a union of sovereign states (Figure 5.4). Several short-term measures such as restocking of breeding stock and improvement in farm structures and long-term strategies such as enhancing smallholder production and investing in infrastructure have been proven to better prepare nations facing food security issues. ASEAN and its partner countries (ASEAN +3 and ASEAN-China-India) offer a huge potential to produce animal products for the community. Arrangement within the ASEAN community could be made to produce animal produce and feeds beyond the need of the community, thus the nation's domestic need for beef, mutton, milk and pork could be fulfilled.

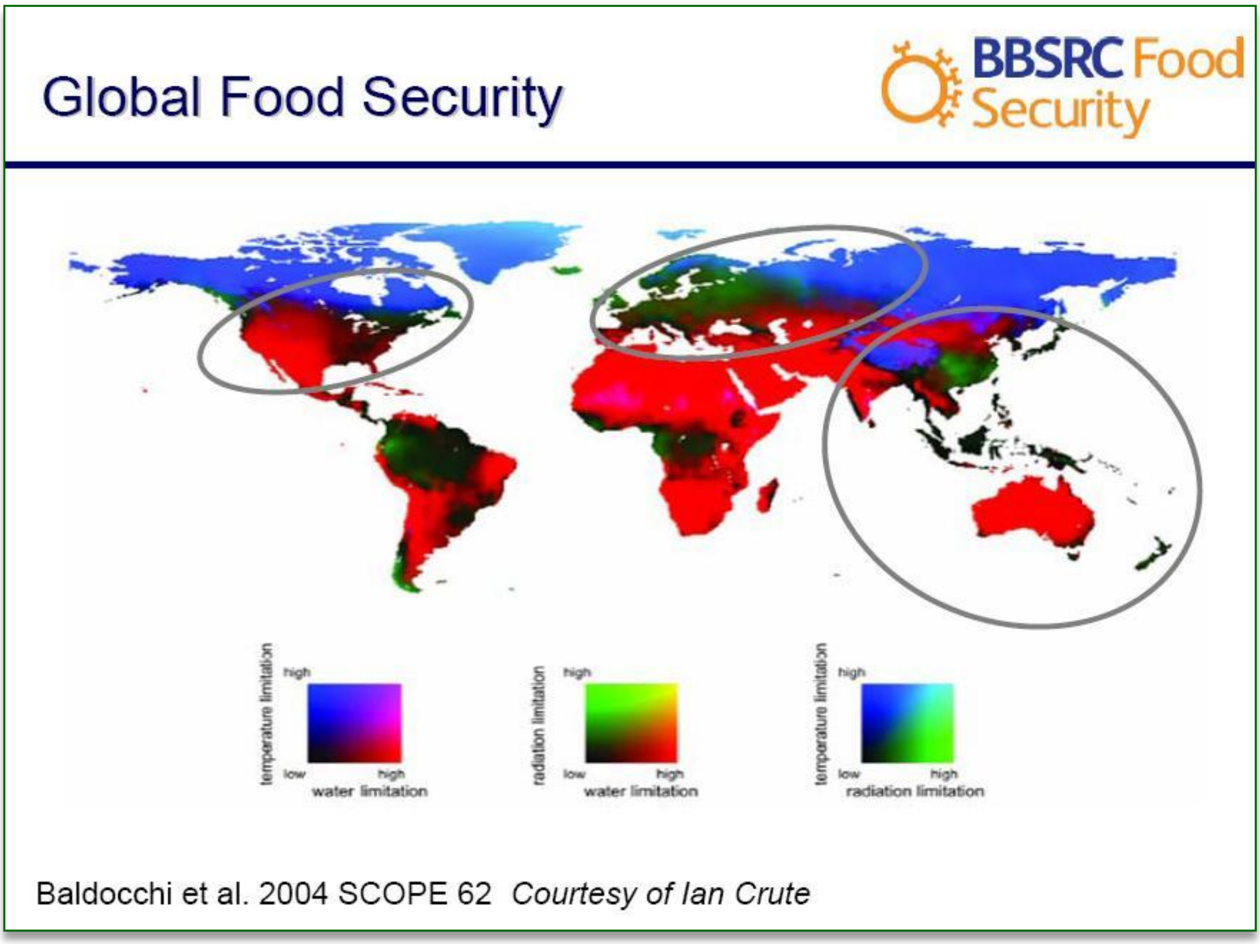


Figure 5.4: Global food security

Research programmes in finding solutions for the ruminant sub-sector planned for the decades leading to 2050 should address the following issues:

- Increased our understanding in the biology of feed utilization by animals
- Tapping the beneficial attributes of indigenous germplasms of animal species for incorporation into genome of production animals to develop disease and stress resistance
- Finding products which could enhance the bio-degradability of fibrous feed materials

- Technologies to better manage animals in intensive systems, including alternative uses of animal waste that minimize environmental degradation
- Developing animal and farm management protocols in animal farms to ensure the highest levels of food safety
- Reduction in pathogen burden in food-borne illness and detection methods of pathogens and toxins in foods
- Simpler methods of tracing the origin and path of food products

iv) Other Livestock and Wildlife Species

Traditional sources of beef from swamp and river buffaloes, mutton from Katjang goats, meat and eggs from ducks and village chickens have not been accorded due importance in domestic livestock development in this country, due to intense preference for modern breeds of livestock excelling in many traits of economic importance. The rich fauna and flora biodiversity found in Malaysia remains largely untapped both for knowledge enhancement of genomic profiling and commercial exploitation of potential animal protein sources. *Gallus gallus* red jungle fowl, *Bos frontalis hubbacki* gaur, *Hystrix brachyura* Malayan porcupine cervus unicolor sambar deer and *Aerodramus fuciphagus* swiftlets are among many species of wildlife that offer opportunities to generate niche products for domestic and foreign markets. Birdnest of swiftlets is a high value product whose production requires minimal space compared to range beef cattle farming.

Many aspects of biology and economics of captive breeding of jungle fowl, gaur, procupine and swiftlet have not been documented. To further explore the potential of these species as economically viable sources of animal proteins and other niche animal products it is imperative that further research be expanded in these areas.

Research programmes for the other livestock and wildlife sub-sector planned for the decades leading to 2050 should address the following issues:

- Highly efficient production system for traditional livestock species of beef animal, goats, ducks and fowls
- Enrichment of knowledge of the biology and economics of captive wildlife species of red jungle fowl, gaur, porcupine sambar deer and swiftlet
- Finding niche products from traditional livestock and wildlife species

v) Livestock and the Environment

The livestock industry will continue to develop large-scale production farms in localities close to human dwellings. Livestock producers should sensitize the many demands of the firm and society to arrive at amicable solutions balancing optimal profitability and good environmental management. Failure to meet the societal demand may force intensive livestock industry to relocate to other regions less frequented by humans.

Potential of some wildlife species such as gaur, sambar deer and porcupine as new sources of animal proteins need to be explored

In many densely populated areas where there are also the presence of highly concentrated animal populations in intensive production systems, the amount of animal waste being produced far exceeded the absorptive capacity of land and water. Overly rich nutrients of animal waste and waste water when not managed properly would pose a series of negative implications on the environment, resulting in biodiversity losses, ground water contamination and soil pollution.

Integrated waste management incorporated into a pig production system as practised in New Zealand is an example of an environmentally-sound intensive livestock production (Ministry of Agriculture New Zealand, 2010). Runoff of waste and waste water are treated and recycled for farm use or processed into various industrial products.

Ways to contain runoff from manure after its discharge include use of grass strips to remove sediments, nutrients and bacteria, control of runoff from open lots, preventing access of animals to open water bodies. Biological treatment of manure through use of anaerobic storage facilities and composting are effective in reducing pathogen burden in animal manure.

Global surface temperature is projected to increase by 1.5 to 4.5^{0}C within the next ten decades. The emission of green house gases from farm animals has been identified as the major contributor to rising global temperature. Crop yield is expected to decline with increasing global temperature. The attributes of current species of farm animals may change as a defence mechanism to counter the adverse effect of global warming. This may be an evolutionary process which eliminates species less suited to the changing environment. Indigenous animal populations may contain genes whose gene products may suggest better adaptation to a more stressful environment.

With anticipated global warming, loss of biodiversity in some fauna and flora would seem to be inevitable. Identifying which particular species of organisms are most affected by increase in surface temperature is an arduous task. Most mammals live within a narrow range of body temperatures, 35 to 40^{0}C, while the ambient temperatures of the rain-forest regions within the tropical belt range from 22 to 33^{0}C for most parts of the year. Humidity remains at high levels in the tropical regions within the latitudes 5^0 north and 5^0 south of the Equator. Native fauna and flora in the tropical region offer much diversity and potential, both for economic uses and wellbeing of humans. Changing global climatic conditions may affect the survivality of many of these species of plants, microbes and animals. Cataloging an inventory of these natural biodiversity is an enormous effort at conservation while exploring their many beneficial attributes to humans is a scientific feat to which a country must take responsibility – both efforts perhaps would ensure the sustainability of the human race.

Risks associated with change in surface temperature are difficult to quantify. Damage to farmland with global warming could occur due to increased precipitation, damage to the ozone layer in the atmosphere and more emission of green house gases. Emissions of green house gases could be curtailed when more carbon and nitrogen are deposited into the soil. Steps to store greater amounts of carbon and nitrogen in soils would soften the effects of global warming . Perennial trees such as timber species, oil palms, rubber and coconut have the potential to store more carbon in their biomass. Carbon dioxide and methane are released into the atmosphere once the plant biomass is broken down due to decomposition. Soil microbes thrive well in warm sub-soil level and speed up the rate of decomposition of organic matter, thus emitting more carbon dioxide into the atmosphere.

Increased temperature may have adverse long-term effect on the reproductive efficiency of farm animals. Greater proportion of genome of tropically adapted breeds of farm animals raised for meat, milk and egg production could mitigate the down-side of climate change on the productivity of farm animals. The present situation in the global poultry industry is vulnerable since 90 percent of the poultry breeds come from four major breeding companies in the world. The genetic base may not necessarily be narrow but the selection objectives may be too restricted as to exclude attributes important for adaptation to a more stressful environment – rising temperature, higher exposure to pests and diseases, increasing resistance of disease pathogens to drugs and pesticides.

Malaysian agriculture has thrived over the past several decades through mostly the pursuit of increasing yield in major agricultural and food commodities. Research and development on crops and farm animals have largely addressed to overcome limiting factors to increased production. The use of chemical fertilizers, weedicides, pesticides, veterinary drugs, feed additives and post-harvest treatments to enhance yield and quality of food crops and livestock is borne out of findings from research works done locally and abroad in laboratories and fields.

Often times the opening of new agricultural areas, intense use of chemicals and non-discriminatory discharge of animal waste have created major concerns about the safety of food products, deterioration of the surrounding environment and quality of water supply. These are valid questions to which research should give priority to provide appropriate solutions.

In a livestock production environment a producer of animal products cannot evade the use of inputs such as nutrients in the form of feeds, feed additives and feed supplements, veterinary drugs, antibiotics, pesticides and actinides for the purpose of enhancing growth and fortifying disease and pest resistance of the animals. In a natural ecological environment fauna uses nutrients and water for growth and survivality. The two systems: man-made production environment and natural eco-system, have many similarities in their input-output cycle. Producers have many things to learn from the natural ecological environment, especially the replenishment process in the nutrient cycle. The sustenance of a food chain in a natural ecological system is a very much inter-dependency of resources from one stage or phase to another, essentially utilising all output for mutually derived benefits. Livestock producers need to understand better about feed utilization and the metabolic process that controls the efficiency of the process. Knowing this would limit the amount of feed fed to animals and controls the amount of waste discharges, thus minimizing potential pollutants.

With easy access to information on health and environmental issues, communities are increasingly aware about the cleanliness of their surrounding environment. Many communities view locating animal farms close to peri-urban areas as potential sources of air and water pollutants.

Sustainable livestock production depends on many resources with water as one of the key resources. Ensuring the surrounding environment remaining clean and free of pollutants would help to keep water shed areas and waterways available to supply quality water for many uses of the general population and farming communities. The management of areas with high concentrations of farm animals needs to be concerned with potential air, soil and water pollutants. Agricultural activities use about 70 percent of water available. At the same time large human settlements are mushrooming in per-urban areas, thus putting added pressure for high quality water supply. In ultimatily the increase in the supply of food and non-food products must come from increased productivity on existing land using less water.

Research programmes for livestock and the environment planned for the decades leading to 2050 should address the following issues:

- Technologies are needed to better handle animal waste from intensive animal rearing facilities, reduce green house gases and find alternative uses of animal waste.
- There is a need to understand the effects of climate change on the productivity of farm animals. Developing ways to integrate food animal production with clean environment and water management
- Developing environment friendly solutions to current and emerging disease and pest outbreaks
- More judicious use of chemically based solutions to enhance animal health
- Developing science-based farming choices based on technologies that include new ways to manage natural resources.
- Finding products which could enhance the bio-degradability of fibrous feed materials

vi) Animal Welfare

The general public needs to be better informed about how animals are being treated at the farm level. Stakeholders of the animal industry have the responsibility to communicate with the public about the good animal husbandry practices that are being adopted by many producers. Standards of practice based on science that meet the accepted provision for the well-being of farm animals should be developed by incorporating many disciplines of science, economics and sociology (Farm Foundation, 2006). It is crucial to disseminate widely information to consumers on methods being adopted by producers to improve the well-being management of farm animals. This is to allay any concerns about the misconstrued perception of ill-treatment of farm animals.

Research into the well-being of farm animals needs to be intensified. More cost-effective methods of raising animals that are not in conflict with animal welfare issues need to be identified to sustain the animal industry. Curriculum in animal sciences, veterinary medicine and general agriculture at different levels of tertiary, vocational and continuing education should incorporate various aspects of animal welfare, including legislation and regulatory requirements. Coupled with this effort to increase knowledge acquisition and awareness of stakeholders in animal welfare issues, extension service rendered to producers should empathize the need to adopt appropriate methods of humane animal care and management (Figure 5.5).

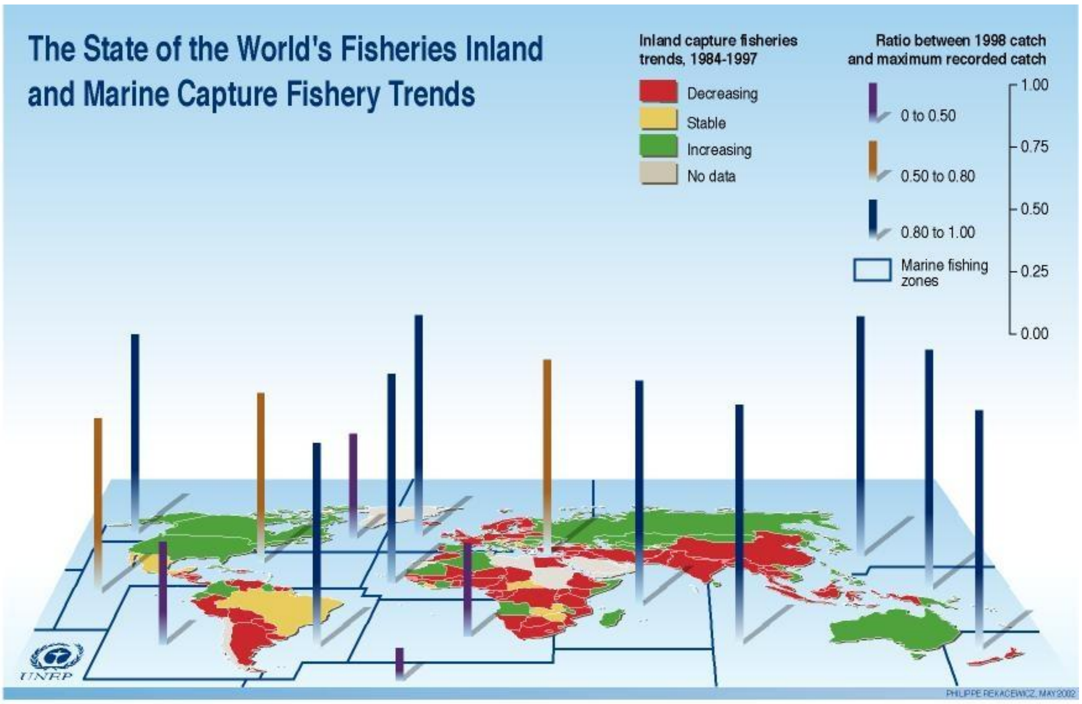
Since May 2005, the World Assembly of OIE Delegates (representing the 177 Member Countries and Territories) has adopted seven animal welfare standards in the Terrestrial Code and two animal welfare standards in the OIE Aquatic Animal Health Standards Code (Aquatic Code). These standard covers:

- The transport of animals by land
- The transport of animals by sea
- The transport of animals by air
- The transport of animals for human consumption
- The killing of animals for desease control purposes
- The control of stray dog populations
- The use of animals in research and education
- The welfare of farmed fish during transport
- The welfare aspects of stunning and killing of farmed fish for human consumption.

These standards are regularly updated to take account of latest scientific findings and should be used as the basic qualification. Research programmes in animal welfare planned for the decades leading to 2050 should address the following issues:

- Adopting global standards of animal welfare of tropical environment

- Labelling of products with appropriate globally accepted information including traceability and animal treatment



Source: *The State of World Fisheries and Aquaculture 2000* ; *Review of the State of World Fishery Resources: Inland Fisheries*, Food and Agriculture Organisation (FAO), 1999, Rome.

Figure 5.5:The state of the world's fisheries inland and Marine capture fishery trend

5.3 Trans-Global Tropical Agriculture

The theory of evolution was independently conceived by two British scientists, namely, Charles Darwin and Alfred Wallace, during their voyages to the rainforests of South America and the archipelagic islands of South East Asia. It is their keen observations and analytical minds that spawned and inspired the ideas of bio-geographical transplant of rainforest species between similar but distantly isolated rainforest habitats for agriculture. Two examples of successful bio-geographical transplant of species were oil palm and rubber introduced into a similar habitat or climatic conditions (Malaysia from Brazil and Africa), distantly geographically-located continents, and away from its closely associated natural enemies (South American

Leaf Blight for rubber) or the obligate, natural pollinator (*Elaeidobius weevil for oil palm*). Early 17th century British explorers worked closely with scientists to experiment the initiative for the benefits of the British colonial master. Early thoughts on the species-rich, diverse, tropical rainforest setting suggest there could be more possible introductions of trans-global tropical, continental species exchange for agriculture between the continents of Africa, South America and Asian Archipelago. There has never been any country in the world whose economy thrives excellently on the introduction of foreign species for agriculture that virtually transformed the economy and demography like Malaysia. The unexpected in the Malaysian agriculture happened when the biogeographically allopatric species from similar tropical rainforest habitats like rubber, oil palm and cacao were introduced and took foothold via the extensive and relentless establishment of the plantation industry in the late 19-century. Invariably, the success or partial success of these introduced crop species into the similar habitats in the New World Tropics from the continent of the New World Tropics was in part due to its alienation from the natural enemies. Rubber trees experience similar habitat in the rainforest of Malaysia, but without the hazards of pestilence from the South American leaf blight. However, oil palm was introduced into Malaysia without the accompaniment of its obligate pollinator, *Elaeidobius weevil* (*Elaeidobius kamerunicus*).thus deprived of the pollination services of the efficacious *Elaeidobius weevils*. There are plenty of successful biogeographical introductions of crop species of similar habitats for agriculture from another continent of similar habitats of the hot and humid rainforest. Banana originates from South East Asia but successfully introduced into South America. Similarly, coffee originates from Africa but succeeds in South America.

This formula of biogeographical transplant of flora and fauna species for agriculture must be continued for future explorative undertakings in agriculture. This success formula in the introduction of allopatric species into similar habitats from different continents must be continued in the quest of sourcing of new species for agriculture. Malaysia should continue to approach the tropical-rainforest countries in the continents of South America and Africa to pursue the trans-global tropical agriculture. Brazil, Colombia, Peru, Belize, Costa Rica, and Trinidad-Tobago of South American continent, and Cameroon, Ghana, Nigeria, Guinea, Congo, Uganda and Mali of Africa are possible partners in the trans-global agriculture partnership (Figure 5.6).

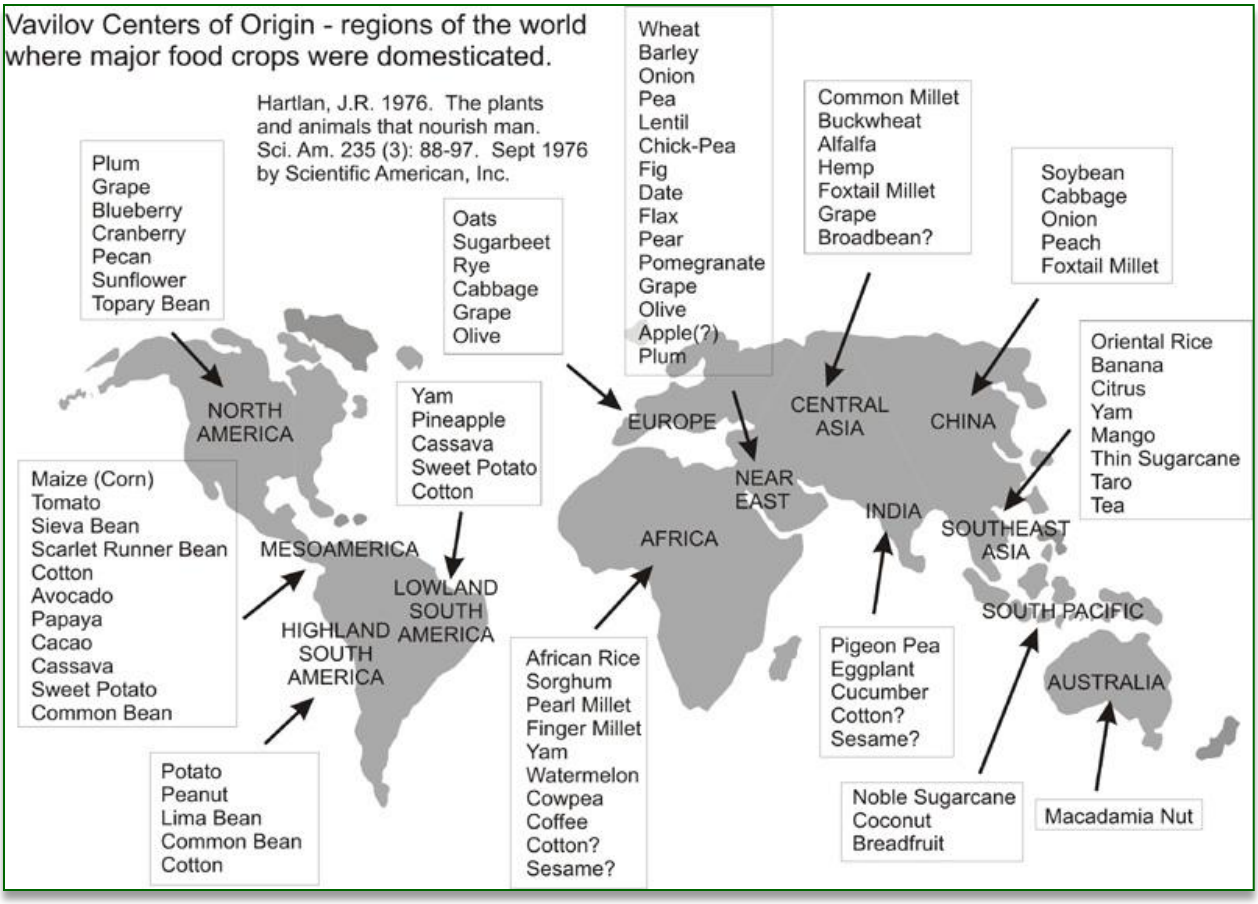


Figure 5.6: Regions of the world where major food crops were domesticated

5.4 Agro biotechnology

The genetic engineering/biotechnology possibilities for genetic engineering are limitless; if only it is limited it would be our imagination. Worldwide, major GMO successes via many fold increases in cereal crop yields from more than 300 million hectares of commercially planted crops by more than 15 million farmers in more than 40 countries have encouraged the planting of GMO crops in many more countries. Noteworthy, some of these traits, such as, disease resistance, pest tolerance, reduced use and dependence on weedicides, pesticides, insecticides and biocides, etc. have led to increase in farm profits and are environmentally less destructive. This is indeed a positive move towards going organic and sustainable agriculture, and shifting from the overdependence of petroleum-based fertilizer and biocides. The detractors of GMOs are lessening in numbers and being drowned by the major headways and successes of the GMO crops. A major issue of consumer concerns on health risks, or penetrating the system of the human food chains has thus far been far from the truth. Efforts are underway in China, after having sequenced the DNA genome of rice, to fortify the rice genes with vitamins and other pharmaceuticals or medicinal properties, so that the staple food of more than 3.5 billion Asians will be able to address the concerns on nutrient deficiencies. We have a foretaste and glimpse of many more genetic inroads across species from the success gene transfer in the insertion of the beneficial omega-3 genes into the poultry eggs, soya beans and even the far out Omega-3 soybean that can be used to make 'tempe'. It is conceivable that the field of pharmaceuticals and neutraceuticals would develop in tandem through genome engineering. In that sense the field of synthetic biology would rewrite major approach to pharmaceutical and the neutraceuticals industries. Towards this end, China has sequenced more than 150 economically important crop plants for the benefit of her agriculture. In this regard, we can assume that the Bio Valley initiative of the touted National Genome Institute and Institute of Agriculture and Biology would make major genomic headway in years to come. Designer rice fortified with vitamins; designer cows producing human milk, spider-goat producing biosteel silk, biosteel production from tobacco plant are not remote possibilities in the near future. It takes imagination and bold initiatives to make headway into molecular breeding of crops for the benefit of agriculture and pharmaceuticals.

The recently completed sequencing the oil palm DNA genome by several entities in Malaysia opens up greater opportunities for the oil palm industry in the coming decades. It has created tremendous opportunities in improving the specific traits of these economic crops via molecular breeding for pest and disease resistance, longer palm bunch stalk for improved fruiting habits, tolerance to higher temperature, resistance to droughts, tolerance to higher salinity and tolerance to longer period of flooding in addition to enhancing the derived vitamins and fatty acide content. Equally, the completed mapping of the rubber genome and the developed transgenic rubber clone will enable the creation of new far-out possibilities of transgenically inserting new genes possibilities, such as, inserting the biosteel silk protein genome from spider into the rubber trees to explore the possibility to produce biosteel silk from rubber trees. Such initiatives of new possibilities from the genome engineering can potentially create new materials and new opportunities and enhance or add value to the existing industrial crops of rubber and oil palm.

So, in many important ways, advances in agri-biotechnology is nothing short of staggering and promise much with the mapping of rice, oil palm cocos , fruits, herbs, and other genomes and the spread of biotech crops, livestock, and fisheries. The 21st Century has been touted as the "Biology Century" and agri-biotechnology is expected to lead to "New Agriculture" where plants and animals are endowed with new value creation mechanisms. Consequently, we now have focused research and development in "Bio-Farming" (biotech crops, bio-fertilisers, bio-pesticides); "Bio-Pharming" (bio-factories for moalical product and vaccines); "BioFuels"; "BioPlastics"; and "BioRemediation".

Teng (2007) contends that the reported crop biotech R&D to date is "just the tip of the iceberg". In the area of agronomic traits we note the progress in biotic stress (insect and disease resistance) as well as herbicide tolerance; abiotic stress (drought, cold, heat and poor soil tolerance); desired or hedonic quality traits (taste, shelf-life, nutrients, seedless); novelty products (oils, nutraceuticals); and renewable resources (biomass conversing, biofuels or energy farming) is noted. A more detailed listing of the possibilities is provided in Table 5.1. We are sure the same holds true for livestock and fisheries. Consequently, there are great expectations that agri-biotechnology will contribute greatly to innovations, cost reductions, productivity increases, new processes and new products that will benefit mankind in general. However, as in all forms of technology they would tend to be embodied and hence would benefit different stakeholders in the respective supply chains unequally (Figure 5.7).

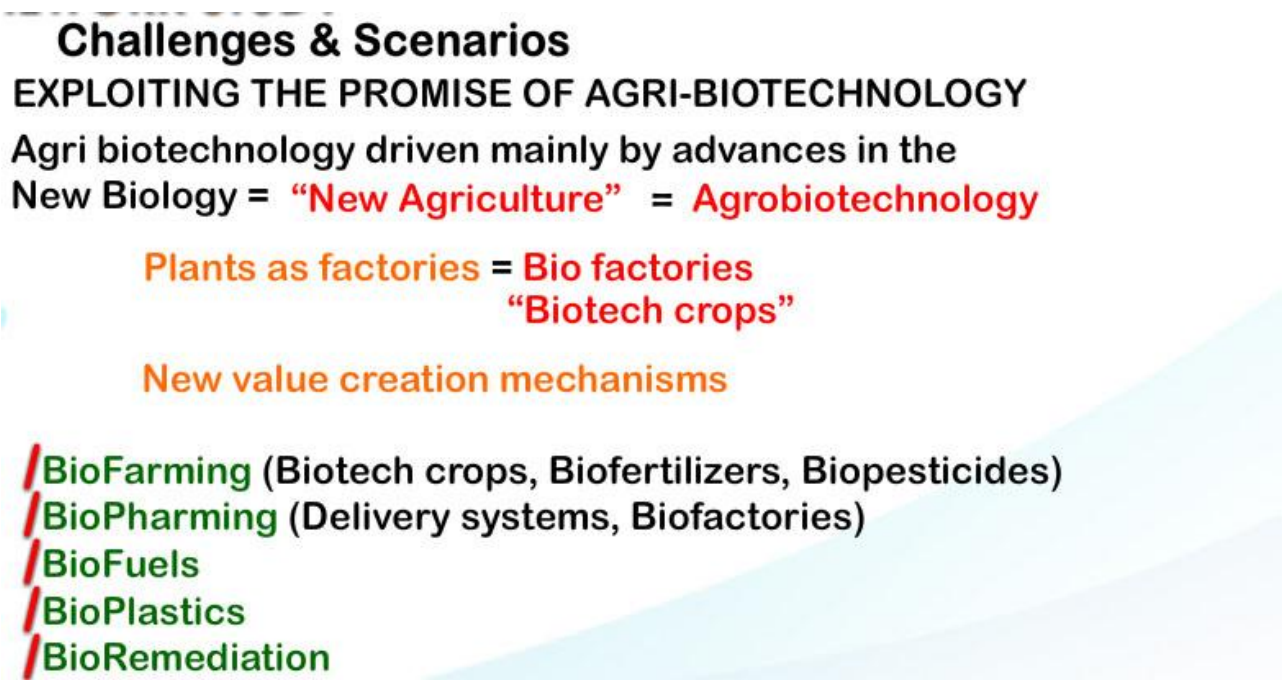


Figure 5.7: Challenges and Scenarios

Table 5.1: Agro-biotechnology prospects in agriculture

Agronomic Traits	Biotic Stress Insect resistance Disease resistance: viral, bacterial, fungal, nematode Weed-herbicide tolerance Abiotic Stress Drought, cold, heat, poor soils Yield Nitrogen assimilation, starch biosynthesis, O2 assimilation
Quality Traits	Processing Shelf-life Reproduction: e.g. seedlessness Nutrients (Nutraceuticals) Macro: Protein, carbohydrates, fats Micro: Vitamins, antioxidants, minerals, isoflavonoids, glucosinolates, phytoestrogens, lignins, condensed tannins Anti-nutrients: phytase, allergen and toxin reduction Taste Architecture Fibre Ornamentals: colour, shelf-life, morphology, fragrance.
Novel Crop Products	Oils Proteins: Nutraceuticals, therapeutics, vaccines Polymers
Renewable Resources	Biomass conversion, feed stocks, biofuels

5.5 Controlled-Environment Agriculture System

The onset of unpredictability of weather brought about by climate change leads to yield unpredictability. This increased unpredictability would evaluatly translates in to high costs of farm products, especially vegetables and other easily perishable products. Stability and predictability of yield can only come about if the production system can be Controlled and Regulated –Enrolled –Environment Agriculture System (CEAS). CEAS affords control of input-output, reduce waste and saves time, reduce cost on pest and weed control and disease incidence in the long –run, reduces carbon emission and water use, etc.

The unpredictable and less-controlled nature of the weather will make farming vulnerable to crop failures. However, there is a general and growing worldwide trend in the innovations towards controlled-environment agriculture (Figure 5.8) and agroecosystem approach. There are now many controlled-environment laboratories being built for commercial farming which temperature, humidity, light quality and duration, water and energy can be regulated and calibrated and retrofitted for any agroecosystem of food production. For instance, the Controlled Environment System Research Facility for the NASA programme at the University of Guelph can be attuned into a unique hypobaric condition of low oxygen and stressful atmospheric conditions for farming in a facility to prepare for outer space program in the flight to Mars which is expected to take more than 1.5 years. The Biosphere 1 and Biosphere 2 projects controlled-environment conditions are designed to create a microcosm of a biosphere of the earth that can sustain a life support system for humans. Similar efforts of the closed environment of the 7 types of earth-biome conditions ranging from the likes of tropical rainforests, savannah, tundra, desert, etc. in Cornwall England reflect the myriads of efforts towards a closed-loop, sustainable and inclusive ecosystem for living. Such varied and diversified experimental approaches to develop a life support system or biosphere will gives technological spin-offs towards an inclusive and sustainable agroecosystem supported by precision farming.

Figure 5.8: Model of vertical farming

5.6 Precision Agriculture

The evolution of agricultural development has seen the shift from human power to livestock power contributing to greater productivity. The advent of industrial agriculture brought to good use the mechanical power from farm machineries, such as, tractors, combine harvesters, lorries, etc. to enable greater hectarage of land for crop cultivation and livestock rearing. The use of petroleum-based, chemical fertilizers, insecticides, weedicides, and other biocides for industrial agriculture has caused environmental degradation that pollutes the streams, river systems and water bodies. But now, in the Information Age, agriculture productivity is also enabled by the information and communication technologies (ICT-enabled), knowledge powers productivity in the form of information enabling more efficient production in agriculture. The practice of precision agriculture or farming via computer-power processing, using electronic sensors for surveillance and monitoring, satellite remote sensing (RS) ,geospatial information system (GIS), traceability studies (GPS and RFID-tagged), molecular breeding (rather than conventional breeding), compliance to standards (health and food), etc. affords greater productivity via reduced wastage, recycling technologies, optimal use of input resources to reduce wastage for greater efficient utilization of scarce resources to increase farm productivity (Figure 5.9). We can expect in the coming decades that elements of the Biological Age will see the shift of agriculture into the controlled-environment, biotech farming, where agriculture will be conducted increasingly in indoor facilities (with control temperature, humidity, pest disease, fertilizer , water, etc. to cope with the vagaries of weather caused by Climate Change (Figure 5.10).

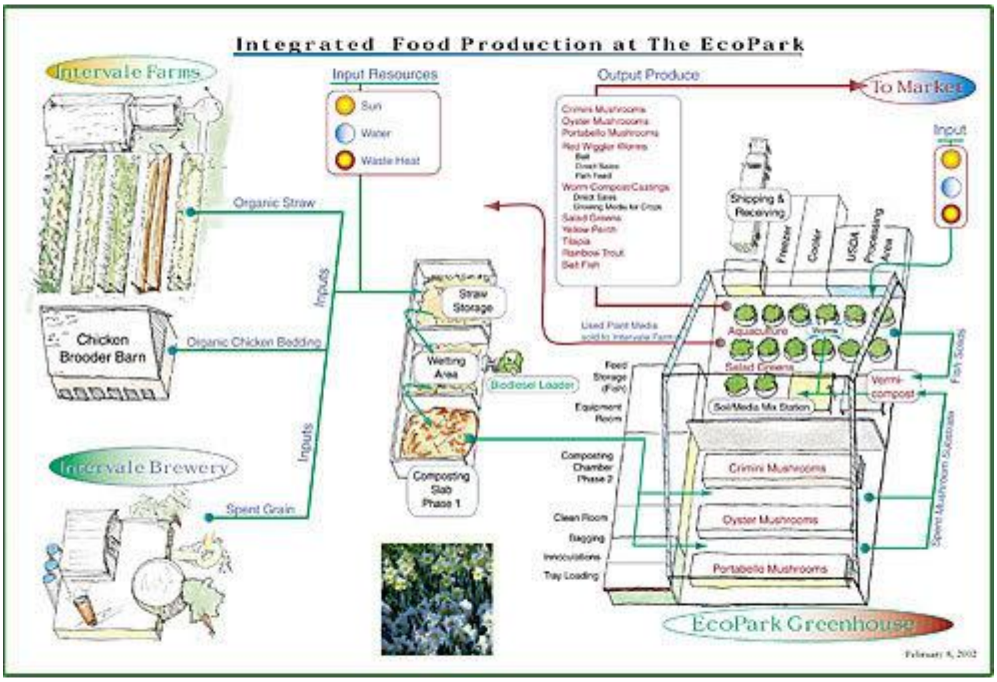


Figure 5.9: Integrated Food Production at the Eco-Park

The 5S technologies are as follows:

i) Global Navigation Satellite System(GNSS)

Specific locations in the farms are determined using global navigational satellite system (GNSS). Many GNSSs are being deployed such as global positioning system GPS-(USA), GLONASS-(Russia), GALILEO-(Europe), COMPASS-(China), IRNSS-(India), and QZSS-(Japan).

ii) Sensor System

Sensor system can be by multispectral and hyper spectral ground based, airborne and satellite remote sensing. Other ground-based sensors include weather radar, soil sensor, water sensor, crop growth sensors and yield sensor.

With the launch of Razaksat on 21 April, 2009, Malaysian agencies are increasing their effort to sell services from the satellite, whether data for GIS, or expertise in some area of satellite operations, to other nations. Countries on the equator will benefit because Razaksat is the only current remote sensing satellite in an equatorial orbit. This means it comes over

Malaysian territory on every orbit – about every 90 minutes. This gives the satellite operators the best chance of exploiting holes in the cloud cover.

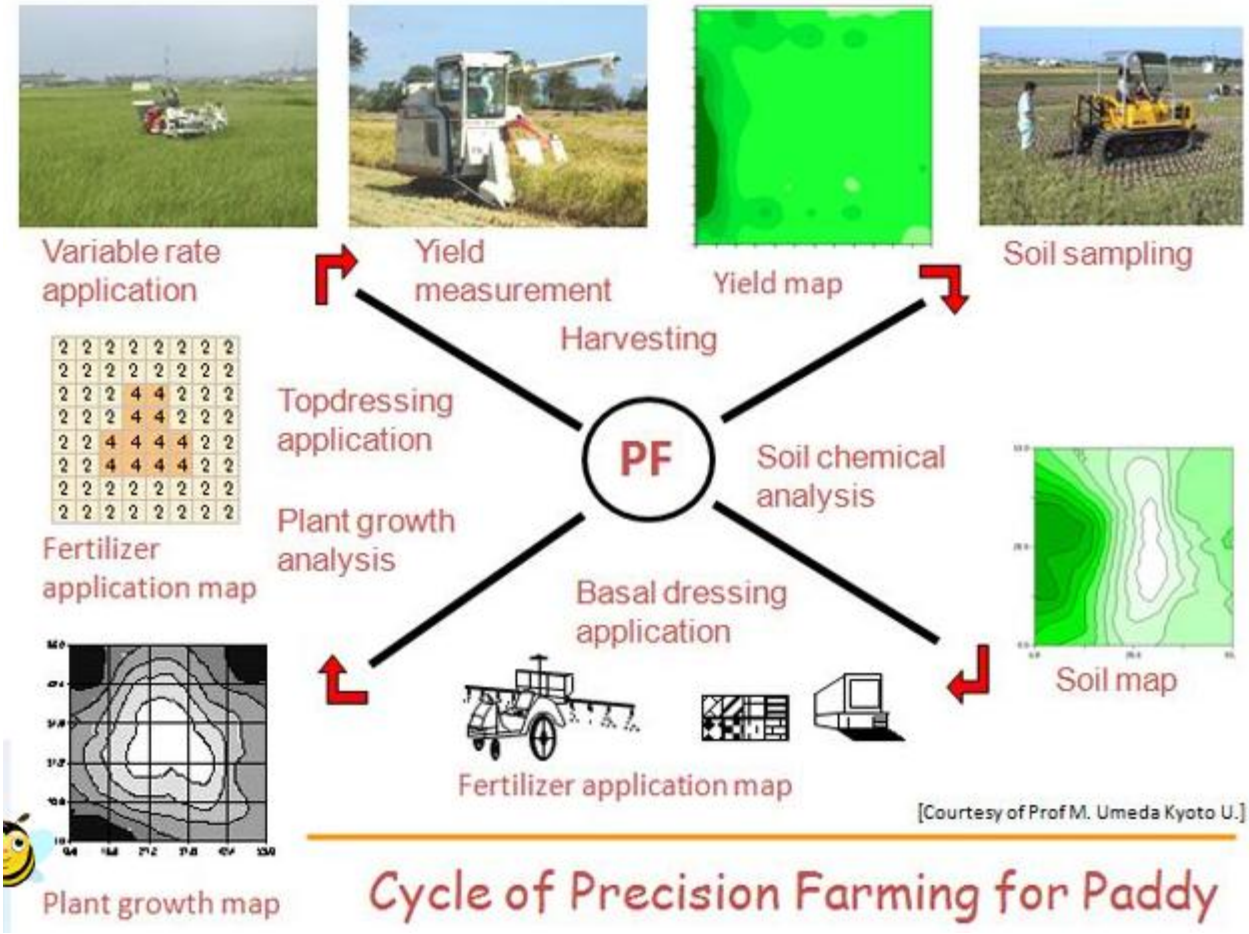


Figure 5.10: Cycle of Precision Faming for Paddy

Normal polar orbiting satellites might return to Malaysia only once in a fortnight, and then see nothing but clouds. As a result, it takes the Malaysian Remote Sensing Agency years to generate images of some parts of the country using US or European satellites.

RazakSat operations will be carried out by engineers at Astronautic Technology's ground station at Hicom-Glenmarie Industrial Park in Shah Alam. Two other ground stations in communication with the satellite are the Malaysian Remote Sensing ground station in

Temerloh, Pahang and Angkasa's ground station in Banting, Selangor. Angkasa is the Malaysian space agency. The image receiving and processing station at Shah Alam will receive and archive images for post processing and distribution to users. The RazakSat system is a collaborative program between Astronautic Technology and Satrec Initiative Co Ltd, South Korea.RazakSat will be able to offer images of Malaysia, Indonesia, Singapore, Thailand, Brunei, India, Sri Lanka, the Philippines and some African and South American countries.

There is a need for more coordination among government sectors, the universities and the industry in Malaysia. A major problem is accessibility to data. The government can do more to facilitate that. The sources are there but not easily available to users and without addressing that, the technology cannot be made operational. Data have to be made available as when and where they are required to people at the universities and in the industry. There is still a lot of bureaucracy and red tape on the pretext of public security and safety. Many of these are not necessary as those with high resolution technology outside Malaysia can easily access more information on the country.

iii) Geospatial Information System

Data and information collected via the sensors is stored in a Geospatial Information System (GIS) platform for storage, retrieval, processing, mapping and modelling.

iv) Machinery System

Some sensors and variable rate applicators are carried on vehicles with implements or machinery system, such as yield sensor and monitor on rice combine harvester or soil EC mapping sensors and variable rate applicators attached to tractors.

v) Control System for variable rate application

Once the collected data are analyzed and information has been obtained, the application of production inputs such as fertilizers, seeds, irrigation water and chemicals for pest and disease control is done by an automated or control system on the vehicle. The variable rate application can be done directly if sensor based applicator is used or by a previously prepared prescription map for a map-based applicator.

Precision Farming (PF) is considered the best practicable approach to achieve sustainable agriculture . Precision farming is an integrated, information- and production based farming system that aims to raise efficiency, productivity and profitability of long term, site-specific and whole farm production while avoiding the undesirable effects of excessive chemical loading to the environment or insufficient input application.

Role of PF in crop production technology was recognized worldwide, but so far, it is applied mostly on large farms in developed countries. Implementation of PF should be followed in three main steps of information gathering in terms of variability, data processing to evaluate the significance of variation and employ new management strategy to apply farming inputs. Figure 5.11 demonstrate some equipment and technologies in a typical precision farming crop growing cycle.

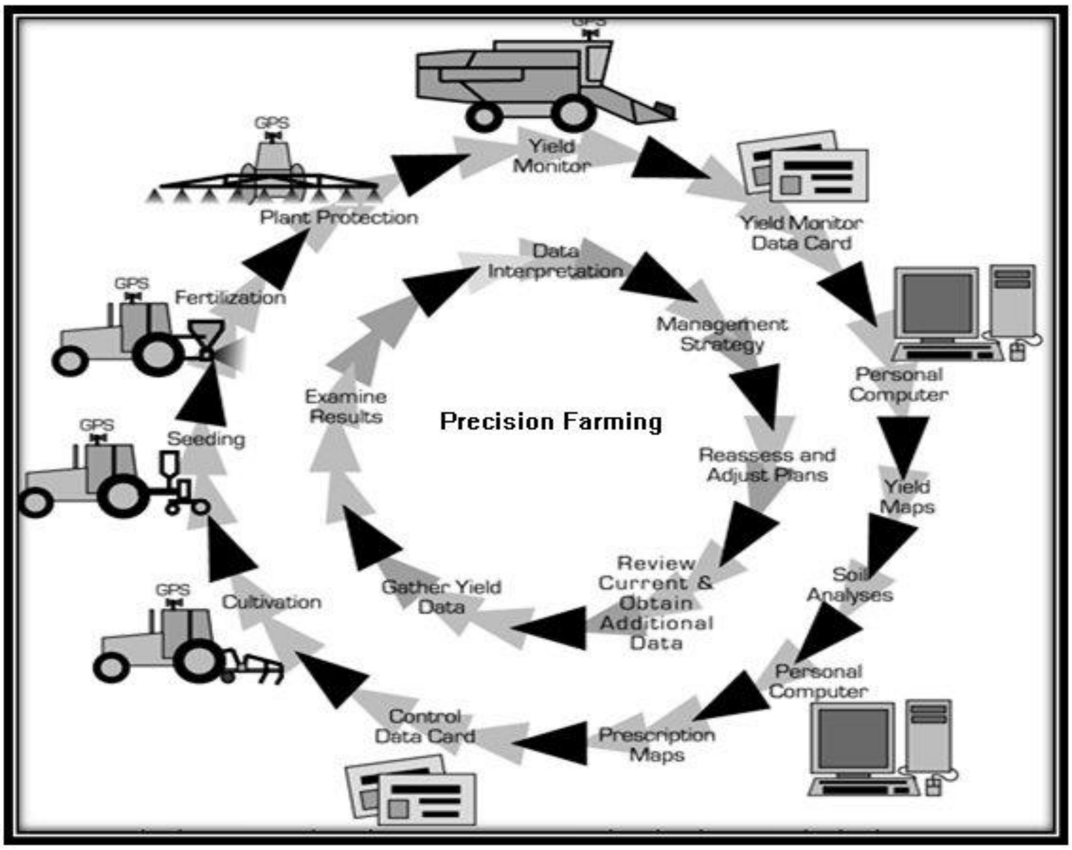


Figure 5.11: Precision Farming Cycle (Grisso, 2009)

Implementation of management strategy based on precision farming concept is the vital factor to achieve a desired outcome for the farm. Managers should make out their own strategies that allow them to manage variability precisely. Blackmore (1999) stated the three types of variability that have been identified are spatial variability, which can be found through changes across the field, temporal variability which means changes over time and predictive variability, that identifies the difference between predicted and what actually happened in the field.

One of the precision farming approaches to manage spatial variability is site specific crop management (SSM). In order to match application of farm practices with soil and crop requirements, zone management was suggested. Zone management represents subfields with similar characteristics including soil properties, topography, slope, nutrient levels and so on.

What went before in precision farming indicated that the early research focused on different methods of sampling and interpolations for mapping as well as analyzing spatial variability of soil and crop properties. Pierce and Nowak (1999) asserted that high charges of sampling are noticeable obstructions in precision farming profitability. Afterward, variable rate technology (VRT) came up to PF to manage spatial variation (e.g. variable rate fertilization) . Hence, recently emphasis moves to utilizing a variety of data layers (e.g., maps of soil properties and real-time sensors,) to split the farm into sub-units named "management zones" . Different zones behaved independently based on zone characteristics including soil requirement, moisture condition, slope, drainage condition and so on. That is why, farming treatments vary by zones. While unique characteristics of each zone should be realized. Importance of site specific management is much clearer when there are interactions between variable factors. "Responding to those interactions, paying attention to details of the system is the key to profitable implementation of site-specific management. Successful action begins with field assessment that focuses on the spatial and temporal differences in manageable production components instead of on the production uniformities".

Precision farming is an infant technology. This infant has some of the signs of eventual greatness, but its full capacities will not be evident for some years. Like all infants it will require an investment of time and resources to help it matures. This investment will have some short term payoffs, but the main benefits will be in the future. Jess Lowenberg-Deboer

(1996) discussed adoption of precision farming technology for future payoff with the specific objectives to review what have we learned about the economics of precision farming, identify future benefits and outline an adoption strategy designed for long term competitive advantage.

Economics change as technology changes. Almost every week new equipment and software are put on the markets that improve our ability to collect and use site specific data. Our understanding of the economics of these new tools is far from perfect, but gradually we are beginning to understand the trends and the general characteristics.

Studies of site specific management have often focused on changes in crop input costs, such as fertilizer or herbicide, while sometimes ignoring investment costs. In particular, the cost of developing "human capital" is often omitted. We are not born with the capacity to use site specific management profitably. It must be developed. Costs might include: workshop and short course fees, time away from other work and "wrong decisions" made while learning.

The annual cost of using site specific tools depends heavily on the useful life of that equipment, software, databases and skill. If site specific management tools are obsolete in 3 or 4 years, like other computer based technologies, the annual cost of use can be surprisingly high.

The benefits of site specific management have proven difficult to measure. Crop yield changes in side-by-side comparisons of site specific and whole field technologies might be due to inherent soil differences or microclimate. Simulation of what the field might have produced under another management system is time consuming and often inaccurate. The environmental benefits of site specific management have been much discussed, but they have not been measured.

Currently available site specific management technologies are profitable in some cases, but studies suggest that they often fail to cover all additional costs in the production of bulk commodities. The profitability of precision management is greater in higher value crops, such as vegetables, potatoes, and seed. Low profitability in bulk commodities may be due as much to management problems as to technology. The importance of having a site specific management system emerges clearly from available studies. It is unlikely that one or two inputs will consistently pay the costs of site specific data collection and use.

Long run profitability of precision farming technology depends on the development of management systems that link inputs applied with yields harvested on specific sites. These management systems will be some combination of computerized decision support systems and the accumulated wisdom of experienced managers. Decision support systems require databases. Wisdom comes with long experience. These management systems will be site specific. Generic decision support systems will be developed, but their performance on the farm will be enhanced by data from the farm.

Agricultural databases take time to accumulate. For example, because of weather variability, accurate information on site specific yield potential and problems may require several seasons of data. Retesting soils at the same sites creates data on fertility trends.

History shows that most of the benefits of any new agricultural technology go to the early adaptor. Those who lag have often been forced out of farming. Precision farming is expected to follow the same pattern. Those who begin to accumulate data and experience now will be ready to use improved precision technology as it matures.

Whoever benefits from precision farming will be determined by how management of precision data is organized. To realize the full benefit from precision farming farmers will probably need to pool data. By pooling data with other farmers who have different management approaches it will be possible to identify the best combination of seed, fertility, tillage and pest control.

Four alternative organizational forms have been proposed for data pooling:

- Agricultural input manufacturers and suppliers,
- Independent data management companies,
- Non-profit data management groups, and
- Public universities.

Each alternative has its advantages and disadvantages. Data management by agricultural input manufacturers raises questions of credibility and representativeness. Some suspect that manufacturers would manipulate the data to enhance sales. Data collected exclusively from the clients of a manufacturer might not be representative of farmers as a whole and as a consequence the fine tuned crop plans developed might not be useful outside the client group.

Strategic Management for precision farming eventual developments can be grouped in three scenarios:

i) Information Agriculture - This is the rosy scenario in which farmers share data and results, and as a consequence costs are cut, yields improved and the environment is maintained. Farmers, industry and universities are partners in developing these better crop "recipes".

ii) Industrial Crop Production - Precision data and analysis are controlled by large companies. They develop proprietary crop recipes. Some farmers become minimum wage tractor drivers and other become "integrators." Only part of precision farming potential is developed.

iii) Technological Dead-end - Practical and profiTable uses are not developed for precision farming, perhaps because data is not shared.

i) Adoption Strategy

In this environment of rapid technological change, farm and agribusiness adoption strategy should be based on finding the least cost way to build site specific management capacity and databases. Agriculture is becoming a knowledge based industry where what the farmers know is a key factor in profitability. Ownership of precision farming tools has a place in this strategy, but it is not the only option.

For some farmers the least cost learning strategy will be using custom services to build databases and gain experience with the spatial variability of their fields. With custom services, data ownership will be an issue. Farmers who plan to use custom services to help build their precision farming database should have a written contract that specifies their rights to the data and they should take care that the data is available in a format that can be transferred to other software.

For many grain farmers, a yield monitor will be the point of entry to ownership of precision farming tools. Yields are an essential layer in a spatial database for the farm. Interpreting and using yield maps is key step in developing precision management skills. Mapping packages sometimes store data in proprietary formats that can not be used by the next generation of software. To facilitate use of previously collected yields by new software, raw yield data should be retained.

Soils data is another essential layer in the precision farming database. Soil sensors may eventually make grid sampling obsolete, but in the meantime grid sampling is the best way to collect soil data. If purchased services are used to collect soils data, care should be taken to establish ownership of the data and to conserve the raw data.

Some aspects of precision farming will become standard practice for agriculture in advanced countries, but we do not yet know which aspects will prove most practical and profitable. The most durable investment that farmers and agribusiness can make in this area is the development of management skill and databases. Hardware and software are sure to change, but site specific databases and the capacity to use precision management tools profitably will provide a long run competitive advantage.

ii) Barriers to adoption of precision farming

After about two decades of research, assessing the potential of PF remains difficult, both in terms of its impact on farmers and the underlying agronomic principles that hamper faster progress. Examples of success have been reported, but well-documented improvements in yields, profitability or environmental quality remain rare in the scientific literature. Lambert and Lowenberg-DeBoer (2000) reviewed 108 articles published in the scientific and popular literature reporting economic results of PF based on either simulated responses or actual field studies. Most reports (73%) focused on VRT and 63% claimed higher profits. However, many studies omitted important costs such as soil testing, data analysis, or training. Only 40% of all articles provided actual field evaluation results. Only three articles were field studies published in peer-reviewed scientific journals in which site-specific treatments were implemented over several years, with appropriate measurements of the agronomic, economic, and environmental impact.

In general, adoption of PF in North America, Europe, Australia and other parts of the world has progressed patchily. Worldwide, yield monitors have clearly outpaced the adoption of other PF components.

Producers want cost effective, easy to use, integrated PF systems and more thorough and scientifically based advice. Developing them requires understanding of decision processes and sources of uncertainty in the context of site-specific management problems (Adams et al. 2000). In data poor situations, knowledge-driven models may be less accurate but preferred by the farmer, while in data rich situations data-driven models may be more appropriate. Considerations for this involve: (1) Is the information *deliverable* and what change in management could result from more information and control? (2) Is the information *new*? (3) Is the information *significant* to the person who makes the decision? (4) Is the information *actionable*: given that I believe this variation to be significant and that I am certain enough about the causes (likely outcomes of change), then I will change. This is by far the most difficult barrier to overcome. If a farmer is not certain enough to take sub-field action, he may still consider making whole-field changes.

High costs and knowledge demand, unavailability of many services, and uncertain benefits seem to preclude any possibility of PF in developing countries. However, the basic purpose of PF - to provide spatial and temporal information to reduce uncertainty – should be viewed as essential to accelerate change in the developing world, even if it is used in a different form to that offered in Europe or North America. The need for spatial information is actually greater in developing countries, principally because of stronger imperative for change and lack of conventional support. A large body of spatial information exists in the developing world, much of it freely available. The challenge lies in overcoming issues of scale and uncertainty, and finding meaningful ways of delivering this information to farmers. Promising approaches are those in which farmers create their own local spatial data at appropriate scales. One example for this is the SSNM concept developed for rice using a combination of regional and local information. Other examples include sugar cane growers in Colombia who have organized themselves to use spatial information for site-specific management, site-specific natural resource management at catchment and community scale, or participatory three-dimensional mapping, in which a terrain model is the basic information source, generated by the local community itself. In export-oriented cash crops, PF may be similar to that in developed countries. First examples of this have emerged for fruit, tea, or oil palm plantations. The much reduced cost of labour may in fact enable developing countries to obtain spatial knowledge at a lower cost than in developed countries.

iii) Water Management

Crop yields in rain fed agriculture are unpredictable unless supplemented with adequate water management to reduce the risks of crop failure. Malaysia, for example, receives abundant rainfall, averaging about 3000 mm annually. Major crops like oil palm and rubber are grown under rain fed condition, but double cropping of rice in paddy fields needs irrigation. The total irrigated rice area is about 0.32 million ha. In the main irrigation schemes, a cropping intensity of 180% is achievable. Irrigation water usage is about 30 to 50% of total water consumption and the rest are supplied by rainwater. Irrigation is not only the largest consumer in terms of volume, it is also associated to comparatively low economic value, low efficiency of about 30-45 %, and water productivity index less than 0.4 kg/m^3.

In rice granaries, there are seasonal water deficits, resulting in conflicts in the use of water stored in dams. A large amount of water is required for irrigation of rice during the dry months, and at the same time it is also required for non-agricultural uses (domestic and industry). In addition, water storage has to be maintained for recreational purposes. Shortage of water for irrigation of rice during dry months is also frequent.

The conflicting use of land for agriculture versus water catchment is being increasingly felt. Although water catchment areas are gazetted, encroachment by agriculture and logging activities both legally and illegally has been occurring frequently. There are cases where water catchments are being polluted by agricultural and industrial wastes.

Groundwater resource is used for domestic consumption and is also being used for irrigation of tobacco in Kelantan. There is an indication of over tapping of groundwater during the dry months, which causes the intrusion of saline water.

With growing industrialization and urbanization, water pollution problems began to spread rapidly in various parts of the peninsula. The impacts of fertilizer application on the environment are more pronounced in areas with short-term crops where intensive farming is practiced. In intensive vegetable farming, excessive amount of chicken dung and inorganic fertilizer have been repeatedly applied to the soils. The excess plant nutrients may leach from the farm and ultimately pollute the water and the environment.

There will be keen competition for resource use in the future between the main competing sectors i.e. agriculture, forestry, residential, industrial, wildlife, recreational and water catchments. In this regard, the main challenges for the future include, improving the collection, storage and accessibility of the database for land and water resources, providing the policy makers with sound land use options, addressing the problems associated with land ownership. There will be more widespread use of ICT for precision agricultural water management.

The main challenge for the future is to enable continuous crop production with high yield per unit area. Intensive agricultural exploitation of arable soils remains the only option as well as a challenge for the future. Unfortunately intensification of agriculture will also result in excessive and indiscriminate use of agrochemicals, which contribute to soil degradation. Against this scenario the future agricultural practices adopted on arable soils must be productive, environmental friendly and sustainable. Improved agronomic practices are specifically required to maintain or enhance crop yield. This calls for, more efficient water and fertilizer use, soil fertility maintenance, and adoption of soil conservation measures, introduction of new farming technologies such as precision farming and protective shelters for high valued crops, and adoption of good agricultural practices for sustainable use of soils.

The management of irrigation system has become a prime issue in many countries, as revealed in recent studies that disappointing performance was observed in many irrigation schemes. Poor distribution and management of irrigation water is a major factor contributing to this situation. The term water management may mean different thing to different people. This may mean a reliable, equitable and predictable water supply to farmers. In irrigation schemes, it has usually been used to refer to the management of irrigation systems with optimum crop production and efficient use of water resources. The objective of irrigation and water management is to distribute the water more evenly and to irrigate more areas served by the irrigation systems. It is evident that better management skills automatically lead to improved management system. Good water management involves the timely and equitable distribution of irrigation water among farmers. The management of irrigation system aims to achieve optimal crop production and efficient water use or in other words a reliable, equitable and predictable irrigation water supply to farmers.

The effectiveness of water use can also be enhanced by increasing the irrigation efficiency in the paddy fields. In this case, automated water control was implemented since early 1970's, and has been improved continuously. It is now capable of supporting daily operations such as seasonal crop planning, and irrigation scheduling. The future challenge for higher water use efficiency is felt even more, in view of the anticipated increase in cropping intensity, and also the increase in water demand from non-agricultural sectors. It is envisaged that in line with advancement in farming technology, automation of some irrigation structures with real time data will be greatly needed.

In terms of policy, water resource use is presently under individual states jurisdiction; thus there is an urgent need to integrate the harvest and usage of water resources at the national level. This is being undertaken by the recently formed National Water Resource Council. Hopefully it will provide guidelines on the sharing, planning and allocation of water resources for the various competing user sectors. The policies on Integrated River Basin Management (IRBM), Integrated Water Resources Management (IWRM), and Manual Saliran Mesra Alam (MSMA) for urban drainage are most welcome. With global warming and climate change, greater competition for water is expected among the users. Paddy irrigation may be sacrificed during water shortage in dry months favoring domestic and industrial users. However, rice granaries have yet to improve on the use of "effective rainfall".

The measurement of rain falling in a rice growing area is based solely on the available rain gauge network. These gauges are located at convenient locations which may not be representative of the whole rice growing area. Hence, under or over estimation of runoff occurs and consequently affects the management of floods during rainy seasons or base flow for irrigation during dry seasons. Therefore, better estimates of mean areal rainfall are needed as contribution of effective rainfall in the water balance during the irrigation season. A new technique to improve rainfall distribution estimation based on weather radar-derived rainfall throughout the rice growing area was developed. Using GIS tools, virtual rainfall stations are created uniformly throughout the area. The rainfall data for these virtual stations are estimated from raw weather radar data using a newly developed Program called UPM-RaDeR ver1.0. The calibrated radar-derived rainfall is used as input data in the rainfall-runoff model. Results show that virtual rainfall stations distributed throughout a watershed can be used to derive a more representative rainfall distribution. The watershed river flow can be better estimated by using the virtual rainfall stations with radar-derived rainfall data. This in turn will help to improve the contribution of effective rainfall in the overall water management of a rice granary area. Irrigation can be stopped when enough rain water has already refilled the soil moisture reservoir for crop use.

To improve the spatial distribution of rainfall over a watershed with low density rain gauges network, virtual rainfall stations can be distributed in terms of grids centers to cover the whole study area as shown in Figure 5.12. The rainfall data for these virtual rain gauges are estimated from raw radar data using UPM-RaDeR ver1.0 Program. The derived rainfall data is then compared and calibrated with actual gauge rainfall records for the same periods to identify the calibration factor. The calibrated radar derived rainfall data will next be used as improved rainfall input in the hydrological model for watershed runoff estimation. On the other hand, knowing the amount of rainfall that occurred in a rice granary or an agricultural field, a suitable amount of irrigation water can be supplied precisely and better irrigation water management can be adopted. Hence some amount of irrigation water supply can be saved and used in other part of the scheme or for other purposes.

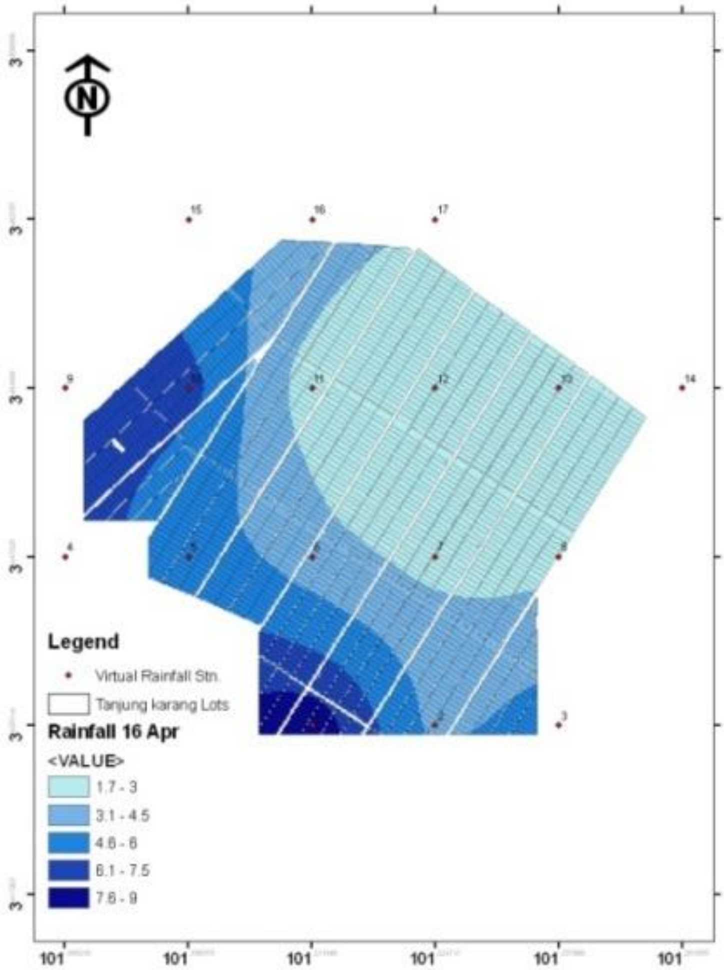


Figure 5.12: Rainfall distribution pattern using Virtual Rainfall Stations and Radar Derived Rainfall for Sawah Sempadan Irrigation component, Tanjung Karang, Selangor

UPM-ViRaS-RaDeR system was developed as a tool to improve agricultural water management. Its use to generate rainfall distribution maps from the virtual rainfall stations using weather radar rainfall data will be useful in flood estimation, flood early warning, and irrigation water management especially in the rice granaries.However, the data processing and data transfer to achieve the desired results will require high performance computing and high speed broadband communication.

iv) Future of Precision Farming

Blackmore suggested that if we take a systems approach to forecasting what a future crop production will be like, in say 2025, we need to make some assumptions. 1. Land will still be used for crop production and hence will need mechanization, 2. IT progresses at the current rate enabling more intelligent systems, 3. Economic and environmental drivers still promote efficient use of inputs. Over the last decade new information technologies, such as GNSS (Global Navigational Satellite System) and GIS (Geospatial Information System), have been introduced that has allowed the scale of management to be reduced from farm level, down to field level and occasionally to sub field level. With the advent of new information technologies, such as behaviour-based robotics, this process can be continued into the future by looking at an even smaller scale such as plant scale technology or Phytotechnology. These new Phytotechnology units will be small autonomous systems that can behave in a sensible manner for long periods unattended, caring for the individual plant from seeding through to selective harvesting. With this level of sophisticated equipment, it is likely that higher value crops such as in horticulture or forestry will be able to justify such an investment first. Very little new hardware will be needed but the challenge will be in defining and implementing *sensible behaviour* and developing the systems architecture to support it. If we try to utilise ICT to the full extent we could replace many of the high-energy inputs such as fuel, herbicides and fertiliser, with more intelligent processes to achieve the same ends.

Site specific farming is an emerging technology with substantial promise to aid both farmers and society. There is a need for research that examines economic and environmental impacts of site specific farming adoption. In particular, it attempts to quantify the degree of variation of yields within a field and to determine that portion of variability that is due to factors under the control of the farmer; to compare the financial performance of variable rate fertilizer applications relative to a uniform rate of application; to evaluate the environmental consequences of site specific farming practices; to estimate the profitability of adoption of site specific farming technologies; to examine how farmers will use information provided by this technology to make a range of farm decisions; and to estimate the impacts on rural communities of widespread adoption of site specific farming technologies.

Research results will be helpful to farmers as they make site specific farming adoption decisions, will help direct the future development of this technology by improving our understanding of important decision parameters, and will help society evaluate the potential improvements (or harm) that this technology might contribute to the environment and to rural communities relative to current agricultural production methods. Extension education component is intended to facilitate transfer of information to farmers and others facing adoption decisions. For the rice granary areas, the setting up of precision farming community ICT centres such as the one in Sawah Sempadan Tanjung Karang Selangor should be encouraged. The ICT facilities with internet connection will not only benefit the farmers but also the whole paddy farming community through group businesses created by the tertiary-canal based water users associations.

The adoption of precision farming for agricultural production requires educating the human resources at all levels from the potential researchers to the technicians and the farmers. There must be a concerted effort by the Universities, Research Institutes, Government Departments and Agencies, and the private sector to facilitate the education of the new farmers. Some of the tools and technologies need to be developed locally by our engineers and scientists or adapted from the developed countries.

5.7 Agriculture and Human Nutrition

Reliable data are required for preparing nutrition policy and national plans of action appropriate to national scenarios and needs. In preparing NPAN Malaysia (1996-2000) data was needed of the nutrition situation and detailed examination of the current intervention strategies. In setting objectives and goals of the policy and plan, sound data was required. In the exercise to update NPAN II (2006-2015), it was necessary to review the food and nutrition situation and to identify current and emerging food and nutrition issues. Reliable data will continue to be needed to enable the NPAN to be tuned to the problems that need to be given the higher priorities and the community groups that need the greatest attention.

The 2004 WHO Global Strategy on Diet, Physical Activity and Health is aimed at reducing the risk of the population to chronic diseases. The WHO has called on all stakeholders, including governments, professional bodies, non-governmental organisations and the food industry to work together this goal. WHO has emphasised that strategies need to be based on the best available scientific research and evidence. Approaches need to be comprehensive, incorporating both policies and action and addressing all major causes of noncommunicable diseases together. The world health body has emphasised that strategies undertaken must be multispectral, taking a long-term perspective and involving all sectors of society.

There is a need for continued monitoring of food consumption pattern of the population; we need to know what people are eating and the changes over time. Malaysia has not had a periodic national food consumption survey until the first attempt in 2003, in the form of the Malaysian Adult Nutrition Survey (MANS), coordinated by the Ministry of Health Malaysia. Besides food consumption, other data collected in the survey include weight and height measurements and habitual physical activity pattern. It is vital that we continue with such efforts periodically. We need a periodic national nutrition survey. Although National Health and Morbidity Surveys, now having completed the third in its series, now include some data on BMI for adults and children, it would be preferable that a dedicated national nutrition survey series be initiated in the country. This should then continue periodically, e.g. every 5 years.

In combination with health and nutrition data, good food consumption data are also required to enable us to better understanding the role of foods in health and disease. It is important to have better understanding of the role of specific causative factors of various nutritional disorders. There is also greater interest in understanding the role of functional (bioactive) components that are abundant in the local cuisine. Such data are also essential to substantiate nutrition and health claims linked to these food components which is the key to the marketing and promotion of functional foods.

It is vital that a good food composition database is available for a variety of food and nutrition activities. The current food composition database, established in 1997, is incomplete and lacks data in terms of number and type of nutrients as well as food items. There is also a need for a database of other food components or bioactive compounds in foods. Such data are required for assessing adequacy of nutritional intake of individuals and communities, studying association between nutrient intakes and disease patterns, nutrition education activities, establishing dietary guidelines, food product development, nutrition labelling, planning of nutrition policies and programmes.

A variety of scientific data are needed in supporting and strengthening food regulatory systems. There must be scientific basis in establishing safe levels of the wide variety of food additives permitted in foods. Permitted maximum levels of chemical and microbial contaminants in food regulations must also be based on scientific data. At the same time, quality specifications or requirements of food standards must be based on established data. This is also true for establishing labelling and nutrient declaration needs.

The Food Quality Control Division (subsequently known as the Safety and Quality Division (FSQD) of the Ministry of Health Malaysia was established in the 1974. The Food Act 1983 and Food Regulations 1985 were subsequently enforced. Over the years, periodic review of the Regulations has been undertaken, as and when the need arises and when data become available to enable amendments to be made.

For better risk assessment of communities to hazards in food, greater efforts in exposure assessment of contaminants and food additives have been carried out by FSQD. For this purpose, better food consumption data are required. At the same time, a good database of health hazards (i.e. chemical, microbial, veterinary drug residues) in food is required.

It is recognised that more effective participation in the work of Codex Alimentarius is vital as Codex is the international reference point for food safety. This requires full commitment of relevant stakeholders at the national level, including the food regulatory authority and the food industry. Local producers must realize that in order to participate in international trade, they must keep up with global specifications.

Malaysia joined Codex in the 1960s. The country has participated actively in various activities including serving as Coordinator and Representative for Asia, hosting the Codex Committee on Food Labelling and Codex Committee for Asia. Malaysia was Vice-Chair of the Codex Alimentarius from 2005-2008 and took over as host country for the Codex Committee for Fats and Oils from 2009. There have also been intensified efforts to harmonize Malaysian Food Regulations with Codex Alimentarius.

i) Bridging data gaps

It is vital to work towards bridging the gaps in knowledge and data. Promoting continuous research and development is one of the Facilitating Strategies n NPAN (II). Efforts must be made to identify research gaps and priorities. The need for periodic reviews in view of rapidly changing situation has been identified as one of the activities in NPAN II. In mid April this year, a workshop for research priority setting in Malaysia was conducted to provide input into the 10th Malaysia Plan (2010-2015).

The challenge is to convince funding agencies or senior management of the importance of allocating resources for generation of the much needed research data. Strengthening of institutional research capability must also be an essential part of national development plans. Indeed, these have been identified as one of the Facilitating Strategies of the NPAN (II). However, no dedicated funding has been set aside for these activities. It is recognised that nutrition plans and activities compete with many other public health issues for funding. NPANs must have its own funding for the various identified activities in order to realize its goals and objects.

Malaysia must be able to meet the challenges of becoming a developed nation. Development must mean more than just infrastructure development. Development must include promoting and maintaining community wellbeing. Meeting nutritional needs must therefore be part of the national development plans, to enable the country to grow and develop confidently.

5.8 Future nutritional issues in Malaysia

Malaysia has made impressive socio-economic developments in the past 4 decades. These developments have brought about marked changes to the lifestyle of the population. These changes include dramatic changes to the health and nutrition issues, with “impressive” increases in obesity, hypertension, diabetes, coronary heart disease rates. In recent years, the country has continued on its path towards greater growth and development, in spite of the current economic slowdown. This will certainly further impact on the food and nutrition scene. A greater number of people in the country will be affected, including more segments of the population. For example, more “rural groups” will become afflicted with obesity, diabetes, hypertension and coronary heart disease. More younger age groups may become similarly affected. There are already data to indicate these trends in the country.

Over the years, there has also been greater globalisation in every sense of the word. Globalisation has brought about greater movements of food nationally and internationally. This has great impact on consumers in the country as they are exposed to world foods and cuisines. This also has implications on the nation's participation in international trade, including commitment to World Trade Organisation (WTO) Agreements.

Much of the changes in socio-demographic pattern highlighted above by the WHO in the previous section will certainly be applicable for this country. Similarly, the increase in the burden of diet-related chronic diseases as well as the double burden of undernutrition and overnutrition will certainly be applicable for this country.

- **Intensification of nutrition intervention programmes**

The continued changes in the food and nutrition scene in the country will also mean greater demand for food and nutrition activities in the country. Food and nutrition scientists must take on the challenge to try to cope with the new health and nutrition scenarios in the decades to come. Nutrition policies and programmes must be continuously reviewed and intervention programmes re-examined. The National Plan of Action for Nutrition which was established after the 1992 WHO/FAO International Conference in Nutrition has been re-aligned towards combating both extremes of the malnutrition problem. The revised NPAN II continues to give focus to the dual burden of undernutrition and overnutrition. In the decades to come, nutritional deficiencies will continue to decline. They are however not likely to be eradicated completely. Persistent problems like iron deficiency anaemia and poor growth will continue to afflict the underprivileged communities.

The implementation of the programmes and activities identified in NPAN II must be continuously monitored and evaluated. There must be political will and true collaboration among the various government agencies to work together towards the realisation of the objectives of NPAN II. Similarly, collaboration between government and non-governmental organisations as well as with the food industry must be encouraged.

Some major intervention programmes identified in NPAN II must be given continued attention and emphasis. Nutrition promotion activities, to give nutrition education and dissemination to the target groups and providing the infrastructure for the community to have access to the nutrition information. The Healthy Lifestyle Campaigns have long been major health and nutrition intervention programmes for all Malaysians. All stakeholders must be involved in the promotion of breastfeeding amongst mothers. Dietary guidelines have become an almost universal tool in food and nutrition policy development and for nutrition promotion. Malaysia recently revised its dietary guidelines and launched it in March 2010. It is a totally revised and revamped science-based guideline, with key messages.

These messages cover the whole range of food and nutrition issues, from importance of consuming a variety of foods to messages for guidance on specific food groups (Figure 5.13). The revised guidelines also include specific messages to encourage physical activities, consuming safe food and beverages and making effective use of nutrition information on food labels. A new food pyramid was also introduced to the consumer. These guidelines should form the goal that Malaysians should target, in order to achieve good nutritional health.

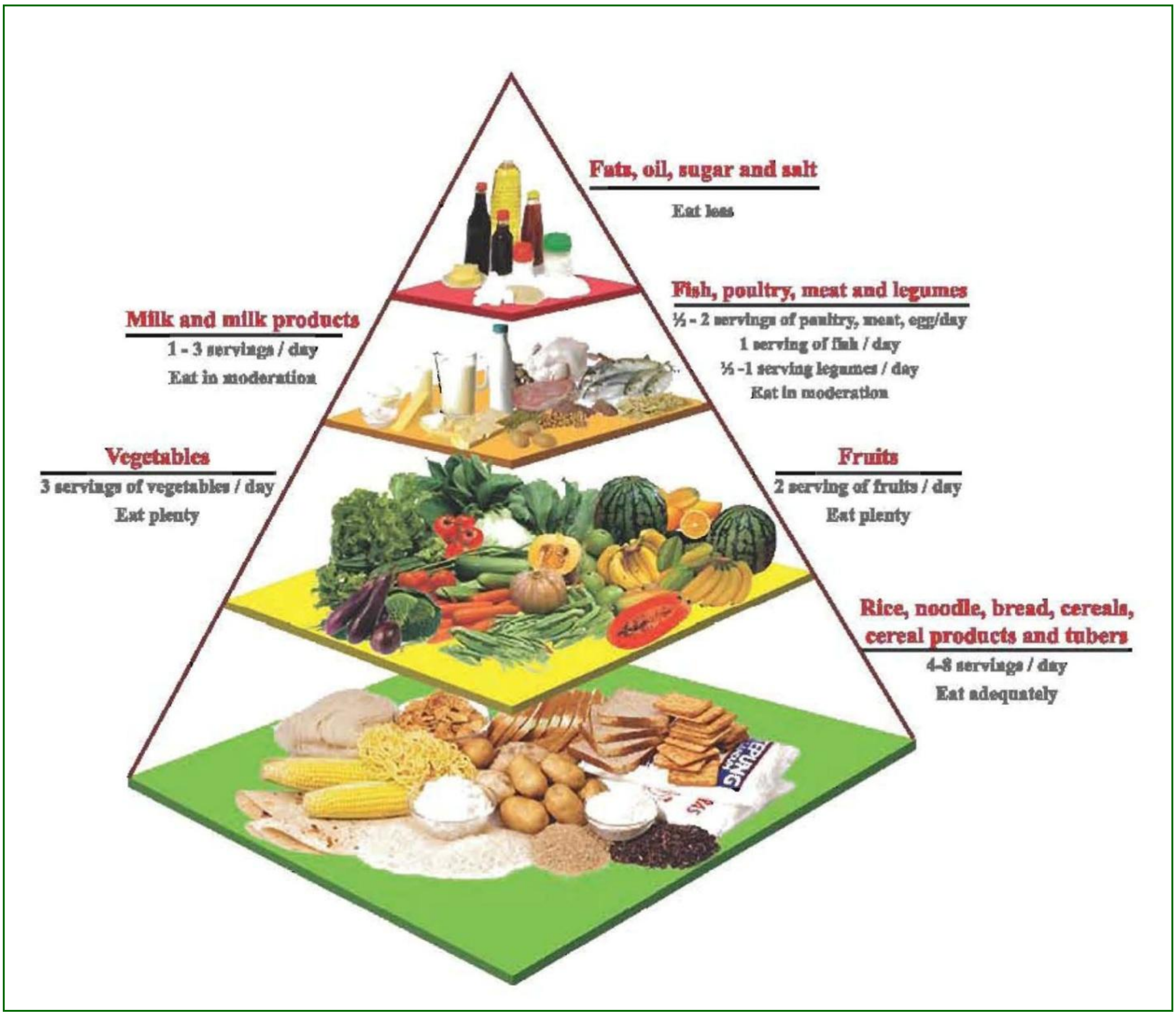


Figure 5.13: Food Pyramid

A great deal remains to be done to ensure that the revised guidelines reach the intended target groups. It is even a greater challenge to ensure that the consumer adopts these dietary guidelines. What is therefore clearly needed is greater efforts of all stakeholders to help the effective implementation of these guidelines. It is the responsibility of health care professionals to ensure that consumers have access to the information. They need to fully understand these messages and help in promoting them. The food industry can do its part in helping to disseminate these messages widely through their own network. It can also contribute by making healthier choices of foods available to the public.

The consumer should empower himself with the knowledge contained in these guidelines, and practise the messages recommended. Eventually, it is the consumer himself who must take charge of his own health and that of his family.

- **Greater consumer awareness for food safety and quality**

Over the years, the country has strengthened its national food regulatory system to protect the health and to minimise the threat to safety of consumers. There has been greater recognition of the importance of the work of the Codex Alimentarius. It has become clear that Codex has huge economic implications on local produce in international trade as well as importance for the protection of local consumers in relation to imported foods. The country has therefore been participating actively in the work of this international food standards setting body. There is however, much room for improvement. Policy makers and managers must recognise the importance of these to national food, agriculture and trade. It is important for Malaysia to to participate actively in international trade and in the activities of the Codex Alimentarius.

There has been generally better consumer awareness of food and nutrition issues. There is greater demand for safe and quality food. Consumers demand for more information on nutrients in food and even non-nutrients or bioactives in foods. This has necessitated the periodic review of food regulations and guidelines. The continuous updating of other aspects of food regulations must be given further emphasis. Efforts to align Malaysian food regulations with standards and guidelines of the Codex Alimentarius must be continued. Aspects related to contaminants in foods and food additives are of particular importance to the consumers.

In line with efforts to promote healthy eating, regulations on nutrition labelling and claims, already enforced in the country since 2005, need to be further monitored for compliance. At the same time, educational efforts to the consumer must be intensified to ensure they fully understand and utilise such nutrition information on food labels.

- **Need for sound scientific data**

Sound scientific data are required for each and every of the food and nutrition activities outlined above. Scientific data is vital for these food and nutrition activities and in many cases, data gaps exist.

Reliable data are required for preparing nutrition policy and national plans of action appropriate to national scenarios and needs. In preparing NPAN Malaysia (1996-2000) data was needed of the nutrition situation and detailed examination of the current intervention strategies. In setting objectives and goals of the policy and plan, sound data was required. In the exercise to update NPAN II (2006-2015), it was necessary to review the food and nutrition situation and to identify current and emerging food and nutrition issues. Reliable data will continue to be needed to enable the NPAN to be tuned to the problems that need to be given the higher priorities and the community groups that need the greatest attention.

The 2004 WHO Global Strategy on Diet, Physical Activity and Health is aimed at reducing the risk of the population to chronic diseases. The WHO has called on all stakeholders, including governments, professional bodies, non-governmental organisations and the food industry to work together this goal. WHO has emphasised that strategies need to be based on the best available scientific research and evidence. Approaches need to be comprehensive, incorporating both policies and action and addressing all major causes of no communicable diseases together. The world health body has emphasised that strategies undertaken must be multispectral, taking a long-term perspective and involving all sectors of society.

There is a need for continued monitoring of food consumption pattern of the population; we need to know what people are eating and the changes over time. Data need to be gathered on the nutritional value of family “food baskets” of various segments of the community. Malaysia has not had a periodic national food consumption survey until the first attempt in 2003, in the form of the Malaysian Adult Nutrition Survey (MANS), coordinated by the Ministry of Health Malaysia. Besides food consumption, other data collected in the survey include weight and height measurements and habitual physical activity pattern. It is vital that we continue with such efforts periodically. We need a periodic national nutrition survey. Although National Health and Morbidity Surveys, now having completed the third in its series, now include some data on BMI for adults and children, it would be preferable that a dedicated national nutrition survey series be initiated in the country. This should then continue periodically, e.g. every 5 years.

In combination with health and nutrition data, good food consumption data are also required to enable us to better understanding the role of foods in health and disease. It is important to have better understand of the role of specific causative factors of various nutritional disorders. There is also greater interest in understanding the role of functional (bioactive) components that are abundant in the local cuisine. Such data are also essential to substantiate nutrition and health claims linked to these food components which is the key to the marketing and promotion of functional foods.

It is vital that a good food composition database is available for a variety of food and nutrition activities. The current food composition database, established in 1997, is incomplete and lacks data in terms of number and type of nutrients as well as food items. There is also a need for a database of other food components or bioactive compounds in foods. Such data are required for assessing adequacy of nutritional intake of individuals and communities, studying association between nutrient intakes and disease patterns, nutrition education activities, establishing dietary guidelines, food product development, nutrition labelling, planning of nutrition policies and programmes.

In the mean time, work on the newer area of genomics in nutrition should be given focus by researchers in the country. Nutrigenomics, the study of the effects of foods and food constituents on gene expression. Should be on the researcher agenda of local institutions. Nutrigenomics has been associated with the idea of personalized nutrition based on the genotype of individuals. Though the science is still in its infancy, there is hope that nutrigenomics will ultimately enable such personalised dietary advice.

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5.9 Agriculture and Economics

We should be mindful from the outset that some quarters contend that science is hard to predict as breakthroughs often happen unexpectedly, although they contend that technology might be predicted at a maximum of 15 years. For example, we must admit that we could hardly have predicted the science, technology and innovations we have today if we were asked to do so 40 years ago. And that's exactly what this foresight study has to address, looking 40 years into the future.

Consequently, we have elected to look at broad megatrends within both the spatial and temporal context and 'predict' those key areas of breakthroughs over the next 40 years that will undoubtedly be made, for example in the areas of renewable energy and the blurring of the end use of agricultural products as food, feed, fibre, fuel, and pharmaceuticals. So, taken in this light, we contend that it is possible to make such predictions. However, for it to be useful and tangible, it may be prudent to consider a step by step approach (which will also come in useful when we have to come up with the roadmap subsequently) where we view long-term strategies by 2020 as the first step, by 2035 as the second step and by 2050 as the destination.

Management of Supply Chains and International Trading Networks

At this juncture it may be prudent to provide an overview of supply chains and the relevance of supply chain management, moving forward. Supply Chain Management (SCM) has, in recent years, attracted the attention of a cross-section of academics, researchers and practitioners alike. It has spawned textbooks and even dedicated journals like '*Supply Chain Management*, *an International Journal'* (Figure 5.14). The development of the idea of supply chain owes much to the emergence from the middle of the last century of systems theory and the associated notion of holism. It has been contended that the behaviour of a complex system cannot be understood completely by the segregated analysis of its constituent parts. New (1997) has suggested that despite the undisputed importance of financial services, electronic communication and media industries, the economy still resolves around the production, processing, moving, buying and selling of 'stuff' and that SCM is about mechanisms and processes by which these activities are organized.

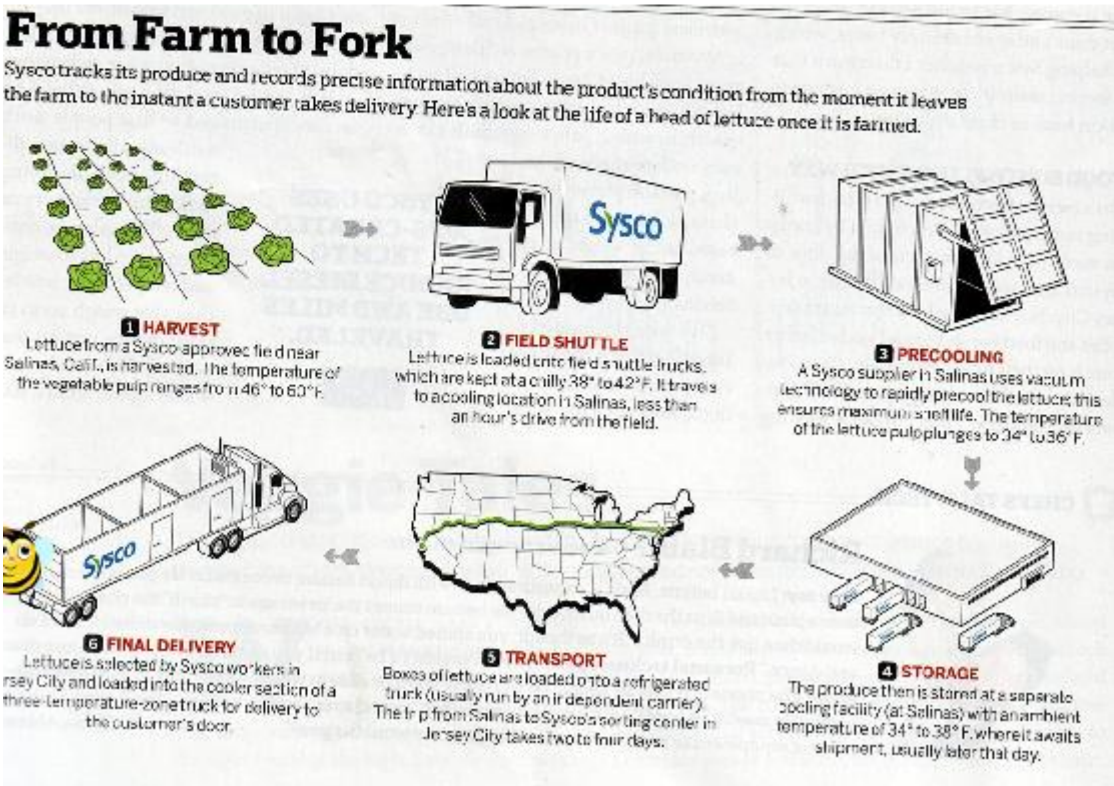

Figure 5.14: Farm to Fork

A central tenet of supply chain management (SCM) is that in future, competition will no longer be between firms but rather be between supply chains, comprising groups of companies intricately linked through a series of partnerships and alliances at the various levels of the supply chain. A cursory review of the literature indicates that SCM has been applied from the perspective of an individual firm; related to a particular product or item (such as the supply chain of oil palm, or rubber, or rice); and from the perspective of industry group or sector (such as grains and agri-food).

As all components along the supply chain need not belong to one company or group, varying degrees of strategic alliances can be observed at the operational level: from loose structures (JV "at the door") to dedicated/designated suppliers (as in the case of supermarkets), through to cross investments. At the operational level, there is significant value-adding along the entire supply chain. Furthermore, supply chains can reduce asymmetry of information at interfaces with each subsequent level, thereby reducing transaction costs as well as increasing feedback and improving response rate to changes in consumer preferences and tastes. They thus enable the capturing of premiums. Of course, this sharing of information is greatly facilitated, enhanced and even revolutionised by recent advances in ICT.

Empirical evidence suggests that there can be amicable/sustainable sharing of margins along supply chains, including the transmission of prices back to farmers/producers. Consequently, an appealing strategy is to hook up (or integrate) small farmers/producers to increasingly sophisticated local supply chains (involving supermarkets) and more lucrative overseas markets, especially niche markets.

In Malaysia, supply chains can and will speedily exploit advances in biotechnology and its impending convergence with ICT as well as innovations. Similarly, there will be exponential growth, if and when interconnectivity of supply chains was exploited, as is already happening with telecommunications (telcos) and multimedia superhighways.

From a policy and institutional standpoint, most government interventions and programmes in Malaysia have invariably been overtly "production-centric" so much so that the farming/production subsystem is not well linked or integrated (and often "out-of-sync") with the post-harvest subsystem. As can be gleaned from the big picture of a generalized agri-food supply chain depicted in Figure 5.15 the power of supply chains is the value-adding potential at each level of the chain when agriculture is viewed in its broader and more holistic, agribusiness perspective. This will offer the basis for agriculture to drive overall development by leveraging on inherent advantages and potential of nations at the inputs, processing, wholesale and retail trade as well as international trade levels. In so doing, agriculture via its linkages in the supply chain, will also contribute to overall national economic growth from agro-based industries and value adding as well as agro-based services and consultancies at all levels of the supply chain.

Now, in order to track the more holistic contribution from agriculture for purposes of monitoring and evaluation or otherwise, we should build on the crucial first step taken in the 9MP which incorporated the contribution from agro-based industries. Now, the computation of the contribution from agro-based services along the entire supply chain will be more challenging but not insuperable. For a start some coefficients can be computed to provide some estimates of the contribution from various types of services, using Input-Output (I-O) Tables. These coefficients can be refined over time by conducting supply chain studies for the major commodities, starting with rubber and oil palm as well as the identified 'new areas of growth' (where the development strategy will obviously be a supply chain management approach rather than the hitherto more 'production-centric' one). Consequently, these contributions should be added to that from the agriculture sector (conventionally measured) to provide a more relevant indication of the real impact of this (re)emphasis on agriculture as the engine of growth. In this regard, it is heartening to note that the Third Industrial Master Plan (IMP3) supports and reinforces this shift in focus.

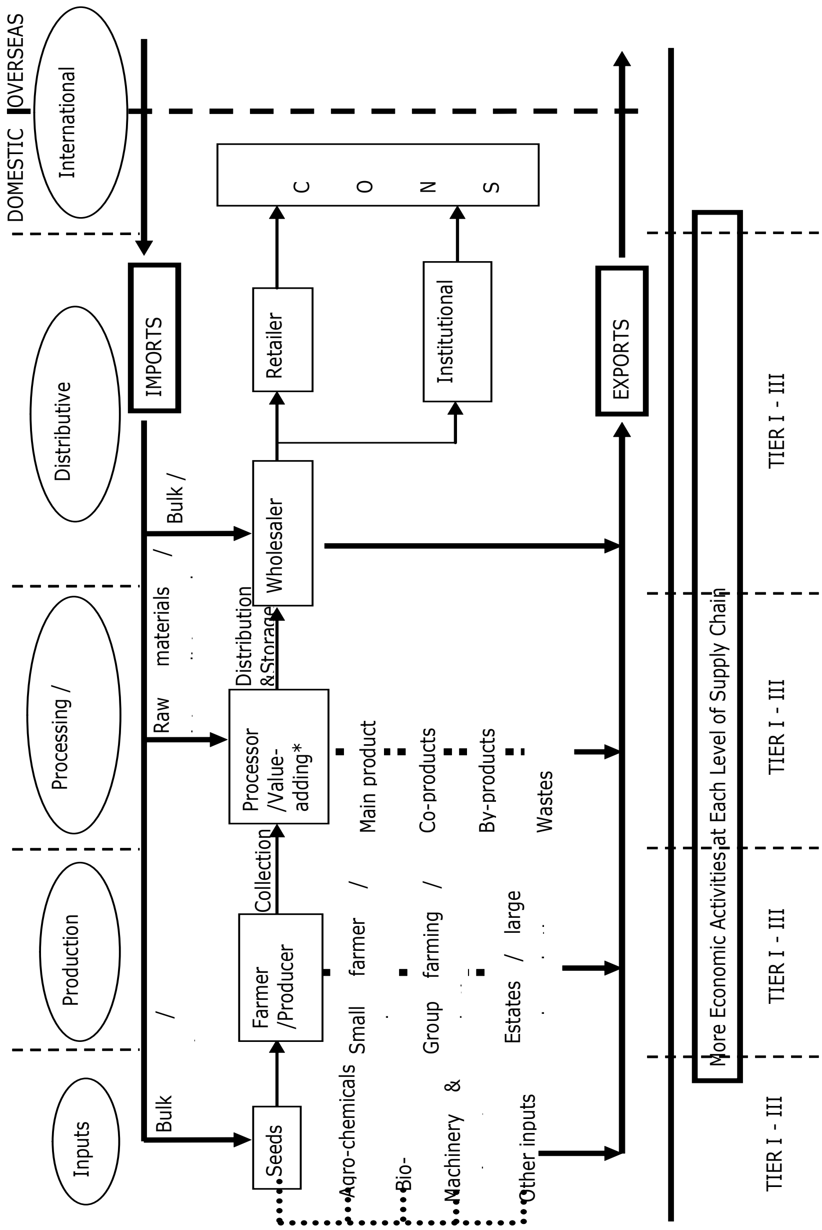

Figure 5.15: Agri-food supply chain: from seed to shelf

5.10 Sustainable Agriculture

Farming activities have to be INCLUSIVE and SUSTAINABLE in that we have to part ways with the excesses of the industrial agriculture of LINEAR production system into a SYSTEMIC or the ECOSYSTEM approach of being cyclical-and-loop process and exponential in productivity. Everything is to be accounted for, for example wastes are recycled or reutilized (zero wastes) and the impacts or footprints or traces of the production process, that is the carbon and water footprints, will enable TRACEABILITY of food/agricultural products and by-products for food safety (diagnostics) and environmental health (bioremediation) by using tracking devices. Compliance to health, conservation of biodiversity and environmental standards will increasingly become the norm and it will become a standard practice as requirements to be complied with for global trade practice. The inclusive wellness of the environment is strongly catered for and will be incorporated in global trading activities. Vertical farming is currently being practiced in many parts of the cities of the world where there is high concentration of human population. The key change factor in this concept is that we think in terms of cubic meters and not square meters when it comes to space for agriculture. Think in terms of arable space rather than arable land for agriculture.

With the unabated rural-urban migration trend as we approach towards 2050 it is predicted that by mid-century more than 80 per cent of the world's population would be urban. By then, land spaces become competing constraints for industrial needs, human dwellings or agriculture. Therefore arable land for agriculture in the urban areas would be marginalized. Agriculture has two major issues that confront and challenge global food production towards 2050. Inevitably, the world's agriculture will have to cope with the daunting task to feed another 3 billion mouths by the year 2050 when the burgeoning world's population is expected to reach the 9.6 billion people. By 2050, As more than 80% of the world's population will be urban and the competition for land space for farming with either for industrial needs or for home and shelter will make it even more difficult for agriculture. Water to irrigate arable land would be more difficult It will take more than just technological inroads, methodology and astute policy-making to bring about the much needed, corresponding exponential increase in production capacity to meet the Malthusian challenge of producing more food for the burgeoning population increase.

A change from a linear production towards a sustainable and inclusive, cycle-loop, controlled-environment agroecosystem is very much needed to cope with the multititude of imperatives for increased food production with guarded considerations of the environment. That it is even more heighteneded by vagaries and unpredictability of weather, and other related consequence of Climate Change. Such controlled environment for agriculture will ensure certainty of production and creates the opportunity to grow and raise a wider range of crops and livestock.

6 SUPPORTING ACTIVITIES

i) Development of Human Capital in Agriculture

Knowledge-based Agriculture (K- Agriculture): Education and training in agriculture becomes more important with the shift from conventional farming towards knowledge-based agriculture or precision farming. Generation of knowledge or acquiring knowledge is key with respect to the innovations and technological developments in the K-Agriculture era and the activities in research, especially collaborative research, by human talents residing in the R&D institutions The precursor to the Knowledge-based Agriculture (K Agriculture), or Innovation Economy is the relentless utilization of knowledge in agriculture or related fields that triggers technological innovations to uplift productivity through reduced wastage of resources, doing more with less, due consideration for the environment, public health and shared well-being and destiny with the community. There is indeed a niche for knowledge-based agriculture for the education sector of the New Economic Model (NEM). The inclusiveness target of rural economic model in NEM will definitely capture the rural poor in the agriculture sector and hence there must be programmed to partake in them NEM to improve the livelihood of the bottom 30-40 % of the population lower income groups. We can expect the majority of the bottom 40% of the Malaysian households are mostly poor paddy-growers, rubber tappers, artisans, odd-job seeking of rural poor. In fact, there is a clear layer of economic building blocks of the knowledge-based or Innovation Economy to be placed on top of the economic layers of the agro-based manufacturing to move up the value-chain in the agriculture sector.

To be precise, one must have accurate and in-depth knowledge. including to perform molecular breeding which requires expensive tools and genomics. as opposed to sufficient generic knowledge as in conventional breeding. To be adept in knowledge-based agriculture of K-Agriculture requires high technical knowledge and skills which we get from formal tertiary education or post secondary education to perform such accurate, tedious and in-depth training on advanced frontier knowledge in remote-sensing, genomics, ICT, biochemistry. In Israel, where arable land is scarce and expensive, only those educated are preferred to go into farming. To be productive in controlled–environment agriculture you need to use advanced technology.

Currently, agriculture is not the preferred career of choice to many in Malaysia that at times those who cannot make it into other fields join agriculture. However, the expected growing importance of urban dwellers, with population increase and the era of Climate Change, agriculture will become attractive again and become preferred by those who have the capital and resources in the urban areas. Proper incentives, rewards and policy adjustment will have to be formulated.

The knowledge, skill sets, and core competencies and training requirements for hunters and farmers are diametrically different. In hunting, you need the knowledge and skills in knowing habitats, detecting symptoms of animal presence, recognizing poisonous fruits and edible fruits, trekking and tracing hoof prints of wildlife, smelling danger, tracing flora and fauna species of the forest and knowledge of the rainforests. The role of daily child play is an informal, elementary education to acquire the skills and knowledge that will become relevant for hunting and gathering. In the daily life of the adolescent and children's play that includes hide-n-seek, like catapult toys, climbing trees are informal social classroom in learning the living skills of hunting gathering. That skillset in child play is slowly evolving to become irrelevant to the adult life of farming that supersedes the hunting gathering as a life style. Quite the contrary, the skill sets for farming requires more knowledge and understanding of the plants to be cultivated and the animals to be domesticated. In farming, the knowledge on breeding, soil fertility, securing water source, phenology of the crop plants and animals are knowledge heavy and these knowledge and training are amenable for learning from the formal education of vocational training.

The agglomeration of agricultural institutions (UPM, MARDI, MPOB, DOA, CABI.) in Serdang, Selangor serves as the cradle of human resource for research training and continuing education in agriculture since 1920's. The human talents and agriculture think tank of the country comes from the training institutions from Serdang and this has to be sustained into the future towards knowledge-based Agriculture. In the twenties, the Sekolah Pertanian (School of Agriculture, 1922) was established in Serdang to train school leavers in agriculture. The institution was further upgraded as Kolej Pertanian (Serdang College) in 1937 to train hands-on diploma graduates in agriculture to meet the human capital needs is foundational to the development of the agrarian economy of the country through the sixties and seventies. By 1971, the Serdang College was upgraded into a university (Universiti Pertanian Malaysia and later as Universiti Putra Malaysia) which is primarily targeted to meet the human resource requirements (officers) of the proliferating agriculture-based agencies under the Ministry of Agriculture and the other ministries as well as the private sector. That role in human resource training in agriculture was fitting nicely because the needs were created by those expanding number of agencies. But in no time by the year 2000 that need was fulfilled and the graduates produced even became redundant when several agricultural agencies were amalgamated (KEDA, PERDA, FELCRA, etc.) or closed. By then, UPM has been so prolific in developing so many programs in the non-agriculture areas that agriculture become drowned in the diversity of programs, and become less focussed that the *raison d etre*, identity and character and the education DNA-genome of UPM, as an agriculture-based university, has been tampered into a multi-disciplinary-based and UPM is anyting, but agriculture. What the UPM’s caretakers, board of directors, top managers and administrators may not realize over the years is that they have been producing officers, researchers, but not farmers and few entrepreneurs in agriculture from amongst the students; who can easily capitalise the various opportunities in the agriculture related areas. The baccalaureate degree education program in agriculture has become less market-driven and losing relevance of the vocational, diploma programs. At one time in the mid nineties, UPM shelved or temporarily discontinued the Bachelor Pertanian Program and replaced it with a generic degree, the Bachelor in Bioindustry. UPM and many other local IPTAs were a little bit hasty to shorten the B. Sc program from the usual 4-year curriculum (with industrial training) into a 3-year curriculum and the hands-on training period was reduced or removed. Consequently, for a spate of few years, the UPM graduates in Bachelor in Bioindustry were clearly becoming irrelevant because they have no hands-on practical training to make them wanted by the market. In the last five years that flaws have been corrected and UPM reverts to the old formula of 4-year program with an even more pronounced practical training of 6 months at the end of their baccalaureate years.

Research being Divorced from Extension: In the past research and extension in agriculture are both equally and inextricably linked in the Department of Agriculture. Then in the 1970's the research and extension for agriculture were decisively separated into MARDI (research) and DOA (extension). Research in rubber under the purview of RRIM but the extension belongs to RISDA. Research in oil palm was apportioned to PORIM (taken away from MARDI) and the downstream business to MPOB. The 80's and 90's were the mushrooming years of many agricultural institutions into up to more than 40 institutions in the country. But that sprouting years were being scaled back in the 90's when the manufacturing industries overtaken agriculture to become the main economic engine of growth for the country. Many of the non-performing agriculture institutions were amalgamated. Efforts in agriculture extension in the country later sprouted into many agencies into multi-efforts of land development schemes for the various commodity crops like RISDA, FELCRA, FELDA, LPP, KEMUBU, MADA, etc. There were good reasons to separate the research from extension then, but the tandem between research and extension should have been maintained through the close connection between the newly-formed entities for research and extension. In doing so, it is clear that the separation of research from extension into separate government agencies in agriculture were as good as separating the science from its relevance. Extension without research is nonsense. Research without extension is useless. To a certain degree we can say that there is a need to bring back research and extension into a cohesive form in its early bid. That reduces or continuously connected underscored by the supply-chain integration in the current agriculture concept.

ii) Training of Future Farmers

There is a growing need for the UPM and other local universities to train and produce future undergraduates with the skills and competencies to meet the needs of future agriculture in the evolving Climate Change era. Farmer or vertical farmer of the future operates small farms of multi-storey, controlled-environment or indoor-housing (control temperature, humidity, pest, disease, water use, energy, etc.) facilities by operating sustainably in using less chemicals to control diseases and pests, recycling habits, using less water, partially generating energy for the farm operations thereby producing organics farm produce for city folks and being mindful of carbon and water footprints and adopting green-friendly technologies for energy and recycling technologies. Opportunities and cooperation between the human resource in agriculture through research collaboration in the Agropolis, between UPM, MARDI, MOB and DOA have been there but it need a renewed impetus to ignite the common platform of shared values and integrated goals from the various ministries. AGROPOLIS is the platform for the renewed opportunity. A practical and functional showcase in agriculture (Agropolis) is needed to create an environment for the all-in-one and hands on agriculture throughout the supply chain.

iii) Extension Education

Even though the benefits of agroforestry are well documented, the technology is not well received at end user level. Many factors are responsible for this problem. The forward and backward linkages between researchers who generate new technology and the farmers which use them are often weak. To overcome this discrepancy, agroforestry extension is deemed necessary to enable information to flow rapidly from the source to end-users. Technology need to be transferred in the right form, at the right time and in the right place . Successful efforts to introduce agroforestry often combine modern science and traditional knowledge. Experience has also shown that individual preferences, adaptations and entrepreneurial skills make a great difference. Agroforestry has made tremendous strides in recent years, but many challenges remain in terms of its wider application.

The Southeast Asian Network for Agroforestry Education (SEANAFE) was launched in April 1999 with the objectives, among others, to help the technology transfer in agroforestry. By August 2004, SEANAFE has 76 members of universities and colleges in Indonesia, Lao PDR, Philippines, Thailand and Vietnam. This networking initiative will provide a forum for knowledge management and a tool for joint action. It works closely with established networks, government agencies, and regional and international development organizations in building capacities in agroforestry and natural resources education. SEANAFE believes that strengthening capacities in policy analysis and communication leads to the formulation of more effective forestry and agroforestry policies, which ultimately contribute to the network's aim of improved livelihoods and sustainable natural resource management. Many agricultural and forestry universities in Southeast Asia experience difficulties in interpreting national and international forest policies. Appropriate curricula need to be developed, effective and stimulating teaching materials have to be designed, and delivery capacity need to be strengthened to prepare students to better understand and more effectively participate in forest policy processes.

SEANAFE has initiated several projects aimed at strengthening the teaching capacities of higher education institutions (universities and colleges) in the region on subjects relating to agroforestry. The projects include major activities such as regional training, national case studies and the development of curriculum modules and training materials. However, agroforestry education faces different challenges in the different countries and it is essential that there is full freedom for the national networks to adopt the strategies most relevant to respond to the local situations. In SEANAFE Malaysia is represented by Malaysian Network for Agroforestry Education (MaNAFE).

In order to promote various types of agroforestry systems as an important option for livelihood improvement of stallholders and rural farmers, sustainable development for food production, research, policy and practice will have to progress towards:

i) Effective communication between the extension workers and farmers in order to improve agroforestry practices with primacy to multifunctional values. Extension/publicity activities should be strengthened to help create awareness in better adoption of agroforestry practices. In many cases on-farm trials are essential for new agroforestry technologies to be successfully transferred and adopted by farmers.

ii) Maintenance of the traditional agroforestry systems and strategic creation of new/modified systems to serve as gene pools of crop varieties and for commercial improvement to uplift household economics of smallholders.

iii) Enhancing the size and diversity of agroforestry systems by selectively growing specialty trees and crops for livelihood improvement

iv) Designing context-specific silvicultural and farming systems to optimize food production, biodiversity conservation and carbon sequestration function

v) Participatory domestication of useful lesser known herbal and medicinal plants, fruit trees and multipurpose tree species to provide more options for livelihood improvement, and

vi) Reinforcement of the markets for non-timber products such as traditional medicines, essential oils, agarwood, rattan, bamboo, etc. Predominance of traditional agroforestry systems (e.g., home garden, community forests) offers opportunity worth considering for livelihood improvement, biodiversity conservation, soil fertility enhancement and poverty alleviation and carbon sequestration.

vii) Diversify the products with down stream processing for value added and to capture new market segments, e.g. honey products, herbal and medicinal products, processed foods.

viii) Priority setting for agroforestry research and development (R&D) should be undertaken. R&D work should be promoted for agroforestry practices including production/supply of quality planting materials and value added agroforestry produce for commercialization.

ix) Initiate R&D activities to increase sustainable production from agroforestry systems through species selection, improvement of the genetic stock, and new breeding and propagation techniques

x) Incentives in suiTable forms (e.g. grants, input subsidies, benefit sharing schemes, reviewing land tenure) need to be introduced to encourage participation of agroforestry among the smallholders

xi) The public and private partnership should be further enhanced to improve national policies for promoting agroforestry.

iv) Technology Transfer

In many developing countries agricultural development has been variously used to bridge the wealth gap between the urban and rural populace. Agriculture programmes are means of restructuring the rural economy and attempts at social engineering to narrow the extremities in income levels between the richest and poorest 20 percent of the population. Agricultural technology is needed to boost agricultural productivity and increase efficiency of production. Prices of commodities have to be adequate to make farm investments profiTable. With better prices of farm commodities and readily available agricultural technology income derived from agricultural enterprises is expected to increase which would subsequently spur commodity output and lift the rural economy out of poverty. Education of the rural populace and support in the development of agricultural technology could speed up the process of the transformation of the rural economy (Figure 6.1).

Producers of farm commodities are exposed to modern agricultural technology through participation in the extension service which imparts agricultural knowledge via the training modules and advisory service. At present extension service catering to the needs of the livestock producers lacks trained personnel in the business of livestock production, especially in the breeding and feeding of cattle and goats. One issue is the fragmented structure in technology transfer with the technology generators is divorced from the agency responsible for industry development. Ownership of technology is seen to be with the technology generator and the onus of transferring the technology has been laid totally with the technology generator. A solution to get the technology passes smoothly from the technology generator to the user of technology is to have the scientists, the extension workers and the users involved in technology development from the planning stage to the technology transfer stage. The collaboration between the land-grant universities and United States Department of Agriculture in the United States of America in research, teaching and extension could provide a template for an efficient technology transfer programme in this country.

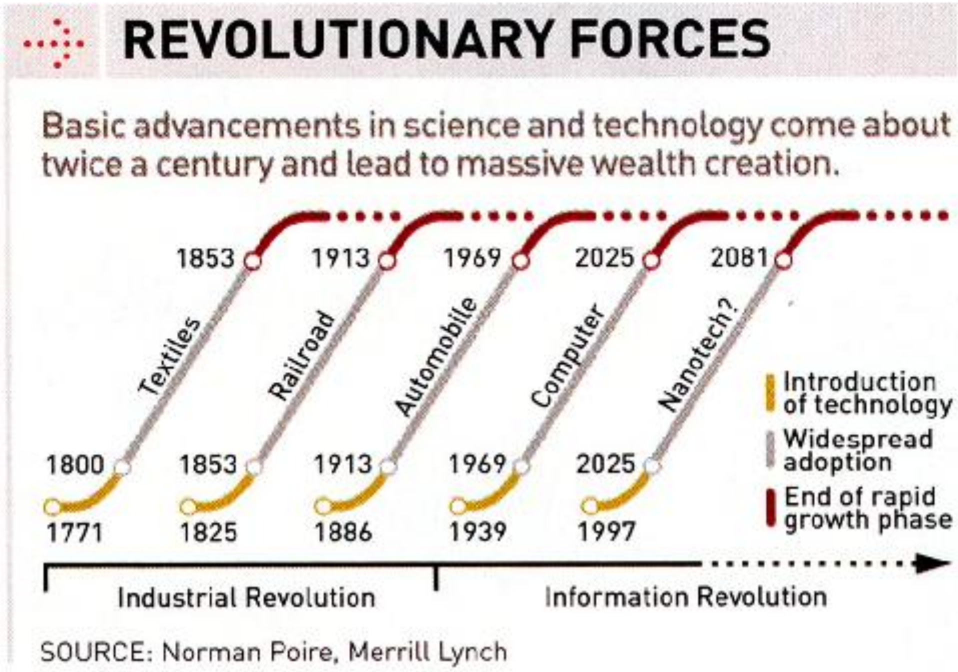

Figure 6.1: Convergence of ICT and Biology

Malaysian poultry producers are adequately served by technical personnel from integrators and feed mills and pig producers that are exposed to new feeding management technology through the technical service provided by feed mills and feed additive companies. Thus both the poultry and pig industries are able to increase output through the use of good genetics, better feeding strategies and effective health management.

In contrast,the cattle and goat producers have little support from the commercial technology providers but instead have to rely on public sector extension service. Much of the function of extension service in livestock production is covered within the responsibility of DVS. Besides national research institutes such as MARDI and MPOB and public sector universities have listed technology transfer programmes as parts of their statutory functions. But these extension programmes are not well coordinated nationally as such the adoption of technology is rather patchy and inconsistent. The beef cattle industry depends on good genetic materials from proven breeds to increase beef output in such a system as the integrated cattle-oil palm production. Supply of breeding stock of Brahman crossbred cattle are not presented to beef cattle producers in adequate supply, although the breed has been proven experimentally to be very productive when reared in oil palm environment.

Technology transfer programmes need to be strengthened to get animal agriculture moving. Each Institution which generate technology for the livestock sector has to have a technology transfer programme in place and conduct technology briefing such as field days on a regular basis. National research institutes and universities need to work closely with dedicated agencies involved in technology transfer throughout the whole process of technology development so that ownership of the technology is equally shared among the many agencies involved. The ultimate motivation for all agencies involved is the improvement in farm output which would contribute to increase in farm income.

7 CURRENT POLICIES

7.1 Policies Pertaining To Development of Crops

Before the enunciation of the National Agricultural Policies (NAP), agricultural development was guided by the policies contained in the Five Year Development Plans. The First Malaya Development Plan (1956-1960) initiated at the early part of independence called for the development of crop commodities for export and the production of food crops. The export crop then was rubber. Food production was in the hands of small farmers planting paddy, coconut , fruits and vegeTables. The Second Malaya Plan, the First, Second and Third Malaysia Plans which covered the period from 1961 to 1980 focused on the eradication of poverty and rural development. This period fell within the initial period and overlapped with the implementation of the New Economic Policy (NEP) with the overriding objective of NATIONAL UNITY through a two-pronged strategy of eradication of poverty and restructuring of society. Agriculture became an important instrument to meet the NEP objectives, by uplifting the socio-economic condition of the farmers and at the same time, increasing the agricultural production for self-sufficiency and export. Land development schemes and land consolidation and development schemes became important strategies to meet these objectives. Large tracts of land were opened up and consolidated for oil palm, rubber and cocoa during this period. This was the golden era of oil palm and cocoa.

The First National Agricultural Policy (NAP 1) and NPA2 were promulgated for the period of 1984 – 1997 and its objectives fundamentally adhered to the spirit of the earlier development plans i.e. poverty eradication, employment creation and enhancement of foreign exchange earnings through the opening of land for the planting of such export crops as oil palm, rubber and cocoa.

NAP 3 drawn for the development of the agricultural sector for the period 1998 – 2010 focused on food production and identified the private sector to play an increasing role in this aspect, particularly in value adding activities and the development of agrobased industries. For the first time the policy recognized the new emerging global challenge –

climatic change with the identification of sustainable agriculture as a strategy in its agricultural development, emphasizing the importance of the conservation and protection of the country's agro biodiversity (Figure 7.1).

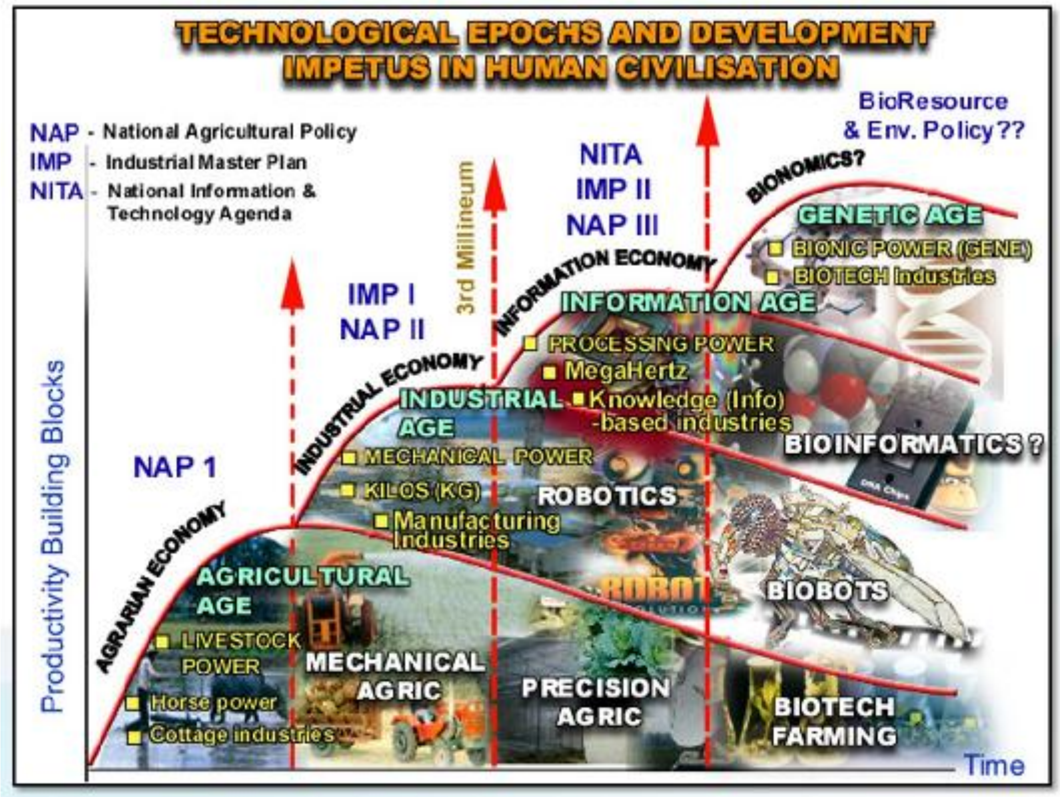

Figure 7.1: Technological epochs and development impetus in human civilisation

The gestation period of NAP 2 that was to last until 1997 came to an abrupt end with the emergence of the currency crisis of 1997, which shook the foundation of our economic strength. NAP 2 was reviewed and NAP 3 emerged in 1998 and the Policy was to extend until 2010 (Table 3.10). NAP 3 contained the previous development plans initiatives of food production and increasing farm income but with the new twist in its strategies. It still emphasized on domestic food production but it has to be implemented with cost competitive consideration. The Policy also recognized the need for strategic sourcing of food from neighbouring ASEAN countries. NAP 3 introduced another new important concept and emphasis of agriculture – the SUPPLY CHAIN ELEMENTS – where the sector is viewed beyond production of primary products to include improvement of market efficiency by initiating market intelligence, establishing collection and regional distribution centres, direct and wholesale marketing, branding and establishing the international Halal food hub. It also identified the new agriculture that the country needs to embark in – biotechnology products, utilization of crop biomass, aquarium fish and agrotourism and that 'agriculture is businesses with enabling facilities such as agrotechnology parks, incubation centres, land banks and private sector investments.

7.2 Policy frame work in Livestock

With the exception of palm oil and rubber, the private sector participation in other food agricultural activities has been dismal and not in the scale of investment as envisaged by NAP3. Plantation companies with large tracts of oil palm and rubber planting have generally shied away from investing in integrated beef cattle and goat production within their estates, although its benefits have been generally positive . However forays into cattle breeding in oil palm areas by several plantation companies such as Chin Teck, Austral, Far East Holdings, Paspa and Sawit Kinabalu have provided much corporate experience for future investment by private sector entities.

Land for livestock production has always been a contentious issue especially with regards to land tenureship. The establishment of Permanent Food Parks on land belonging to federal and state governments has invited some investment by the private sector in food production, mainly fruits and vegetables, beef cattle and goats. A long term 30-year lease arrangement for tenants of these food parks has eased investors to spend on capital equipment and infrastructure. Idle land belonging to smallholders has been suggested to be listed in a National Land Registry which could match demand and supply of land for food production (ACCCIM, 2006). More land should be released to private investors who profess to invest in food production.

Areas designated for pig farming in several states have not been developed fully, due to the vehement opposition by inhabitants living in the surrounding areas. In spite of the assurance of modern and sophisticated pig management modelled after the best practices of European pig farms to be adopted in these modern pig farming areas many inhabitants and environmental advocates are sceptical that the new pig farming method would not result in more pollution to the environment . Public awareness of environment-friendly modern pig farming has to be heightened to gradually educate, sensitize and pacify consumers and local inhabitants about the sustainability of pig farming in this country.

Timely market information and long term forecasting of supply and demand of food products are lacking to assist food producers in making crucial production-related decisions (ACCCIM, 2006). Over supply, low price and peak demand of many food products are events less communicated and made known to producers. Compilation of database on demand conditions of both domestic and overseas markets, an inventory of food suppliers and supply statistics are recommended to be strengthened and relevant information made available to producers and marketing entities.

R&D programmes organized nationally through public-sector research institutes and public institutions of higher learning have been pointed to be not market-oriented (ACCCIM, 2006). The findings of many research efforts in the field of livestock production have remained within the laboratories of many scientists. Cost of products is high which discourages take-up of the technology by the private sector. The private sector needs to be engaged early in the technology development process so that entry to market and cost reduction of the intended product can be smooth and optimized.

The pool of skilled workers and knowledge personnel in livestock production is shrinking as graduates move to other fields of specialization and occupation and farm labour is very much dependent on foreign workers (ACCCIM, 2006). Labour saving devices, including mechanization and automation, are needed to ensure animal products can be produced at reasonable prices.

Extension service in livestock management is still under stuffed and needs to be beefed up to advise producers on health management, food safety, better feeding methods and environmental management (ACCCIM, 2006). Beefing up the extension agencies with personnel of the right attitude could assist producers in the long term.

7.3 Research Funds

There are currently many available sources of research fund that can be sourced by researchers in agriculture viz., e-science, FRGS, (Fundamental research grand scheme), agriculture research fund, RUGS (Research university grant scheme) LRGS(Long term research grant sheme),ERGS (Exploratory Experimental Grant Scheme) , PRGS (Protype Research Grant Scheme) etc. Apart from that, there exist cess funds for research in oil palm and rubber.

The dynamic and creative apportioning of cess fund from the oil palm and rubber taxes provide major impetus towards a continuous financial source to sustainresearch and innovations in both the palm oil and the rubber industries. However, there are efficient or improved ways to disburse the cess funds in sourcing for competitiveness in research in strategic areas of the economy of the country. There ought to be greater and active sourcing of research talents and initiatives to bring about greater competitiveness and technological innovations.

Coordination: Malaysia is probably one of the few countries in the world with too many government ministries that are stakeholders or beholden to the progress of agriculture and the related areas: namely; Ministry of Agriculture; Ministry of Primary Industries; Ministry of Natural Resources and Green Technology, Ministry of Higher Education, Ministry of Science, Technology and Innovation; and Ministry of Domestic Trade and Industries. Currently, there are too many ministries have direct or indirect responsibilities and beholden to the agriculture sector and it has created too many connected bureaucratic walls that impede coordination between the ministries. It is a nightmare for any farmer to be redirected the attempts to seek enquiries or reference to the many ministries. Overlapping roles and bureaucracies pose even greater problems in coordination, especially now that there are many roles for agriculture in food, feed, fuel, fibre, furniture, felicity, pharmaceuticals, etc. Since agriculture and the related industries are connected through the process-chain of production therefore there has to be a mechanism to facilitate and arbitrate any disputes and blurred issues to tear down the wall of bureaucracy. Probably, the renewed appointment of the position of the National Science Adviser in the Prime Minister Department should examine this contentious issue and streamline the coordination between ministries related to agriculture, especially so now that the country is moving towards the Knowledge-based innovation economy initiative where research and innovation are identified as the major primers.

Serdang Agropolis Hub: In the coming decades agriculture in the country need to reinvigorate her endeavour and revitalize the synergies from the fortuitous agglomeration of the diversity of agricultural institutions of Malaysian agriculture in Serdang. The co-locations and immediacy of these institutions from several agri-related ministries to interact in Serdang-Bangi (UPM, MARDI, DOA, MPOB, IP, CABI, PLANTI, etc.) areas for more than 75 years inadvertently serves as the nation's hub and think-tank for agriculture (Figure 7.2). Unmistakably, the activities and contents of the Serdang agglomerates present itself as the cradle of human resource, research, training, education and industrial incubators in Malaysian agriculture for almost a century and it will soon be formally galvanised with the establishment of the Serdang AGROPOLIS. As a hub, it will become the 'Mecca' on agriculture knowledge and networks designed and conceptualized on the three-layered economic development model of the combined agrarian, industrial and knowledge-based agriculture (K-Agriculture) (Figure 7.3). Collectively, institutions like UPM, MARDI, Dept of Agric., Institut Pertanian, MPOB, CABI, ASEAN Planti, etc., which are under the purview of different ministries, must converge and join hands to work together in the newly proposed concept of AGROPOLIS. The AGROPOLIS Masterplan, expected to be developed in the upcoming 10th Economic Malaysia Plan, is intended to extend the agriculture value-chain into the development of innovations from research, agrotechnopreneurship, test beds for new innovations, etc.

Figure 7.2: Serdang Agropolis

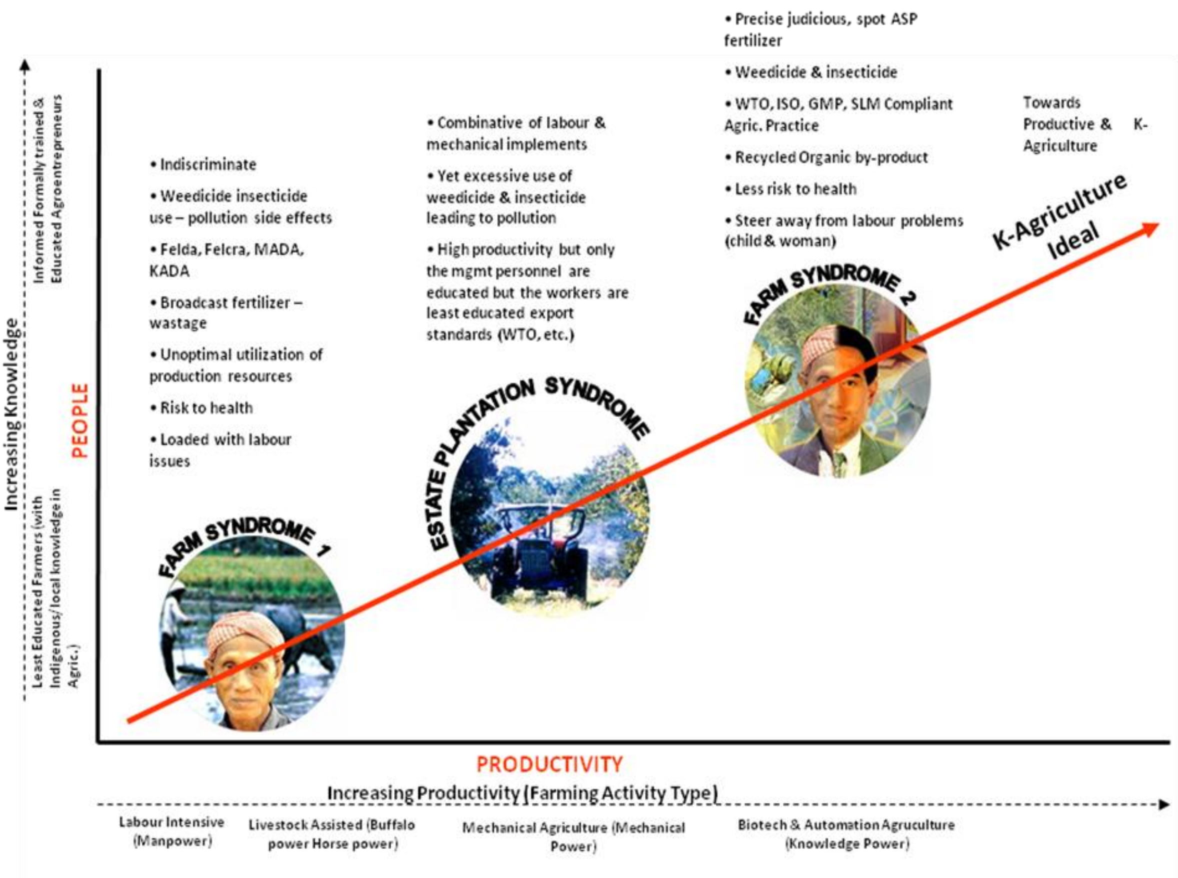

Figure 7.3: Toward Production and K-Agriculture

Fighting hunger and poverty, mitigating and adapting to climate change, and sustainably managing natural resources depends on participatory and enabling strategies to be developed with the large majority of farmers around the world, including their traditional and local knowledge. The following are essential policy directions, which follow from the findings of the IAASTD, to ensure food security for all in the 21st century.

Agricultural research and development should be increased and systematically redirected towards ecological farming systems which can alleviate poverty by improving the local availability of food and can increase productivity in a sustainable manner by lessening the environmental impacts of agriculture. Special emphasis should be placed on reducing the reliance of agriculture and the food chain on fossil fuels (for agrochemicals, machinery, transport and distribution).

Governments should put an end to public subsidies promoting unsustainable input-intensive industrial agriculture and export-oriented farming models. Governments should also halt funding for the development of genetically engineered crops, which support and endorse unsustainable industrial farming practices.

Domestic agricultural policies and international trade regimes should encourage the internalization of environmental externalities, including policies rewarding ecosystem services and imposing taxes on carbon emissions, agrochemical use and water pollution.

Agricultural research, development, trade and financial support should be directed towards ecological farming practices that mitigate greenhouse gas emissions from agriculture (for example, by increasing carbon sinks) and enhance the resilience and adaptation capacity of agricultural systems (for instance, by increasing biodiversity in farming and water-holding capacity of soils).

Special attention must be given to the knowledge, capacity and needs of the world's small farmers, especially women. Fighting hunger and poverty as well as environmental destruction depends upon their access to land, water, knowledge, markets, capital and basic human rights. As recently proposed by UNEP, small-scale farmers should be supported through a global fund for micro-finance in developing diversified and resilient ecological farming systems.

Continuing discussions on the Global Partnership for Agriculture and Food Security must incorporate the findings of the IAASTD in their analysis, and should follow the organizational model of the IAASTD which engaged all stakeholders in defining effective polices.

8 RECOMMENDATIONS

The critical factor in agricultural development is the availability of arable land and it is expected to become more acute in the future. Some out-of-the-box solutions have to be sought in order to overcome the need for arable space for farming to feed the projected growing global population towards 9.1 billion people by 2050. It is no more about availability of fertile soil anymore but merely space for agriculture, even if the soil is infertile, it is already good enough and technology can be sourced and adapted to enable farming in the given space. On another level, it is politically incorrect and not an option anymore to cut down rainforests and clear the pristine jungles for the sake of gaining more arable land. We have to look at the optimisation of the existing hectareage of arable land that are least productive and seek creative means to maximise the land use and resort to technology in the quest to increase agricultural productivity and sustainability. Congruent to this concern, the Malaysian government, in its NAP4 policies put a cap on the opening of more land for oil palm plantations, and therefore, oil palm which serves as the backbone of the agricultural economy, has little room for expansion but resort to technological innovations and management. The main bulk of the arable land for Malaysian agriculture has been utilized for oil palm, rubber, cacao, coconut, rice and orchards have to be explored of their mechanisms and technology to optimize the land use, enrich the agroecosystem, and adopt appropriate technology and management to improve productivity and quality.

The advances in genomics and creative management seem to be viable options. The challenge to ST&I is to allocate human and financial resources and conduct and prioritise R&D activities in the relevant areas and strategic focus. Currently, more than 30 million hectares of land in the world is planted with genetically modified crop plants (GMO plants) by farmers worldwide, in both the developed and underdeveloped countries. In the same vein, China has sequenced and mapped the DNA genome of more than 100 economically important crop plants which underscores the potential of genomic traits to be developed into designer crop plants, such as, rice and other crops for food, feed, fuel, fibre, pharmaceuticals and felicity. The development blueprint in genomics for agriculture adopted in China can be similarly adopted for the benefit of our oil palm and rubber industries. Certainly, the SandT effort in genomics is the answer to address efforts to overcome the constraints of arable land for farming activities.

There are boundless and limitless potentials to leverage on the bio-wealth opportunities residing in the genomics of the rainforests' flora and fauna species. The total or collective genetic diversity of traits and uniqueness of the many flora and fauna of the rainforest reflects the bio wealth potentials of the rainforest and it also offers tremendous opportunities for agriculture productivity via advances in agro-biotechnology – Molecular Breeding. Through this technology, improved plant productivity can be achieved via increase in yield, resistance to pest/weeds, tolerance to increased temperature, drought, floods and increased salinity, and other new innovative, transgenic initiatives can be achieved, which is conducted with greater precision on the specified chemically, marked genes.

Other proposed solutions like ICT-enabled applications, conserving the biodiversity of our agroecosystems, and water technology are also being considered.

Taking cognisance of the critical challenges to agriculture development and notion of the prospect of ST&I, the Study Team recommends several focused areas in ST&I to cope with the need for the inclusive and sustained growth of Malaysian agriculture towards 2050. Recomendations are:

i) Biogeographical transplant of species

ii) Plant Gene Technology

iii) New Fishery and Aquaculture

iv) Sustainable Vertical and Urban Agriculture

v) Energy Crop and Green Technology

vi) Development of ICT-enabled Applications

vii) Appropriate Water use Technology

viii) Collaboration Between ASEAN Countries in Agriculture

ix) Human Capital in Agriculture

x) Human Nutrition and Food safety

8.1 Biogeographical Transplant of species

i) Success Formula of the Biogeographically Introduced crops

The successful formula of prospecting for biogeographically transplant of flora and fauna species from rainforest habitats on other continents must be continued for future undertaking and innovations in agriculture. The successful introduction of flora and fauna species, like oil palm, rubber and cacao for the economic well-being of the country are proven to be unprecedented in the tropical belt and should continue to be pursuedwith renewed vigour and urgency. Rubber was introduced from Brazil with the South American Leaf Blight Disease being left behind. Oil palm was introduced but unfortunately the pollinating weevils (*Elaeidobius kamerunicus*) being left out too. The ensemble or ecoweb of species were not considered for sustainability. Over the years, these introduced crops encountered problems in the new habitat that it would be more appropriate that more strategic and far-reaching plans be in place to meet the ST&I needs of developing 'close-loop, controlled environment agro-ecosystems for the sustainability of these crops. Going back to the native area for in-depth research, in order to reinstall the inclusive, close-loop ecosystem for the crop production system is very crucial for its sustainability in the new habitat. Many of the insights and understandings on the introduced crop agroecosystems are intrinsic to its native area in order to developed an 'inclusive' and 'sustainable' mindsets that is central to the close-loop, sustainable agriculture ecosystem. Along this line of reasoning, it is imperative *that MPOB,* MRB and MCB should enhance their research and prospecting outreaches to the rainforest ecosystems into the continents of South America and Africa. We should also develop and enforce bio-safety protocols for bio-geographically introduced species for agriculture.

ii) **Alternative to Biogeographical Transplant of Allopatric Rainforest Species**

The idea of introducing allopatric species into a similar rainforest habitat, like Malaysia, does not easily fit or is compatible with the current concerns on land developments in agriculture. Arable land is scarce and such undertaking of opening up of new arable land for new crops by clearing and destroying the rainforests is far off from being sustainable and politically correct. It would be difficult to withstand public scrutiny if new land openings that destroy the rainforest be given way for a new crop. The option would be to optimize the existing arable areas by enriching the ecosystem with compatible species. For instance, by growing herbal plants, or planting orchids under the existing arable land in the oil palm and rubber and cocoa plantations to enrich the existing crop ecosystem. Otherwise, it would be amenable to replace the existing uneconomic crops with the prospective new crops. Or else, innovative ways of transgenically inserting the desired genetic traits from other species into the DNA genomes of the extant species of edible (oil palm and cacao) and non-edible (rubber) crops. Equally, many factors have to be considered before replacing existing, commercially established, but controversial crops like tobacco. The idea of replacing the tobacco as cash crop with jatropha is viewed with some scepticism. In that line of reasoning, it is more appealing to redesign the tobacco genome by inserting desirable therapeutic or industrial biosteel gene into tobacco rather than replacing tobacco with Jatropha. Alternatively, certain therapeutic properties of herbal plants can be prospected from the rainforest and grown under the existing land, and later the desirable genes can be inserted into the existing edible crops like cacao or oil palm – biotechnology and genomics.

iii) Research on Plant Based Vaccines

In the control and treatment of animal diseases, plant based vaccines may overcome some of the problems associated with conventional vaccines (that is high cost, low efficacy and poor delivery)..Mode of delivery of plant based vaccines is said to be cheaper when given orally. Plant based vaccines are recombinant proteins sub-unit vaccines with antigens of interest derived in plant tissues. Genomic profiling of native flora would likely be able to identify plant species expressing high level of the desirable antigens.

iv) Genomic Mapping of Indigenous Livestock Breeds

Genomic mapping of indigenous Kedah-Kelantan cattle, swamp buffalo, Katjang goats, Malin sheep and native avian species, including jungle fowls and ducks, would enable the assembly of more precise genetic information of the native animal genotypes. This information would aid in identifying specific genetic markers via micro satellites and other DNA sub-sets which could be associated with traits of economic importance. Breeding values of animals selected, as parents would be more accurate as genomic values could be estimated, thus would vastly increase rate of genetic improvement of the livestock species.

Changing global climatic conditions may affect the survivality of many species of flora and fauna. Cataloging an inventory of these natural biodiversity for many characteristics - to include among others their inherent properties for adaptation and survivality – would be an arduous task but would benefit the country in her readiness to address the negative implications of climate change. Development of better breeds of livestock, biodigesters of fibrous feed materials and enhancers of product quality would be some of the opportunities, which could be realized by tapping into the genomes of native species. Bioprocessing technologies using indigenous microbes to degrade fibrous feed materials to release carbohydrate substrates open up opportunities to increase the use of fibrous feed materials in diets of ruminant animals in this country.

8.2 Plant Gene Technology

i) Molecular Breeding for Precision Agriculture

Genomics or Genetics is again the area of ST&I singled out to be the key technology enabler identified to be the primer of change for productivity in agriculture, dubbed as the Second Green Revolution. We are expecting crop productivity and yield to make quantum gains through inclusive and creative approaches to breeding via precise manipulation the DNA genome (Figure 8.1). Conventional breeding alone would take too long to obtain the desired results. A strip of the DNA from one particular species that carries or controls a particular desirable trait from plant or animal can be genetically inserted into the DNA genome of the key industrial crops and livestock of the Malaysian agriculture.

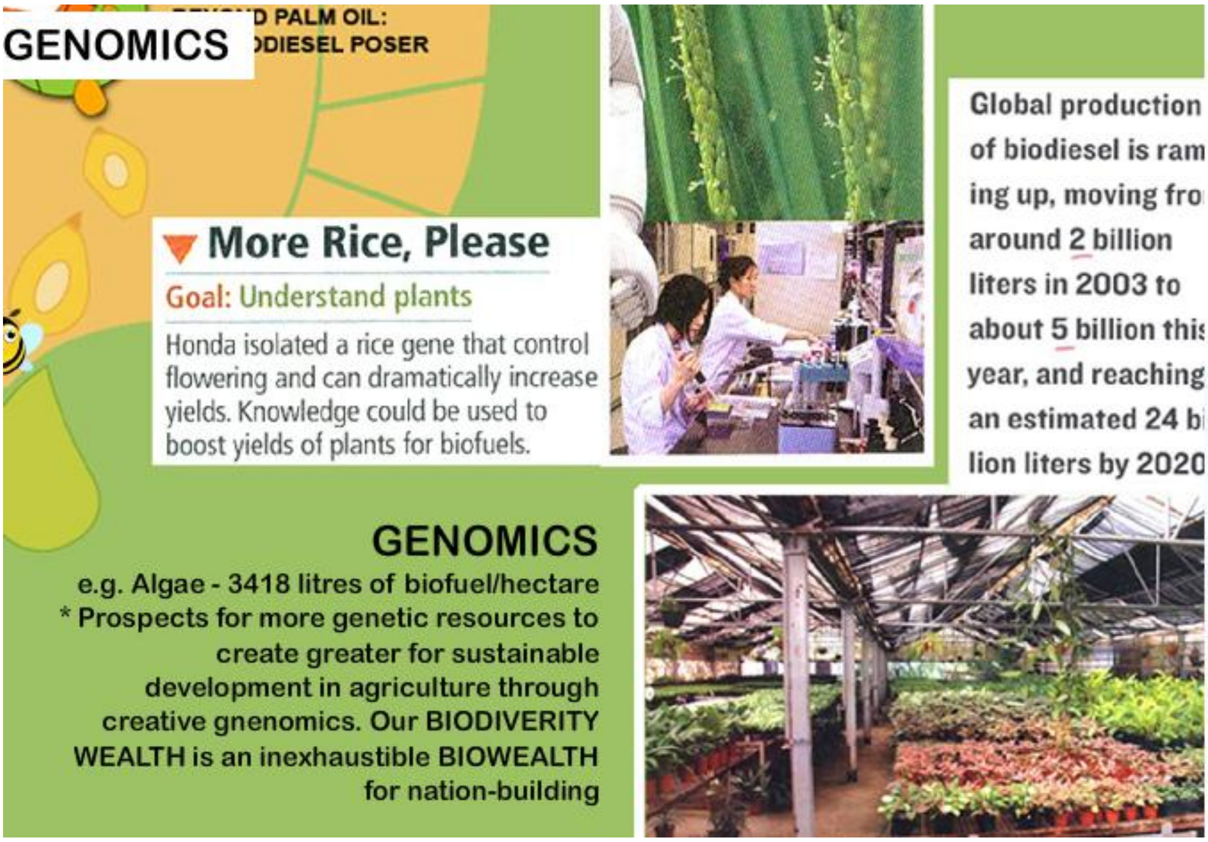

Figure 8.1: Genomics

ii) Gene Traits for Transgenic Transfer

Alternatively, focusing research efforts to improve productivity and developing new products by genomics via molecular breeding on key economic crops oil palm, rubber, cacao is the answer. Hence, focusing on the genomics of the key economic crops is one of the conceived solutions in improving their productivity and competitiveness. Productivity increases and new products and competetivness can be achieved through the development of genetically- modified-plant with resistance to disease or tolerance to weather extremes of floods and droughts, or the transgenic insertion of physiological or morphological traits that are desired by evolving supply chains and trading networks as well as the increasingly affluent and discerning consumers. This solution improves the crop value and productivity without increasing more land for agriculture.

Molecular breeding to produce transgenic crops should be targeted at creating new by-products or bioterials (e.g. biosteel silk for rubber; new and improved biochemical processes (e.g. biochemical enzymes and proteins); disease and pest resistance; tolerance of growth under saline conditions; medicinal and therapeutic properties (herbal properties into edible crops); tolerance to climatic extremes (droughts and floods); and many other innovative products (Figure 8.2). The DNA genome of several food-crop tubers (CHO sources) like sweet potato, yam, and tapioca should be sequenced and mapped for strategic ST&I initiatives and food security and healthcare reasons. We can expect the advances in genomics, specifically transgenic crops for disease and pest resistance, efficient nutrients uptake, tolerance to temperature extremes and salinity, tolerance to floods and droughts, and the production of new materials to become the growth areas in the genomics.

Similar creative ways of procuring desirable genetic traits from a species of flora/fauna and transgenically insert them onto Malaysian economic crops must be pursued and seriously attempted. Some of these traits pose health, dietary, industrial benefits and scientific merits. Some of these desirable traits are the ability of the pitcher plant to digest insects (chitin) which means such enzymes can be used for decomposing kitchen’s garbage as well as bioremediation of polluted lake and streams by using enzymes.

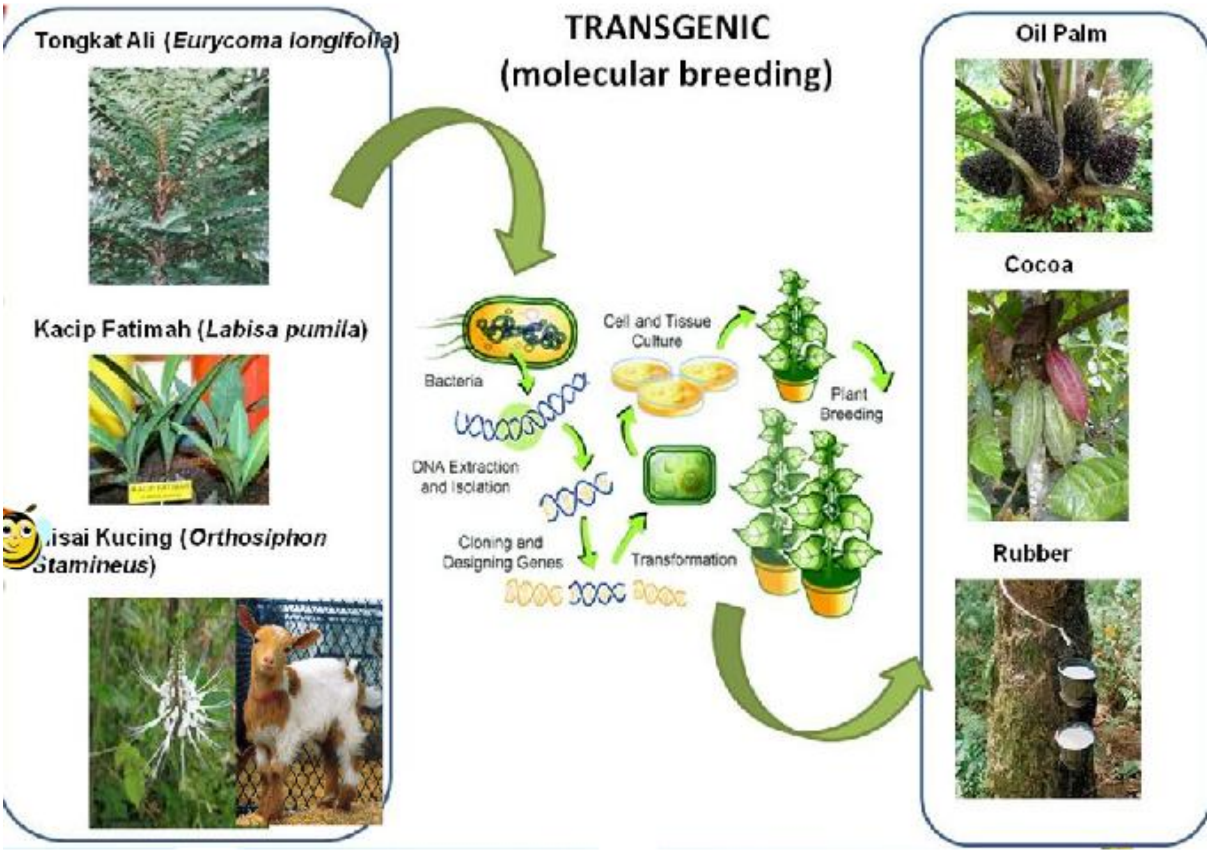

Figure 8.2: Transgenic

iii) Sequencing, Mapping and Redesigning the DNA Genome of Key Malaysian Crop Plants

The advances in genomics offer great potentials and opportunities for Malaysian agriculture. In that regard, there emerge new possibilities in exploring transgenic opportunities via molecular breeding to produce transgenic crops from amongst the Malaysian, flagship crops of oil palm, rubber, cacao, pepper, etc. These crops are the economic cornerstones of Malaysian agriculture and they are worth more than RM 60 billion annually, which account for a third of the nation's GDP. It would be a strategic blunder if we decided to delay or not to sequence and map the DNA genome of our key crops (Figure 8.3). It does not take long and eventually our competitors will see the strategic need to do just that for the sake of improving the technology of the oil palm and rubber. Any significant transgenic change in the crop will be a harbinger of streams of economic benefits to Malaysian agriculture; hence, its potential contribution to the Malaysian economy is likely to be highly significant. Oil palm, rubber, cacao and pepper are commercially established crops grown in large hectarageand they have sufficient critical-mass for economic success (be part of the rural urban transformation plan of the Rural Economic Model of the NEM) because these crops have established production husbandry, market diversity of downstream by-products, connected supply-chains and trading networks, ST&I institutions for technology development (MPOB, MRB and MCB), and human capital resources to enable the easier pathway for quicker success.

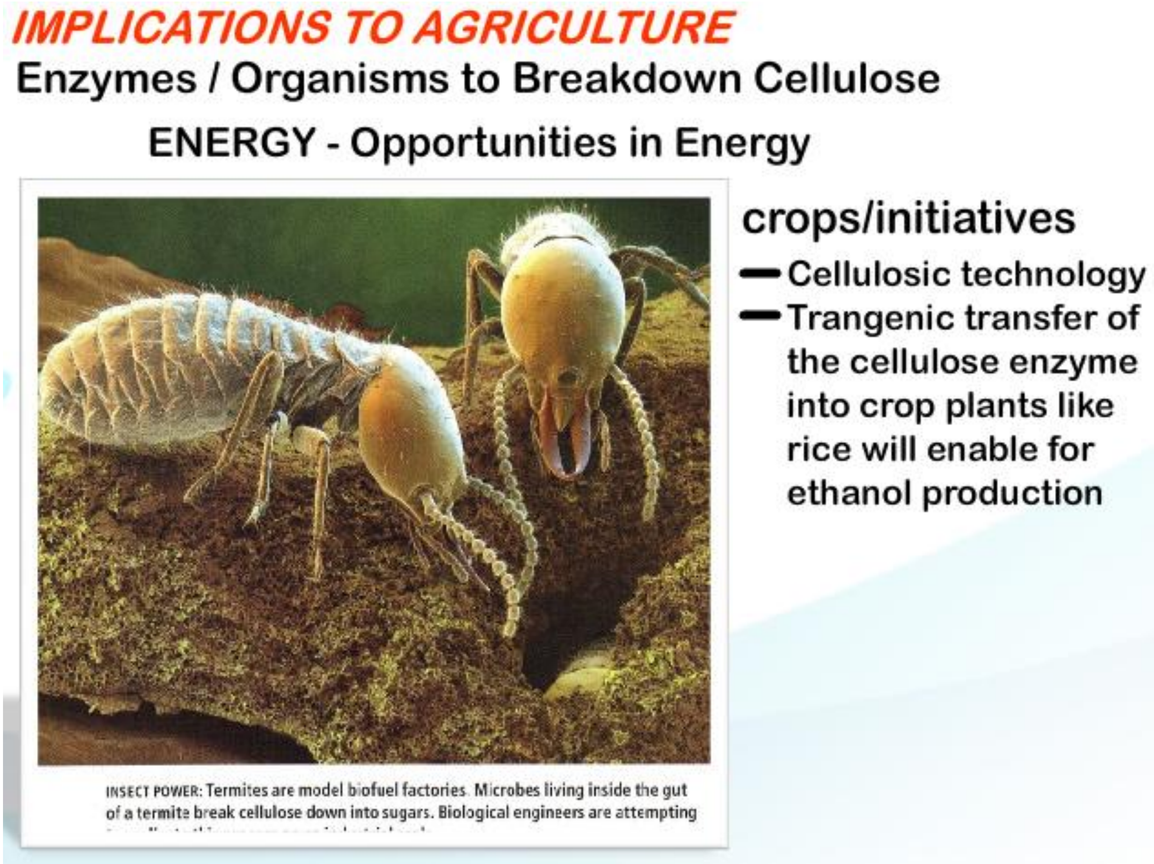

Figure 8.3: Enzymes/Organisms to breakdown Cellulose

iv) DNA Bar-coding Technology for Biodiversity Inventory

The plethora of biodiversity richness in genetic traits of the rainforests' flora and fauna offers tremendous opportunity in the selection of desirable, unique genetic traits for transgenic insertion into the key economic crops for commercial application. But that opportunity is not easy to accomplish if we do not have the identification and inventory of species using new DNA Bar-coding Technology; as it is being promoted and used by the North American scientists, David Janzen in deciphering new species in the rainforest of Costa Rica. Using this technique, new species can be accurately identified in shorter time from days to minutes (Figure 8.4). It is indeed an opportunity for the rainforest countries like Malaysia, Indonesia, Brazil, Nigeria, Kenya, Belize, Colombia, etc. to combine forces to sequence and conserve the flora and fauna species endowed with desirable traits and unique attributes that have the potential to be inserted into our key industrial crops for higher productivity, desirable traits and added value. There are few outlandish examples to think about. For example, the unique pitcher plants have the enzymatic capability to digest ants (chitins) which means it would be an opportunity to develop analogues of such enzymes for the decomposition treatment of the kitchen garbage – recycling technology. That decomposing capability is similarly evident in Rafflesia whose flower decomposes very quickly within a short period of time after it blooms. Abetted by Sarcophagid flies and dung beetles, chicken dung can be treated for quick decomposition as that is needed in recycling technology in the development of green technologies for inclusiveness in our living ecosystem. Intuitively, such ideas present opportunities for the development of generic enzyme analogues for recycling technologies.

As foremost strategy, the Malaysian agriculture research institutions must join forces to sequence and map the DNA genome of the potential commercial crops like that which have been done on the oil palm DNA genome. Not only the DNA of oil palm, rubber, fruits, cacao ornamentals and pepper are to be sequenced and mapped but efforts must be geared towards the isolation and transgenic transfer of unique and desirable traits in the tremendous flora and fauna species of the rainforest of Malaysia and Indonesia which archives more than 40% of the world's flora-fauna. In fact, other new and almost fading out crops like kenaf and tobacco should follow this strategic approach to gain benefit to explore the opportunities of molecular breeding to insert the desirable gene traits transgenically into the established and to be established commercial crops. We must take a cue from the strategic efforts of China in sequencing and mapping the DNA genomes of a few hundred economic crops.

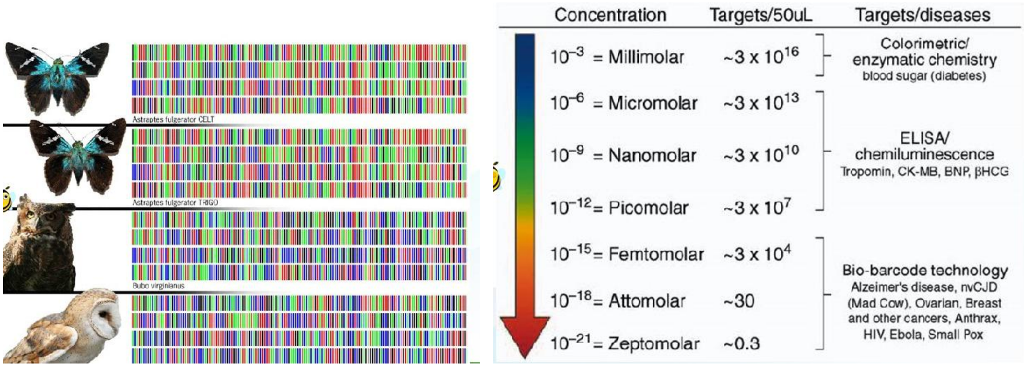

Figure 8.4: DNA Barcoding

v) **Leveraging on the Genomics of Malaysian Economic Crops and the Rainforest's Biodiversity**

Next, once the DNA genomes of the key economic crops are sequenced and mapped, then it is important to develop a strategy to fortify the genomes of these economic crops for commercial purposes and that means we should have in mind different niche strategies of edible crops into nutraceuticals, pharmaceuticals, etc. For example, when China successfully sequenced and mapped the genome of rice within six months, they then develop the blueprint to fortify the genes of rice by inserting those desirous, transgenic traits to become designer rice customize to the diverse needs of more than 3.5 billion, rice-eating population of the world. In another case, the protein genes of human milk production in human are being aimed to be inserted into the genes of milk-producing cows with the aim to produce human-like milk from the cows. In this research pursuit, experiments on animal surrogates (mice, etc.) are being conducted through team efforts. We can foresee the national need for joint ST&I efforts by MPOB, MRB, MCB, etc. to share their human capital resources in genomics, together with the universities and research centres of Malaysian conglomerates or plantation groups (Sime Darby, FELDA, KLK, etc.) in the country to work in concert and joint efforts toward making productivity inroads in molecular breedingof Malaysian economic crops. The cess fund for rubber and oil palm should be retained and imaginatively utilized to bring about combined efforts of 1-Malaysia in fraternity of the oil palm industry to deliver deep strategic research and innovation from the fund.

vi) *Regional Joint Research Efforts in Research Technology and Innovation on Oil Palm*

With ASEAN economic integration scheduled for 2015, it is therefore important for Malaysia to work jointly with Indonesia especially in the area of oil palm genomics and molecular breeding. Both countries produce more than 80% of the palm oil of the world and technically both countries dominates the oil palm plantation technology. It will not be long before other competitors like Korea, Singapore and China decide to embark into the vegetable-oil research and innovations and invest in oil palm plantations. Malaysia stands to gain to become the epicentre of the world's oil palm technology with the combined might of human resource, research and innovations with-Indonesia to become the world's largest producer of vegetable oil from oil palm. The oil palm tree is the most efficient vegetable oil producer per unit area when compared to other vegetable producing plants like soybean, rapeseed (canola), coconut, and sunflower. We should maintain our dominance in the development of technology for oil palm and vegetable oil by spreading our ST&I posture to include the research into other vegetable oil producing plants like canola and sunflower. On the horizon we need to monitor the efforts of Korea and China to go offshore to grow oil palm in Madagascar, Africa and South America. This strategic thrust has in fact been adopted by Cargill, a major vegetable oil producer, who have bought oil palm plantations in Kalimantan in pursuit of opportunities in molecular breeding and genomics.

vii) Designer Crops

We learn with appreciation from the strategic efforts of China in sequencing and mapping the genome of rice, which they then proceed to develop designer rice with inserted genes (transgenic) and hence fortify and redesign the total rice genes. It is therefore not far-fetched for us to explore and tinker with the sequenced and mapped DNA genomes of oil palm, rubber, cacao, fruits, ornamentals and pepper by inserting transgenically desirable gene with therapeutic traits from our indigenous herbal plants into the genome of these food crops to produce designer varieties via fortifying the DNA genomes of these commercial, economic crops. Strategically, a separate genome vehicle for food (oil palm and cacao) and non-food crop (rubber) strategies can be charted and planned for molecular breeding on our key agricultural crops. It is even more relevant to address the national needs rather than based on current market needs in the world. Such innovations should form the cornerstone for future development of economic crops without needing to expand for more land but improving from the existing agricultural land. This is a long term strategy and there is a need for the National Genome Centre to strategically explore these possibilities with imagination and creativity.

8.3 Sustainable, Vertical and Urban Agriculture

The clarion call for the practice of sustainable agriculture is very much brought about by the realization that the world resources are finite and therefore utmost care and concern must be adhered to in utilising the finite resources (e.g. energy, water, etc.) for agriculture. An agriculture enterprise is considered as sustainable if the rate of resource utilization is able to support generations of human population in the future without destroying the environment. The practice of sustainable agriculture impinges on the way we source and judicious use of constrained resources, such as, water, energy, petroleum-based fertilizers, and other inputs, for agriculture production. The onset of Climate Change consequences has invoked strategic thinking on how best to cope with increased needs for food production against the backdrop of diminishing arable land, especially in the urban areas where arable land is scarce. The city populates need more and more food as urbanization accelerates in most countries.

i) Controlled-Environment Agriculture: Inclusive, Closed-loop Agriculture Ecosystem

By constructing a closed space, multi-storey building (up to 32 storeys) with an inclusive agriculture production ecosystem, city folks will be able to indulge a healthy life style of farming to grow their own food. A precise, close-loop, agriculture ecosystem, in the like of a controlled-environment of a greenhouse, regulates key factors of the production ecosystem, including temperature, humidity and air flow, gases (CO_2), intensity of light penetration and duration, nutrient formulation flow and calibration, water regulation, temporal manipulation of flowering phenology, pest control, waste management, etc. Empty spaces on rooftop of buildings in cities and other unsuitable non-arable land space in the cities can be utilised for farming activities. From a given land area of 1,000 square meters engineers can build a closed and controlled-environment, agriculture production ecosystem which can create up to many storeys of space area for a closed-loop ecosystem for farming. Everything that is part of the supply-chain in the agriculture production system is accounted for, reutilized or recycled water and leakages of the agricultural inputs or outputs in the ecosystem will be accounted for and considered.

Inspirational initiatives on the founding of space agriculture and controlled environment like that being conducted at the SALSA (Space for Advanced Life Support and Agriculture) for NASA program at University of Guelph, Canada demonstrates the need to conduct a controlled-environment agriculture for the establishment of human colony on the hypobaric environment (low atmospheric conditions) of the planet MARS by 2035. This initiative is founded on the concept of establishing an inclusive, closed-loop agro ecosystem in a biosphere-like controlled environment of a building enclosure. Everything from the gases, water, nutrients, agricultural inputs, wastes, effluents are to be factored into the sustainability of the total agriculture ecosystem. There could not have been a better time to indulge into this inclusive, closed-loop ecosystem for agriculture than during the unpredictable times of Climate Change. Humidity, temperature, water flow, nutrients, and many other production variables are to be calibrated and monitored.

Poultry producers and eventually producers of red meat and milk, would most likely to wholly embrace the vertical integration model in the production of food animal products. Contract farming under the umbrella of entities adopting vertical integration will ensure participating producers of high quality breeding stock and feed supply and market for the products. More mechanization and automation as well as cooling and ventilation system will be introduced in intensive close-house livestock production systems of the future. New food products from poultry meat and eggs, beef, mutton and milk will be further introduced to meet future demand of consumers.

While oil palm continues to remain dominant in the landscape of Malaysian agriculture, the consideration of integrating the production of food and industrial products vis-à-vis palm oil in the same oil palm areas warrants further R&D undertakings. The current placement of cattle and goat populations within the spatial dimension of the oil palm production life-cycle has to be re-examined. Changes to current production models of food commodities, including livestock produce of meat and milk, may be necessary to adapt to the oil palm culture. Synergistic approaches to the production of palm oil and other food and industrial products have to be worked out as arable land becomes scarce for both commodities. In the intricate value chain of the production and processing of palm oil, many industrial products are simultaneously generated; some of nutritional value as feed stock in livestock feeding, and some of raw materials in the manufacture of industrial materials for many industries. Ruminant animal production systems, both intensive and range models, located close to oil palm estates could benefit from the abundant supply of oil palm by-products as feed stock. Integrated models of cattle-oil palms for beef production needs further scrutiny to evolve into more viable models that accommodate the changes in the oil palm cycle within a given area.

ii) Research Showcase on Sustainable and Inclusive Crop Ecosystem; Enrich the Biodiversity of the Agro Ecosystems on Key Crops, and Indigenous Communities

The case for holistic and in-depth research on close-loop and inclusive agriculture ecosystems for the major key crops like oil palm, rubber and cocoa is needed to demonstrate the sustainability of the agro ecosystem, which is. Inspired by the concept of a biosphere, the elements of inclusiveness and sustainability. Careful study on the rudiments of the agro-based or semi-pastoral, indigenous ethnic tribes/communities like the Kelabit, Penan, Melanau, Iban, Kadazan-Dusun, BajauLaut, Dayak, Bidayuh, etc. need critical appraisal and further scrutiny to decipher the DNA of the rainforest agro ecosystems. For instance, understanding the dietary habits of the Penans of eating beetle grubs (protein) that lives in sago palm trees (carbohydrates) decipher the triad relationship between the penan-dago-beetle. There is a need to identify the critical or keystone elements of the society life style sustainability. The profiling on the life styles, mores, food and dietary habits, medicinal practice and beliefs of the aforementioned, rainforest-based, ethnic tribes or communities will reveal the salient and crucial biological and ecological elements needed for the sustained life styles of these people under the rainforest ecosystem. Such studies will unveil a plethora of information relating to the critical species and resources for the oil palm, rubber and cacao ecosystem. Indigenous, agriculture practices of these ethnic tribes contributes to the establishment of a sustainable agriculture under such sub-ecosystems.

In the same vein, in-depth ecological studies have to be conducted to understand the ecosystem for the key crops like oil palm, rubber and cacao in the native areas in Central Africa, South America, etc. We have learned from previous research undertakings that the South American Leaf Blight (fungal disease) and Elaedobius weevils (pollinator) are critically linked to prevent or to promote the industries of the rubber and oil palm. Understanding the ecological and evolutionary traits of the key economic crops in the place of its origin will widen the opportunities in seeking the genetic diversities for breeding purposes and protecting the crops from its natural enemies in the place of its origin.

iii) Vertical Farming

Vertical farming is an important option to address the scarcity of land space and water, which are constraints for agriculture production. At the current rate of the world's population growth rate, the world would need an arable land space in the size of another

Brazil, if the population continue to increassed by another 3 billion people in 2050 from the current 6.1 billion. By then, it is estimated that 80 per cent of the world's population will be living in urban areas. We can expect that not only do we have a constraint for arable space for agriculture but also a constraint for drinkable water in the urban areas. The cumulative problems of Climate Change will increasingly impact the human race in the run-up to 2050 (Figure 8.5).

We have to think out-of-the-box to resolve these intertwined problems of arable space and constraint water for agriculture. Coupled with these would be the enforced regulations to reduce carbon footprints (reduce food miles or reduced logistics), towards low-carbon agriculture, to conserve energy consumption.

These constraints are a worldwide phenomenon for town planners who have to grapple with myriads of city folk needs of urban development in coping with scarcity of space and water for human dwellings, industries, roads, waterways, including agriculture. In the past, too often a time that land space need for agriculture are being hived off in preference for other urban needs like housing, industries, roads, etc. and farming is practical in the distantly located in rural areas. We cannot continue to push aside the space need for agriculture into the suburbs and rural areas as the areas for cities become enlarged (engulfing the suburbs), yet the city folks need to feed themselves.

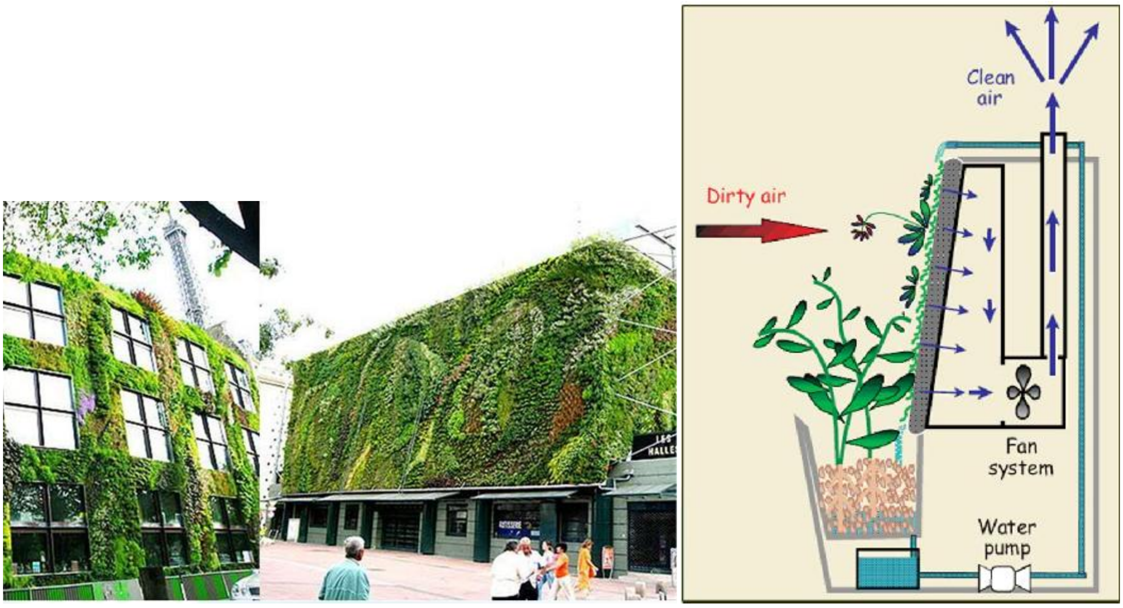

Figure 8.5: Plant wall

There would be problem-specific or piece-meal solutions proposed but what the world needs now is a total, holistic or integrated solution that addresses many problems at one time. We can expect greening of city sprawl in the likes of Kuala Lumpur, Johor Baru, Penang and even densely populated ASEAN cities like Bangkok, Jakarta, Singapore, Manila and many others. This can be implemented via the twin concept of urban vertical farming.

iv) Green Roof

By 2012, Roof-top gardening are being imposed in cities like Toronto, and vertical faming under controlled-environment is an emerging trends adopted by city planners. Such solution is able to address the bigger and related issues of more than just arable space, but water and hot cities (Figure 8.6). That solution on green roof is similar to the traditional farming activities of SALT (terraced agriculture for rice) in that it optimize land space, prevent erosion and accommodates water irrigation which are vital to agriculture. Such initiative caters to the needs for space in growing food in the cities in the pursuit for smaller carbon footprints, building cooler cities from the activities of growing plants in the cities.

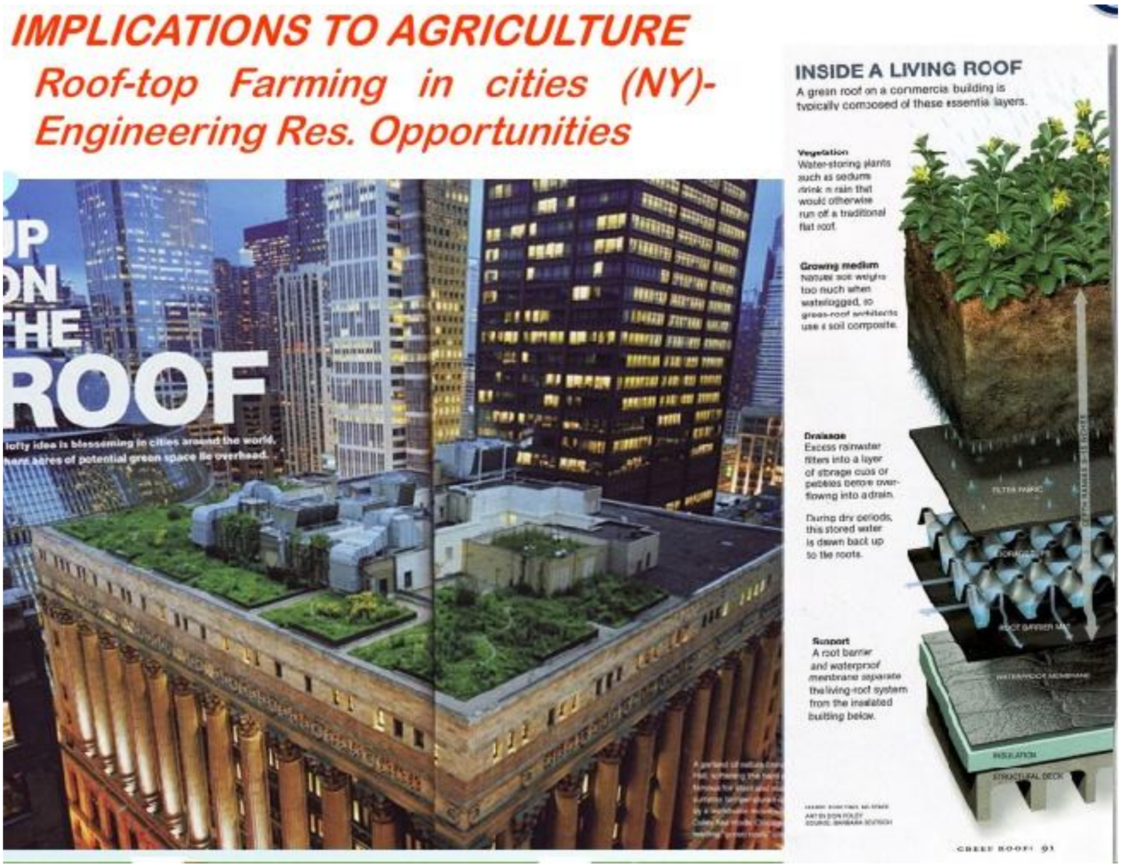

Figure 8.6: Roof Garden

v) Urban Agriculture

In the light of concerns for carbon footprints for agriculture products it pays to grow food in the cities and minimize our carbon footprints. Somebody out there is coming up with a solution to think in terms of space, rather than area for agriculture. Recently, a town planner, professor Despoimmer from New York came up with some creative innovations to propose to town planners to cater the land needs for agriculture in the cities by resorting to the concept of vertical farming to optimize land space to 3D space volume, rather than 2D space area. Think in terms of cubic meters rather than square meters in vertical farming. Urban agriculture, vertical farming and percision agriculture are three overlapping, farming concepts that can be intertwined and integrated to address many issues on future agriculture including space constraints, sustainability of famring activities, urban employment, green-friendly urban environment (cooling the cities) and many other benefits. Precision farming entails the precise manipulations, calibrations and considerations of inputs and outputs of agriculture production system. Precision culture lends to precision farming and inclusiveness of farming activities, whereas, urban agriculture captures the imagination of farming or gardening activities on rooftops, barges on rivers, in the cities and crowded space of the urban areas. Precision farming demands accurate, calibrated and monitored utilization of agriculture inputs to prevent wastage and even saving time and resources. The establishment of space efficient utilization of vertical farming requires the practice of precision farming in urban agriculture setting. The concept city MASDAR to be built in the Middle East is an eco-based development city that addresses those inter-connected environmental problems.

Energy Crops and Green Technologies

i) Energy crops for biofuel

The landscape and sources in the energy sector are fast becoming diversified and departing from the over-reliance on non-renewable sources of fossil fuels like petroleum, coal and natural gas, which unequivocally means less reliance on non-renewable energy sources. In the move towards a greener earth, there exist great potentials and well thought-out planning amongst developed countries to wean off their dependence on non-renewable energy sources from petroleum and coal and hence diversify their energy sources into other renewable energy sources including biofuel from canola, corn, sugar cane, coconut, pongamia, camelina, oil palm, etc. As for Malaysia, it is strategically clear that we should explore on the partial usage of oil palm as a source of energy to begin with. Simultaneously we should explore the niche role in agriculture to prospect biofuel sources from other oil-generating seeds like jatropha, pongamia, etc. So far the current national policy of the Malaysian agriculture sector is silent on research as how agriculture can be of value in meeting the nation's energy sources, policies are still preoccupied with the need to produce food for food security and has devoted less attention for other needs of agriculture for feed, fuel, fibre, pharmaceuticals and felicity. perhaps this may be due to the fact that Malaysia is rich with energy sources from natural gas, coal, petroleum and hydro power.

ii) Carbon and Water footprints of the major crops and their downstream by-products

It is fast becoming a trend in the supermarket of the developed countries that food miles or carbon footprints are part of the product labelling desired by the consumers in the developed countries, In addition to that, there is also developing efforts to establish the initiative to consciousness and educating the public on the waster footprint for food and industrial products. By doing so, the public will be made aware that fresh water is fast becoming a rare commodity and the public should be wise to make decisions to conserve the use of freshwater. It is expected that both the carbon and water footprints will provide the comparative base data for the discerning public to make discriminating or purchasing decisions; choices to do away with wasteful products, or giving preference to similar products that use less water or expending less carbon by choice. Creative derivatives like carbon offset program, tax rebates, green Dollar, credits, are few of the implementable measures to impose the kind of tax credits or offsets to the wasteful products.

It is necessary to undertake research that track and trace the origins of processed products that are from oil palm, rubber, cocoa and many other Malaysian produce that penetrates the international market supply chains and networks. Before measure are introduced to require the labelling of carbon and water footprint of products oil palm has more than 100 by-products and it is therefore necessary for Malaysian product brands to be labeled with carbon and water footprints.

iii) Oil Palm as Biofuel for the Airline Industry

Currently, there is an emerging initiative from the finance subsector on financing and investment program led by the aviation industry to reduce the reliance on fossil fuel into the renewable biofuel for the airline industry. If the aviation industry has tried conducting comparative research in the effective use of oil palm, camelina, jatropha, pongamia and other biofuel resource for the airline industry, it is imperative for the oil palm industry players to conduct similar research or ways to improve the behavior of oil palm as biofuel for jet and airplanes too. This initiative towards diversifying the global energy sources from renewable energy sources from biofuels has caught the imagination of the airline industry where major, long-distance flying, airlines like SIA, British Airways, Virgin Airlines, Lufthansa, Dutch KLM, Qantas, except MAS, are taking part in the consortium to make this technical shift to biofuel. In the effort to reduce the carbon footprint and develop a creative *Carbon Offset Program*, the airline industry is very committed in going green that they are accommodating and providing incentive via the *Carbon Credit Program* and *Carbon Redemption* privileges for European airlines passengers by 2012. Incoming international airlines, who are not signatories to the accord, will be imposed with *Carbon Tax*, if the airline do not commit to the *aviation biofuel* use. Malaysia should explore possibility of utilising palm as biofuel for airplanes rather than be focused strictly for food, Virgin Airlines have pioneered in the use of palm oil for aviation biofuel.

iv) Sustainability In Production Operations

The agriculture sector must step in early to partake in diversifying the global source of energy and efforts must be endeavoured to ensure that the agriculture scientific community must embark in research on sustainable agriculture where the energy source for the farming unit generate its own energy and reduce the food miles or carbon footprints. There ought to be a comprehensive accounts and audits on the farm production cycles on energy, water, nitrogen, phosphorus, carbon and mineral sources (formulated in fertilizer inputs and wastes, etc.) to ensure the inclusiveness and sustainability of the farm production unit. At the moment that 'sustainable and inclusive mindset' amongst the oil palm industry is slowly gaining acceptance. The agriculture production centers like oil palm plantation or oil palm mill factories is slowly capturing and embracing the concept of 'inclusiveness' and 'sustainability'. That emerging consciousness should prevail in the rubber and cacao production farming community to equally regulate the rubber and cocoa industry, if it is to be accepted as global industry standards. Hence, the series on the development of the RSOP should be based on the theoretical framework of the real meaning of sustainability. It is to be aggressively researched and pursued with vigor and subscribed by plantation owners to own up to its intention to become green-friendly and sustainable. The ST&I initiatives must be researched under our own setting, conditions and priorities of ASEAN Economic Community. Lead countries in oil palm producing countries, like Malaysia and Indonesia, should jointly developed the standards in the series of the RSOP discussions based on sound, scientifically-derived and researched standards for oil palm sustainability that considers the economic, social as well as the environmental concerns. A sustainable and inclusive oil palm factory/production mill should be built on both the economic and environmental standards for sustainability..

8.4 New Fishery and Aquaculture

The extensive marine area in the country offers great potential for food production especially when fish protein is a preferred source of protein for health and arable land is limited. New fishery has to be developed and it will require the industry stakeholders to take responsibility for the health of the resources and the sustainability of the resources through greater knowledge of the resources and knowledge management at all levels. The combinations of vision and outcome will bring a new role for scientific advice in the fisheries. General reform is required in terms of the vision for fisheries. The question will be what fisheries management should deliver. The general consensus among stakeholders managers is that fisheries management should deliver the following:

- Healthy marine ecosystems
- A profitable and economically independent sector (i.e. free from subsidies and over regulation)
- The ability to supply seafood to consumers originating from sustainable fisheries and aquaculture
- Contribute to development of coastal regions
- Simple and cost-effective policy with implementation close to the people

i) Marine Capture Fisheries

There is an urgent need to reduce overfishing in the marine capture fisheries. This will require managing fisheries to rebuilt stocks. This can only be done with better regulation and management of the fisheries. Better regulation can be achieved through increased participation by stakeholders in fisheries management. This will require greater devolution of the whole fisheries sector management to fishermen through fisherman's cooperatives and fishing communities. Restructuring the fishing industry will be required with the removal of inefficient fishers from the industry. The overcapacity in the fisheries sector will have to be reduced through a process of restructuring the industry.

ii) Aquaculture Fisheries

Malaysia sees aquaculture as the best means of replacing the drop in fish supply resulting from the depletion of marine fish stocks. However what is the appropriate development approach for aquaculture is still not well resolved. How to organize a smallholder type aquaculture together with an industrial based aquaculture has been the challenge? The government plays a very proactive role in developing aquaculture but success both at the smallholder and industrial level has been limited. Smallholder aquaculture has to be organized better to feed into the industrial aquaculture so that synergy can be obtained from aquaculture as a whole. Organizing smallholder aquaculture farms under the umbrella of larger industrial aquaculture enterprises will provide better results in terms of the marketing, distribution and value chain enhancement for aquaculture products. The aquaculture industry will have to concentrate on quality and use certification and labeling approaches to improve its marketability in the regional and the world market. Over the next forty years focus on a few species for aquaculture will be the way forward. For Malaysia, tilapia is the obvious choice followed by sea bass, grouper and the vanamei shrimp.

Innovation in growing fish and in processing, distribution and marketing—such as the progression of farmed tilapia products from whole fish to packaged value-added products will become more important in the next phase of aquaculture development.

iii) Inland Fisheries

Inland fisheries are generally in bad shape. The rivers and inland waters are increasingly polluted or are facing pollution threats thus threatening inland and riverine fisheries. The enhancement of fish production from inland fisheries however should be a priority activity to ensure the availability of fish in the rural areas and also to ensure that the environmental quality do not decline further. Effective management measures to control pollution, regulate fishing, and control the use of illegal fishing nets, explosives and poisonous substances to catch fish has to be put in place. Recreational fishing is also a important part of inland fisheries. Recreational fishing with proper industrial clustering could become a major contributor to the total value added of the fisheries sector. Clear identification of areas for recreational fishing will be required to manage inland fisheries better and minimize conflicts with commercial fishing.

iv) Aquarium Fish

Malaysia stands to gain from putting in place a better regulatory framework for the aquarium fish industry which has shown a dramatic growth rate of 15 percent or more over the last decade. Today, there are more than 400 farms, 90% of these produce ornamental fishes, and about 10% produce natural feed and aquatic plants. The potential for further expansion of the industry in Malaysia is enormous

The development of a certification scheme either in conjunction with the Marine Stewardship Council or independently will greatly enhance this rapidly growing industry.

v) Fish Processing and Handling

Fish processing and handling will require gearing up in the future. Post harvest losses of up to 20 % of retail value are estimated for fish in Malaysia. Research in this area and reduction of the losses can add millions of ringgit to the fisheries sector value. There is also general under utilization of ice for fisheries in Malaysia due to the high discrepancy on a regional basis between the volumes of ice produced and fish landings. The recommended ice/fish ratio of 1:1 in not practiced in most landing complexes. The drive for quality in fish products in Malaysia will be the focus over the next few decades as the trend towards globalization of the market for foods continues. Science and technology will play a crucial role in developing certain standards for fish products.

The changes and the modernization taking place in the fishery sector requires for greater harmonization of the research between the private sector and the public sector. A holistic approach is required to realize the benefits of research undertaken. Direct participation and involvement of the various stakeholders in the fisheries sector especially the private sector is required to get more direct attention to the key problems faced by the stakeholders of the sector. Research programming for the sector should be carried out on a biannual meeting between the public research agencies and the various industry stakeholders to target relevant research needs to resolve problems faced by the industry.

8.5 Human Capital in Agriculture

i) Human Development

If the developed countries are to be the model of the human resource development in Malaysia, as envisioned in Vision 2020, we can expect about 1-3 per cent of the population to be involved in production agriculture (in the farms tending crops and livestock), whilst between 27 – 40 per cent are involved in the downstream, agric-related industries and services. That literally means, if there are 100 people, there would be 1-3 people tending the crops and livestock in the farms, and about 27-40 people in the processing and manufacturing industries related to agriculture and services sectors. It is therefore important that we have to make projections on the expected human resource population in agriculture production and the downstream activities when Malaysia becomes a developed country by 2020, a generation from now (2035), and what to expect when fully developed and mature Malaysia, by 2050. If that economic growth rate and population growth model sustains, Malaysia will probably have about slightly more than one million farmers tending the crops and livestock, and between 7–

13 million people will be involved in the process chain of processing, manufacturing and services related to agriculture.

Besides emphasising higher education a vocational training system must be developed and geared towards addressing this megatrend of human capital needs along the supply-chain of the industrial, manufacturing and services sectors. From another perspective, it looks like the current 1.3 million people in the production agriculture needs to be replaced with knowledgeable agriculture workers or other means like mechanical robots or farm mechanization to enable to stay at that number (1.3 million workers) for another decade which require a drastic transformation. As cities becoming more populated and urban agriculture begins to develop or catch on, city folks need to be encouraged in gardening or agriculture. Farming or gardening should become critical living skills. Schools and universities should offer the training in new approach to agriculture.

ii) Immigrant labour

The issue of immigrant labour or workers is very contentious in agriculture and it is not an easy problem to overcome. Nevertheless, foreign labour is considered as a potential Achilles heel of the oil palm industry. More than 80 per cent of the oil palm bunch harvesters are foreign workers and should diversify the source and more impotently and must create competition to address the labour shortage in the oil palm industry. There has been periodic reports of unharvested and rotting fruit bunches on account of foreign labour shortage coinciding with stricter foreign labour recruitment and placement. This needs to be addressed urgently through the development and aplication of field robotics.

8.6 Convivialism in Agriculture towards ASEAN 2015

ASEAN, with current population of 583 million, is moving steadily towards regional economic integration by 2015. This strategic move towards into being an economic and trading block is in many important ways similar to the building up of the EU and North America trade blocks. ASEAN countries recognizanced that food security is a pressing issue as ASEAN's population is expected to reach 1.7 billion people by 2050. The pressure to feed ASEAN's population is increasingly daunting and hence positive steps have to be taken to address the food needs of the future generations. It is, therefore, strategic to leverage on Malaysia's potential contribution to ASEAN food security and safety, Relatedly, if the concept of ASEAN convivialism in agriculture is adopted then there would be greater ASEAN intra-trade for agricultural products and this approach is in consonance with the global initiatives to minimize carbon footprints and food miles. For instance, it is preferable for ASEAN countries to trade in palm oil and other vegetable oils produced in ASEAN countries, rather than importing rapeseed or soybean oil from the EU or American countries, which have higher carbon footprints. A close scrutiny on the list of agricultural food items bring imported and exported in all ASEAN countries indicates that there are cases where food imports from outside ASEAN countries can be substituted by intra-trade within ASEAN. There are opportunities to encourage the intra-trade mantra of *"buy local, buy ASEAN"*.

8.7 Water use Technology

Water use for agriculture would face a plethora of problems with the onset of Climate Change in coming decades. Relatedly, there is a need to make people aware that water footprints of agriculture products has become part of the product labelling – for water conservation. Agriculture, especially rice-growing, has been identified as the major inefficient user of water and it is expected that how water is utilized, recycled, purified and made available elsewhere will receive urgent attention. Climate Change will bring about unpredictable availability of water through droughts and floods and hence affect the timeliness of water availability for the growing of crops. Water technologies, where appropriate, must be developed for agriculture and other uses which includes: purification and filtration for drinkable water; bioremediation to clean-up water and streams; recycling and reutilization of household and rain water; and to reduce energy utilisation in the above processes.

8.8 ICT as Enabler for Productivity in Agriculture

i) Advances in ICT Applications

ICT is also identified as another enabler for productivity in agriculture. Commodity crops like oil palm, rubber, cacao and pepper. should be the beneficiaries of ICT and ST&I to become more competitive through productivity enabled by ICT.

After more than a decade of ICT advances, by now we are seeing many wide applications of ICT in other fields that can be utilized for agriculture. Some of the notable technologies that have gained inroads for agriculture includes remote-sensing and geospatial analysis for land use and fertilizer applications; real-time evaluation of crop yields forecast and logistics modelling; pest outbreak monitoring and modelling; real-time distribution of bee plants flowering assessment; distribution of bee trees; video and web-enabled monitoring and surveillance of greenhouses; and field robots for harvesting.

We can expect that our competitiveness in oil palm, rubber, cocoa and other commodities that we are in the top 20 in the world should leverage on ICT to improve its productivity and competitiveness. The Academy of Sciences Malaysia and MDC should rally initiatives and initiate interactive research matching for ST&I collaboration between the agriculture institutions (MRB, MCB, UPM, RISDA, DOA, MARDI, etc) with the ICT fraternity (MIMOS, MDC, etc.). Greater collaboration between the content and technology researchers and developers should focus on ST&I research efforts in ICT applications for the benefit of the major crops like oil palm, rubber, cacao and pepper. Several institutions like MPOB, UPM, MARDI, MRB and MCB should join human resource capital between the ICT and researchers in agriculture. That opportunity for greater collaboration can be easily initiated at UPM where faculty staffs in the Faculty of Agriculture, Forestry and Food Science can be encourage to collaborate with those academic staffs of the Faculty of Computer Science and Engineering.

Some of the identified problem areas for research are the collaboration between content people (agriculture) and developers (ICT people) working on perennial problems of oil palm bunch harvesting, monitoring and surveillance of pest and disease outbreaks (e.g. Ganoderma), bagworm outbreaks and tapping problems (labour) in rubber (figure 8.7).

Figure 8.7: Robotic farming

ii) Knowledge-based Agriculture and the AGROPOLIS showcase

K-Agriculture or Knowledge-based Agriculture is identified as the necessary concept transformation for Malaysian agriculture to migrate from the Industrial Era into the Innovation Era. In the globalised world, information or packaged information (knowledge) becomes commodity and also become the key source for technological innovations from the accumulated and processed knowledge to become the key innovation source and technological innovations.

iii) Develop and Recommend Food Traceability System to Track and Trace Carbon Footprints of Agricultural by-products

The many unfolding consequences of Climate Change to agriculture bring to the fore the realization that the world is finite and many of our wayward ways and life styles are unsustainable and therefore care and concern must be continually exercised to make this finite earth to be habitable and live sustainably. Agriculture activities and life styles have to be considered and fashioned from the standpoint of its sustainability (Figure 8.8). We need to trace the history of our food to ensure that it is sustainable and safe. Not only should it be tracked and traced but also authenticated. A traceability system should be developed for all agriculture-products to enable the tracking and tracing of the origin and monitoring the fate of the resources (minerals, genes, etc.) and authenticated, must be instituted for the benefit of consumers to make choices.

For the sake of concerns in sustainable development, a traceability system is fast becoming a desired feature of agricultural products to consumers worldwide, which reveals the pathway treks of the products which empower the consumers the choice of making informed-decisions to buy or prefer some other products by virtue of its production processes that are in compliance to health, safety and environmental standards. All agricultural products must be tracked and traced of its origin (bar-coded and labeled) and therefore its footprints on carbon emissions and water use, which are constrained resources, must be on board of the traceability system. Resources of agriculture production system must have records of its origin so that any records of contamination (especially food), tracing the genetic origin through its labeling, packaging, identification and authentication system. Any contaminations of disease outbreaks and safety breaches will be tracked and traced along the process of the supply-chain networks.

The outcome from such awareness on food safety protocols and trace of origins to detect contamination will lead to educating the public about the carbon footprints of most products. Hence, measures and solutions are recommended to minimize its carbon or water footprints. As a result, there is now an emerging consciousness of convivial consumerism (convivialism) to be mindful of our carbon footprints by Buy Local and Eat Local and Reduce-Your-Food-Miles campaign. Consumers in developed countries are being made to be aware about the need to minimize the carbon footprints, or reduce their food miles; invariably it heightens the conscience of being frugal and not wasteful in using the finite world’s constrained resources. Wherever they are, people are encouraged to buy local and eat local agricultural produce, despite their production cost is more expensive that the imported ones. The evolution of the inclusive EU in terms of its agriculture production has encouraged the EU countries to grow and produce their own food. The EU agriculture policy delineates and captures this policy concept of EU convivialism.

9 MILESTONES

9.1 Research Milestones

Table 9.1: Milestones for research opportunities in short term (2020), mid term (2035) and long term (2050)

Research opportunities	By around 2020	By around 2035	By around 2050
A. Biogeographical transplant of introduced allopatric, rainforest's flora-fauna species for agriculture	✓ Identify and discover several crop or livestock species for malaysian agriculture ✓ Prospecting: introduce 1 or 2 potential flora and fauna species from trans-global sources from the rainforest of the south american and african continents to enrich the existing crop ecosystem	Establish 1 or 2 commercially introduced or indigenous crops/livestock's into the existing malaysian crop ecosystems of oil palm, rubber, cacao, orchards (banana/durian/starfruit/pineapple, etc.) In order to enhance the biodiversity of the cropped aras.	Develop a combined and integrated a super crop ecosystem under oil palm, rubber, cacao, orchard, etc. For the commercial purpose of agriculture production for either food, feed, fuel or pharmaceuticals
B. Plant gene technology: the promise of biotechnology and genomics	✓ Sequenced and mapped dna genomes of existing key crops (oil palm, rubber, cacao, orchard plants, herbs) in malaysia ✓ Gene isolation (molecular markers) for transgenic transfer or gene insertion ✓ Fortifying the oil palm, rubber and cacao genes via molecular breeding – designer crops of oil palm/rubber/cacao /fruits ✓ Develop the quick identification of the rainforest species using the dna bar-coding technology	✓ Successful integration of 1or2 desired gene traits into the key malaysian crops ✓ Complete the inventory of species (dna bar-coding technology) in the agro ecosystem of the key malaysian crops	✓ Genetically, redesigned dna genome for super crops (oil palm/cacao/rubber) with selected combined transgenic traits
C.sustainable, vertical and urban agriculture	✓ Vertical and urban farms farms – build vertical farms in congested city ✓ Sustainable living ecosystem: urban-dwelling/housing development model for controlled-environment and advanced life support agriculture (salsa) ✓ Rainforest sub-ecosystem studies for rural-urban economic development model: ✓ Carbon tax and offset programs ✓ Green roofs and building green	✓ Successful transgenic insertion of 1or2 desired gene traits ✓ Establish an integrated and sustainable coconut-cacao agro-forest production ecosystem (plantation):	✓ Develop a combined and integrated super crop ecosystem under the key malaysian crops

Research opportunities	By around 2020	By around 2035	By around 2050
	codes ✓ Plant walls ✓ Develop 2or3 controlled-environment vegetable,fruit, herb production systems ✓ Develop an integrated, sustainable cacao-coconut-orchard-herbs agroforest production ecosystem: ✓ Enhance the diversity and the sustainability of the poultry production into a close-loop, integrated ecosystem		
D. Energy crops and green technologies	✓ Fortify the oil palm dna genome with genes from other vegetable oil producing crops. ✓ Designer oil palm varieties (multi-purpose) for food, feed, fuel, furniture and pharmaceuticals, etc ✓ Reduce food miles – carbon and water footrpints. ✓ Asean energy or biofuel policy ✓ Sequence, map and fortify the dna genomes of cacao, coconut & indigenous fruits ✓ Develop st&i on green technologies ✓ Bioremediation technology. ✓ Transgenic nitrogen-fixing legumes to generate organically/indigenously produced fertilizer from transgenic cover crops.	✓ Develop an eco-based, close-loop, crop production models that are sustainable, all-inclusive agroecosystem for oil palm/rubber/cacao/orchard (durian)/ pepper for the plantation industry. ✓ Develop 4 or 5 transgenic legumes (cover crops) to establish a green-friendly, fertilizer production agroecosystem for oil palm and rubber plantations – sub-ecosystem for a cycle-loop production ecosystem ✓ Develop an island into a biosphere or noah's ark like agroecosystem for development on the available 20 000 islands in the ASEAN initiative region.	Establishment of a total close-loop oil palm/rubber/cacao/coconut production ecosystem (including transgenic traits) for sustainable agricullture
H. Ict as enabler for productivity in agriculture	Develop demonstrator, ict-enabled, flagship applications on key agriculture commodity crops (oil palm, rubber, cacao, rice, pepper, coconut): Build serdang agropolis	Develop more demonstrator, ict-enabled, flagship applications on key agriculture commodity crops (oil palm, rubber, cacao, rice, pepper, coconut, etc.): Serdang agrpolis as the ASEAN agriculture hub	World and ASEAN centre for excellence in oil palm and rubber: the total knowledge and economy related to oil palm and rubber is hubbed in malaysia.
G. Water technology	Conduct water footprint for key economical crops with by-products that utilize the most water.. Improve the efficiency of irrigation and drainage infrastructure that caters to timeliness in supply and optimal or efficient water use for the major paddy-growing areas. Develop water-efficient variety of rice in the like of the hill paddy	Rebuild, redeveloped 2or3 improved, efficient and multi-purpose dam for farming, drinking, power generation and environmental conservation.	A sustainable and inclusive closed cycle-loop, crop production agro-ecosystem (oil palm/rubber /cacao/ orchard/ etc.) That includes the conservation of water, energy and environment.

Research opportunities	By around 2020	By around 2035	By around 2050
	which uses minimal amount of water through molecular breeding of drought resistance rice with better developed root system. Develop a mechanism or device for cool upland, cole crop farming that harvest clean water from mist or clouds (like that of the cloud seeder plant which collects dripping water from its out-propping, teflon-like branchlets on the trees in the rainforest). Develop or adopt water technology that collects rainwater and recycled used water in the farm and purify it via bioremediation. (to be reutilized for farming activities, to reduce potash and phosphate pollution into the streams and rivers, especially from oil palm mills)		
F. Convivialism in agriculture towards ASEAN 2015	Enhanced ASEAN intra-trade (conviviialism) arrangment for food and energy as a mechanism to reduce food miles or carbon footprint Quality critical-mass in human capital for st&i in oil palm in ASEAN . St&i initiatives for halal technology and standards.		
E. Human capital in agriculture	Offer scholarships in critical disciplines or competencies in agriculture in order to sustain the quality of st&i knowledge workers in agriculture (e.g. Taxonomy, botany and soil science,) Agriculture to become a component of the plkn(training center of national service) training (national conscription programme) curriculum training to all youths in the country Agriculture to be the mainstay of upm and graduates of upm must be trained to be competent in gardening as competency in living	Agropolis showcase for k – agriculture establishes in serdang and other ASEAN cities.	A fully enlightened sustainable development society feeding off knowledge hubs in ASEAN countries .

Research opportunities	By around 2020	By around 2035	By around 2050
	skills Ensure the board of agric-related agencies incluse knowledgeable, experienced and technically competent k-agriculture people to provide s&t leadership and direction Combined ASEAN excellence in oil palm and rubber		

9.2 Milestones from Crop, Livestock and Fishery Perspectives

Table 9.2: Milestone from crop, livestock and fishery perspectives

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
Oil palm	✓ **Issue#1 – major disease affliction of** oil palm plantations where there can be as much as 3% of trees are decimated by **ganoderma disease** estimated to cause 10-20% reduction of production yield per hectare. ✓ **Challenge** – to develop oil palm variety with transgenic resistance to ganoderma disease.	✓ **Genomics and gene technology**: develop transgenic variety of oil palm for resistance to ganoderma disease via ***molecular breeding***. Splice the resistance gene to ganoderma from other species and insert into the oil palm dna genome. Share the genome library of the sequenced and mapped dna of oil palm by sime darby	✓ Develop a designer oil palm variety for **transgenic resistance to ganoderma** disease. Search and develop oil palm seed with **signature chemical marker (trademark)** for **barcode dna profiling and genome inventory/ library develop chemical marker for terminator genes** to be considered for strategic commercial identification and certification. ✓ **Transgenic oil palm variety:** spliced with desirable gene traits from other vegetable oil producing crops (competitors of oil	✓ **Export and certified for global commercial oil palm seed bank supplier** with transgenic resistance to ganoderma	✓ **Designer oil palm with transgenic resistance** to several debilitating diseases and pest of oil palm

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
			palm), such as, canola, sunflower, soy, coconut, groundnut, etc.		
Oil palm (contd)	✓ **Issue#2** – currently, oil palm production is confined or tailored to **vegetable oil for food production**. ✓ **Challenge** – to develop designer oil palm variety for specific and diverse production needs (vegetable oil, timber, pharmaceuticals, industrial needs, etc.). By repurposing the oil palm genome for diversity or multi-purpose use like : dwarf variety with large fruit bunches, tall variety for timber or bio-composite production, biofuels, as bioreactors for transgenic therapeutic traits from the tropical herbs, etc.)	✓ **Genomics and gene technology:** via ***molecular breeding*** sequence and map the dna genome of oil palm and identify **chemical markers** associated with the desired gene traits (e.g. Dwarf variety with large fruit bunch, tall variety for timber or biocomposite production, or pharmaceutically important traits inserted with therapeutic/medicial traits into the oil palm fruits). ✓ Use **barcode dna technology** to identify functional variety and tag them for bar-code dna technology labelling via prospecting for native oil palm species in the african continent (cameroon) and enrich the oil palm gene bank. Barcode-dna tag them and develop a repository library for quick-diagnostic labelling.	✓ Search for molecular/chemical markers for commercial seed production test – **oil palm gene for designer diagnostic kit**. Desired gene traits for dwarf with large fruit bunch, tall variety for timber production.	✓ Commercial , multi-purpose, **designer oil palm variety**	✓ Develop oil palm as **super crop**
Oil palm (contd.)	✓ **Issue#3**- inorganic, chemical fertilizers are mostly imported, petroleum-based fertilizers and the oil palm plantation of overreliance to inorganic chemical fertilizers accounts to almost 40% of the oil palm production cost. Petroleum price is	✓ **Root architecture** - research to improve the efficiency of the fertilizer root uptake or root architecture and system/alternatives for improved fertilizer uptake, or devising other means of efficient delivery of the fertilizer into the oil palm root uptake	✓ **Improved and avanced root system** for oil palm. Improved root anchoring in peat soil condition and efficient fertilizer uptake for oil palm	✓ Commercial, transgenic oil palm with traits of **disease resistance, weed tolerant, salt-tolerant, and root system** for improved **nutrient uptake and sturdy root system**	✓ **Customised or designer oil palm variety (vegetable oil super crop)**: for order with specified request for desirable gene traits to fortify the oil palm genome with array of choices for either , therapeutic, disease resistance, salt tolerance, temperature tolerance

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	increasing and it is a non-renewable resource input and the current technology of application is causing environmental degradation that requires for bioremediation of the "chemical waste". ✓ **Challenge** – to ***wean off or reduce*** our over-reliance on chemical, petroleum-based fertilizers and adopt towards **organic fertiliser** programme.	**Transgenic cover crops:** research to develop transgenic nitrogen-fixing cover crops spliced with desirable traits of the mycorhizae or microbes through molecular breeding and improve nutrient uptake by inserting desirable genes from microbes into root nodolation. ✓ **Organic fertilizers productiologyclin g technon via recy** – further develop the composting technology to reutilize the 'waste' from efb and pome to convert the efb into bio-fertiliser via the newly developed, **controlled-environment composting technology** (cect) of using microbial inoculants under anaerobic and aerobic conditions. Embed the rfid tagging for tracing of origin in the development of **traceability system for organic efb compost fertiliser**	✓ **Organic fertilizers from cover crops:** develop the transgenic roots of 4 species of plantation cover crops (*pueraria javanica, calopogonium mucunoides,centr osema pubescens , mucuna bracteata*) for both oil palm and rubber to improve uptake of nitrogen, phosphorus and potassium fertilizer	**technology** ✓ **Commercial cover cropsand cropping system:** to improve and diversify sources of organic fertilizer for oil palm plantations	✓ **Commercial cover crops and legumes for enhanced nitrogen**-fixing capability

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
			✓ **Transgenic nitrogen-fixing fern roots**: develop ferns that grow on the oil palm tree trunks with roots with transgenic, nitrogen-fixing traits or associated with microbes, or mycorrhizae in the roots for efficient nitrogen-fixing ✓ **Commercial production of innocultant for controlled environemnt composting:** for efb and other by-products from agricultural biomass for **organic fertilizer production**	✓ Improved dual-capability for either **anaerobic and aerobic conditions via controlled - environment composting (cec),** replete with **traceability system** to link for data-mining and tracking and tracing system for **auditing** on **carbon footprint**	

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
Oil palm (contd.)	✓ **Issue#4** – our dependence on foreign labour and skill for intensive harvesting work routines for oil palm makes it to be the achilles heel of oil palm production in malaysia. ✓ **Challenges** – to reduce and simplify the back-breaking menial task so that ordinary people (not the muscular) can perform the harvesting and loading of fruit bunches	✓ **Robotic farmer: harvesting wearable/ mountable robot** – to overcome the back-breaking weight of carrying fruit bunch weighing between 15 – 40 kg by manual labour in harvesting and carrying oil palm fruit bunches onto the transportation vehicle (lorry, etc.) By using wearable robot (ironman). ✓ **Color sensor-assisted and motion-capture technology robotics** – develop a robot equipped with color sensor to detect and harvest ripe fruit bunch, and also using motion-capture activated robots to pick and harvest the fruit bunch from the oil palm tree.	✓ Develop a wearable robot suit (**robot suite**) that can be worn by ordinary person for harvesting oil palm bunches in the plantation ✓ Develop a mounted **bidpedal robot** to harvest oil palm from tall trees and rough and sloping, hilly terrains.	✓ **Intelligent robot for oil palm harvesting and transportation** for precision farming	
Oil palm (contd)	**Issue** – loss of biodiversity through deforestation and monocropping system in oil palm plantation; agro-ecosystem is weak and vulnerable to disease and pest attack. **Challenge** – to enrich the biodiversity in the agro-ecosystem of the monocropped oilpalm plantation	✓ **Enhance the species biodiversity in the oil palm agro-ecosystem.** By constructing a functional and enriched ecosystem by including a variety of the keystone species into a biodiversed ecosystem in the oil palm plantations. Increase the biodiversity by introducing livestock (cattle/goat/wild fowl/beekeeping/ porcupine to turn the weeds (asystasia/cover crops/etc.), termites, loose oil	✓ **Oil palm – livestock** for **biodiversity enrichment**: several solutions and options on biodiversity enrichment for the oil palm plantation agro-ecosystem via livestock rearing (cattle, goats, wild fowl, bees) and biological control agents (owl - rats control, hedgehog – termite control).		

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
		palm fruits as food sources for the livestock. Biodiversity enrichment or biological control via owl-rats, orchid growing, etc.			
Oil palm (contd)	**Issue** – *implications of carbon footprints/food miles product/carbon tax post kyoto protocol in 2012.* Entrenchment of palm oil merely for **food** but must diversify for **fuel**. **Challenge** – to develop the use of palm oil for fuel blending in ***aviation biofuel and other transportation***.	✓ **Aviation biofuel from palm oil**: test and develop ***oil palm, blending formula for aviation biofuels*** for malaysian airlines and air asia. Virgin airlines have tested and compared the relative efficacy of biofuel, including palm oil, for jet engines. By 2012 eu stipulates that all commercial airlines entering the skies of eu will be levied wtih carbon tax, unless they meet the stipulation of using at least 2% blending of ***aviation biofuel***, adopted by the aircraft carriers (british airways, virgin airlines, klm, lufthansa, singapore airlines, etc are signatories to the commitment). ✓ **Palm oil biodiesel for fruit bunch transportation in oil palm plantations**: use of palm oil biodiesel as fuel for all lorries transporting fruit bunches in the oil palm plantations. Device to modify the lorry for using palm oil	✓ Develop ***several biodiesel blending formula*** of palm oil - petroleum recommended for use as ***aviation biofuel 2%, 5% and 10% biofuel blending*** adopted by malaysia's branded carrier viz. ***Malaysia airlines*** and ***air asia***. Break the long-chain carbon to overcome the coagulant-under-freezing temperatures in palm oil unsuitable for aviation biofuels. ✓ All lorries transporting oil palm fruit bunches in estate plantations are equipped with ***engine modification for the use of oil palm biodiesel for fuel*** which saves carbon footprints and		

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
		fuel in estates.	reduce carbon emissions (if using petroleum/diesel from fossil fuel)		
Rice	✓ **Issues** – use lots of water for flooding (weed control), low-yielding, and it is a contentious food security issue that depends too much on agricultural subsidy. ✓ **Challenge** – to reduce dependence of subsidy, high-yielding variety, and uses less water because of water scarcity issue of tomorrow.	✓ In collaboration with irri and china genome institute to breed drought-tolerant, hill paddy variety that has heavy rootlet system and for efficient water and nutrient uptake and broadcast seeds to save manual labour. ✓ Plant designer rice variety with fortified genes to produce enzymes for vitamin production and customized nutrition needs (personal genomics).. Source such variety from china ✓ Collaborate with ASEAN countries to barter trade with oil palm to ensure food security and self-sufficiency in rice	✓ **Asean intra-trade for food security** in selected item for barter trade (oil palm for rice, sugar cane, beef, mutton, dairy products , etc.) ✓ **Asean economic integration** galvanize on regional food and energy-sharing and security arrangment .	**Trans-global tropical agriculture germplasm exchange for agriculture**	
Rubber	✓ **Issues**– to add more upstream, product diversification of rubber through the opportunities in developing ***bioterials via advances in genomics***	✓ **Barcode dna inventory:** sequence and mapped the dna genome of rubber and develop a *dna barcode inventory* of the thousands of commercial	✓ Develop chemical-marker signatures of rubber clones to ***dna barcode tag them to identify and categorise***	✓ Commercialise several ***designer clones as bioreactors*** for the production of ***bioterials***	✓ Rubber as **non-food industrial super crop**

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	✓ To **reduce the dependence on inorganic, chemical fertilizers** by going organic. ✓ **Challenge –** to sequence and map the ***dna genome of rubber*** and develop new by-products through ***transgenic crop production*** or ***molecular breeding.*** ✓ To develop other **sources of organic mean**s and reduce over-reliance to inorganic, chemical fertilisers	rubber (rrim series) clones that have been developed for almost hundred years and further classifiy them for the production of designer rubber clones for multipurpose needs. ✓ **Molecular breeding - transgenic biosteel silk from protein of rubber latex**: the biosteel silk is a strong-bonding protein spider silk that has been inserted into the milk protein of lactating goats – spidergoats. There is a chance that the protein in the rubber be utilized for biosteel conversion from the protein in the rubber latex. ✓ Develop ***transgenic cover crops and legumes*** (several species) with improved roots capacity for nitrogen-fixing capability with transgenic microbes, myrcohirzae, etc.	***designer rubber clones for commercial tagging*** (timber, latex, disease resistance, tolerant to strong winds, seed production, etrc.) ✓ **Biosteel from rubber**: a prototype of rubber clone that produces biosteel from the protein of rubber latex	✓ **Commercial biosteel, rubber clone**: commercial rubber clone and purification process for commercial production of biosteel from rubber trees	
Rubber (contd)	✓ **Issue** – clearing of virgin jungle for arable land is politically untenable	✓ **Livestock rearing, and intercropping of young rubber land** – enhance	✓ Recommendations for an **integrated**, **biodiversed, cropping**	Several **recommended sets for integrated designer**	A sustainable, biodiversed **rubber agro-ecosystem**

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	anymore. Optimise existing arable land for rubber. To optimize rubber hectareage for higher productivity and address the need to improve productivity without the need to clear the jungles for more hectareage of arable land for rubber. ✓ **Challenge –** to enhance the biodiversity and improve the value-chain of rubber hectareage	the biodiversity of the rubber agro-ecosystem and increase the productivity of the rubber hectareage by rearing livestock (goats, cattle, migratory beekeeping , etc.)	**system for rubber plantation** consisting of several indigenous species that enrich the rubber agro-ecosystem	**rubber clones** of various commercial purposes	
Vegetables and food tubers	✓ Issue – vegetables are easily perished and greatly needed for food by city folks in congested cities. Yet arable land in urban areas are diminishing and give way to other commercial or real estate needs in the cities. ✓ Growing and transporting vegetables in far out, rural places away from the cities endears energy for transportation and it creates large ***carbon footprints***. ✓ The malaysian **food basket** does not reflect or correspond to	✓ **Vertical and urban farming :** congested and populated cities like kuala lumpur, johor baru and penang should resort to ***urban and vertical farming*** where there would be reduced ***carbon footprints*** and ***controlled environment agriculture*** (temperature, humidity, light duration, pest and disease control, etc.) To ensure predictability of food production for city folks. Grow vegetable crops and livestock in abundance for	✓ **Food production hub** for cities like kuala lumpur, johor baru, penang, seremban, etc.	✓ ***Asean as world's food hub*** with advantage of good weather and propitious conditions for food production – (thailand as "kitchen of the world" and indonesia aspires to become the world's food hub – historical streak as 'old spice route'	Indo-malaya as **world's germplasm centre for agriculture** (especially for food and herbal crops and vegetables)

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	the recommended **food pyramid** for healthy life styles, thus producing many obese people in the society. ✓ **Challenge** – to grow food in cities (urban farming) and in multiple-storey buildings in order to reduce carbon footprints and optimize arable land from 2d space into 3d space farming	reduced price that correspond to the food pyramid requirements. Consider production radius to minimize carbon footprints (within 20 kilometers with population around 70 000 people) ✓ **Asean food intra-trade**: develop a regional ***ASEAN convivialism in food security and safety*** for exchange trade for agricultural products. Apart from reducing carbon footprints of agricultural products via ASEAN intra trade the initiative also promote regional economic integration. ✓ **Genomics and transgenic tubers:** important staple food and tubers like rice, cassava (tapioca), sweet potato, yams, etc. Need to be spliced with therapeutic genes and fortified with enzymes for improved nutrients, minerals, and vitamins into some of the food tubers.	✓ Regional ***multi-lateral agreements on food security and safety*** for ASEAN countries ✓ Indigenous transgenic **fortified tubers** with enrich food value nutrients.	✓ **Asean's buffer food stock** to ensure regional food security and safety	
Cacao					

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	✓ **Issue**- cacao hectareage is dwindling (from > 100 k hectares to > 20 k hectares) and it is being replaced by oil palm. The current technology of production is labour intensive and fraught with debilitating viral and fungal diseases ✓ **Challenge** – the malaise of the cacao industry and dwindling hectareage prompt us to upscale st&i to retain the hectareage or reverse the trend in converting cacao crops with oil palm in the coconut-cacao agro ecosystem.	✓ **Genomics and fortify the cacao dna genome via molecular breeding:** sequence and map the dna genome of cacao. Develop the barcode dna inventory and identification of cacao clones through signature chemical markers. Resort to transgenic splicing of desirable traits, like , disease resistance to fungal and viral diseases, and also inserting therapeutic or medicinal properties of the indigenous, herbal plants via molecular breeding into the dna genome of cacao.	✓ **Prototype of designer cacao clones:** develop several designer cacao clones with desirable traits with therapeutic herbal-derived, taste, aphrodisiac, disease resistance traits.	✓ Develop several ***commercial designer clones of cacao*** for multipurpose use	✓ Cacao as another **food super crop**
Floriculture and horticulture	✓ **Issue** – congested cities are becoming hot and air pollution is aggravating the environment. ✓ The indo-malaya region archives > 8000 out of the > 22000 species of orchids, yet we have not leveraged our biowealth assets in orchids into a flourishing industry that produces more than several thousand varieties every year.	✓ **Vertical and urban farming:** the practice of vertical and urban agriculture is to be promoted in cities to make food to be easily available in the cities with less carbon footprints, and to cope with warmer temperatures, air pollution, untimely availability of water to cause droughts and floods. ✓ **Plant wall**	✓ ***Commercial prototype designs of plant walls*** with prescribed nursery of selected tropical plant species to be grown on the plant wall.	✓ Commercial **flora species for filtering polluted air in the cities by plant walls of** herbs and flowers from the tropical rainforest.	

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	✓ **Challenge** – to make the city landscape to be green-friendly, cooler, clean air and habitable ✓ To harness the biowealth potential of the orchid germplasm into a flourishing, floriculture industry in the country.	**construction on city buildings:** construction of plant wall with tropical species of herbs, flowers, etc. And equipped with efficient fertigation to clean the polluted city air by the plant wall. ✓ Coordinate the research-commerce relationship between researchers and growers and conduct germplasm collection of orchids from the rainforest and study their *in situ* habitat and the related keystone species critical to its ecosystem and develop clones and varieties for commercial propagation ✓ Reastablish indigenous breeding herbs	✓ Produce 10 commercial, **transgenic orchid varieties** (with signature chemical markers) for international market		
Fruits	✓ **Issue** –by and large, fruit trees are similarly grown in mono-cropping system like that of the oil	✓ **Ecological approach** to orchard culture: grow orchard with consideration of	✓ **Multi-cropping system** for orchards of banana, durian, carambola,		

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	palm, rubber and cacao plantations. Difficult to open up new land to grow new fruit crops. Since arable land is scarce and diminishing therefore optimal use of the land is needed ✓ **Challenge** – grow orchards not in mono-cropping system but in multi-diverse flora and fauna species.	the functional, bio-diverse agro-ecosystem. E.g durian amongst cluster of banana trees and bats' (pollinator) sanctuary.	papaya. ✓ Gm fruits spliced with gene traits to address disease resistance, weed control, or with smell or taste preference. Designer fruits (papaya, mangoesteen, carambola, etc.) With specific characteristics to suit different markets		
Livestock	✓ **Issue #1** – food security: conglomerization of food animal production through vertical integration and increasing farm size in many commodities such as poultry, dairy and beef cattle could meet a higher percentage of domestic demand for animal proteins from current level but would still be dependent on imports for our needs for beef, mutton and dairy products. ✓ **Challenge** – strategizing on the optimum use of finite local and foreign resources for the production of animal proteins. Adapting new species for food	✓ Intra-ASEAN food production hub – capitalizing on regional production resources for domestic supply of beef, mutton, pork and dairy products while at the same time creating markets for our diversified processed food and animal based industrial products. ✓ Identify potential species	✓ Realize the agreement on win-win production sharing initiatives between malaysia and ASEAN and ASEAN +3 partner countries. ✓ Enhance the productivity of smallholder livestock production units by incorporating advanced reproductive biotechnology and more efficient feeding systems. ✓ Establish jungle food	✓ Realize an intra-ASEAN food security network for livestock produce. ✓ Develop strategies for the commercial production of animal proteins and animal based products from wildlife species. ✓ Continue selecting useful traits ✓ Genomic studies	✓ Continue selecting useful traits ✓ Mass production for local breed

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	and recreation		✓ Incorporate indigenous species of livestock (buffalo, katjang goats, village chickens and ducks) in food production systems.		
	✓ **Issue #2** – concern for a clean and pristine environment by the general public warrants a relook at the presence of highly concentrated animal populations in very intensive production systems such as in poultry, pig and dairy cattle farms and beef cattle feedlots. Intensive animal systems are suspected to contribute more to environmental degradation, including biodiversity losses, ground water contamination and soil pollution. The integration of livestock in crop production systems needs to be attractive financially and environmentally to the investors. ✓ **Challenge** – developing environmentally-sound and sustainable intensive livestock production	✓ Closed house production system as adopted by many vertically integrated poultry producers can be extended to other livestock species of pigs, dairy cattle and feedlots for beef cattle and goats. Close loop system in which zero waste strategies are adopted to ensure minimal waste discharges and conversion of animal wastes into biofertilizers and other industrial products.	Enhance the adoption of closed house and close loop system technologies for pigs, dairy cattle and feedlots for beef cattle and goats. Develop technologies to integrate food production with clean environment and efficient water management.	Develop technologies to better handle animal waste, reduce green house gases and seek alternative uses of animal waste.	Develop a **sustainable crop-animal production system** for multi product and use strategies.

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	system. ✓ Strategizing on resource allocation for a sustainable crop-livestock production system.				
	✓ **Issue #3** – transboundary animal diseases are difficult to control without sharing of information on animal and animal produce movement. Conventional vaccines currently in use to combat animal diseases are expensive, less effective in conferring protection and have poor delivery. ✓ **Challenge** - reducing the risk factors in disease outbreaks through close monitoring of animal movement and host reservoir. Cheaper vaccines with highly efficient delivery.	✓ **Regional network of disease surveillance and control** across different regions of the world and sharing of information on disease risks. ✓ Cheaper vaccines having high efficieny in their delivery systemss. ✓ Higher disease resistant breeds of livestock through transgenesis	✓ Realize intra-ASEAN animal disease surveillance network. ✓ Develop vaccines for poultry in the tropical	✓ Tap the beneficial attributes of disease resistance of indigenous germplasm of animal and other fauna species for incorporation into genome of production animals	✓ Develop plant based vaccines of recombinant protein sub-unit vaccines with antigen of species derived in plant tissues.
	✓ **Issue #4** – vertical integration of poultry production has created a highly efficient industry that is able to meet the needs of the nation for poultry meat and eggs. ✓ **Challenge** – diversifying the processed products based on poultry meat and eggs for	Designer products based on livestock produce with global appeal and consumer expectation. ✓	Expand the array of varied animal based products tailored to changing global market demand emphasizing on wholesomeness, product labelling and traceability. ✓	✓ Create world-class brands of halal animal-based products for the global markets	

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
	domestic and international markets.				
	✓ **Issue #5** – increased temperature which accompanies climate change may have adverse long term effects on reproductive efficiency and adaptation of farm animals. ✓ **Challenge** – understanding the long term effects of climate change on the adaptive physiology of farm animals & birds.	Genomic profiling of domestic germplasm of animal and wildlife species to complete the inventory of beneficial properties of local biodiversity. ✓ Regulation density of swiftlet farming	✓ Complete genomic profiles of indigenous livestock and wildlife species to identify selection markers for traits of economic importance. ✓ R&d on sustainability and wild insect population	Develop stress-tolerant livestock breeds and strategies to reduce losses in fauna biodiversity and animal genetic resources. Search for products which enhance the bio-degradability of fibrous feed materials. ✓ Enhance natural resource of insect	Explore the generation of multi-use products from animals as bio-reactors. Identification of active principle
Aqua-culture and fisheries	✓ **Issues** - continuous overfishing and stock depletion for marine capture fisheries ✓ **Challenge**- to enhance wealth creation for the nation the seas should play a vital role over the next forty years to 2050. Aquaculture is not developing as planned and is underperforming compared to other southeast asian countries ✓ **Issue**- r&d with relevance to the modernizing of the industry is required. R&D in the sector does not involve direct participation o the private sector. Adoption of new technology is very haphazard and on a piece meal basis.	✓ New technologies are needed to better manage existing stocks in capture fisheries while minimizing waste and improving the value of products through processing and handling. ✓ Technology can play a major positive role by reducing discarded by-catch and postharvest losses. Technology will also be essential in improving the quality and safety of fisheries products in the markets ✓ The capacity in malaysia for scientific stock assessment is quite limited. ✓ Investment in new generation of fisheries research vessels and remote sensing projects would considerably	✓ Stock rebuilding through reduction in fishing pressure for marine capture fisheries especially in the west coast of peninsular malaysia. Enabling further exit of fishermen from capture fisheries especially in the west coast of peninsular malaysia. 20% reduction of fishermen in the west coast. ✓ Anticipate on large scale ✓ Access ruined of reefs ✓ Allow capable existing fishermen to stay and improve efficiency in fishing.	✓ Certification of fish quality and traceability of fish along the supply chain is well established. ✓ Stock building continued with wider application of marine protected areas in peninsula malaysia. ✓ Improved diseases resistant species for aquaculture developed through genetic improvement techniques. ✓ Greater ASEAN cooperation on knowledge management on information on the seas surrounding the	✓ Regional & milestone in fisheries for mutual agreement. ✓ Sufficient recovery in fish stocks as a result of management initiative with marine protected areas and reduction in fishing effort. ✓ Malaysian will emerge as a regional hub for certified quality ornamental fish ✓ Aquaculture to produce some 50 percent of countries fish requirements

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
		enhance the information available to stakeholders and policy makers in fisheries. ✓ The use of ***marine protected areas (mpas)*** will increase as a management tool for conservation and stock rebuilding activity. ✓ ***Coral reef ecosystem destruction*** posed by water quality degradation needs better understanding and management. ✓ Aquaculture industry has to use new technologies of breeding and genome development and focus more on quality to better position itself vis-à-vis the neighboring countries. Focus species should be tilapia, carps, catfish and the tiger shrimp. ✓ The ornamental fish industry can benefit from improved genetic development of species and certification schemes will help the industry's long term development ✓ In high valued aquaculture, the possible limiting constraints of fishmeal and fish oil can only be surmounted through feed replacements. This need will be more important for aquaculture and capture fisheries as the pressure on fish stocks increases with increase in demand for fishmeal and fish oil. ✓ The introduction of new species and new traits into	Encourage private sector investment in deep sea fishing. Investment in stock analysis research for deep sea fishing. ✓ Develop aquaculture focus on grouper, sea bass and tilapia and penaeid shrimps ✓ Develop further integrated cage farming. ✓ Develop opportunities in sea weed farming using the mini estate approach especially in sabah. ✓ Try to capture back about 30% of the volume of ornamental fish exported through neighboring country (singapore) ✓ Promote the production of healthy and disease-free fish ✓ Develop viable feed mills to support aquaculture.	ASEAN nations. ✓ Development of new products using sea weeds and biodiversity of the coral reefs of the ASEAN seas	✓ Some ten percent of the seas around malaysia used for sea ranching of tuna, groupers and sea bass. ✓ Wide use of modern technologies in aquaculture production and feed formulation.

Commodity	Issues/ Challenges	Technology/ policy/trends	Short-term (2020)	Mid-term (2035)	Long-term (2050)
		ecosystems, however, must be regulated and monitored with great caution. As aquaculture intensifies in malaysia, technology's role in controlling externalities and minimizing net resource demands will become more important.			

9.3 Logical Framework Analysis (LFA)

Table 9.3: Agricultural Sector (Technologies and R&D)

Current status	Issues and challenges	Gaps in knowledge	Future needs	Proposed recommendations/ action plans	Strategies
Mechanisation **Mechanisation (contd.)**	Harvesting e.g. Oil palm, rubber, aquaculture Poor development of mechanization and over dependent on the foreign labour (guest workers) Lack of connection between the scientist and the farmer to implement the technology Lack of incentives Economy of scale-not applicable for the small holder	Lack in link between the technology development and farmer Lack between the technologies and expertise e.g. Mechanical engineer and biologist to work together The item/tool is too expensive to the small holder Not high technology/ friendly user available machinery for farm	Integrated system of harvesting and transport machine Machine that can adapt with the local terrain condition	Set up a body to examine the farm mechanization Reduce the foreign worker Contract harvesting/farming Technology to provide a better return	Conduct the competition for the advancement of mechanization e.g. Harvesting machine Vocational training/ program introducing of new technology
Genomics and gene technology	Lack of mapping of the genome sequence for the crops /livestock/fish/ microbes Accessibility of the genome mapping studies Lack of bar coding technology Lack of the collaborative	Lack of specialist Lack of the understanding of the importance and use of technology	Studies in transgenic for the new gene Studies in the microbe fertilizer Introducing new species Skilled interdisciplinary researchers	Designer crop Desirable quality for the crop/animal Fortifying of genome by deleting or inserting the genes in key crop of oil palm ,cocoa and rice Food security Form a genome centre	Maintain the gene pool Enhance the biodiversity e.g. Coconut and cocoa

Current status	Issues and challenges	Gaps in knowledge	Future needs	Proposed recommendations/ action plans	Strategies
Genomics (contd.)	genome molecular markers Transgenic initiative for the identified gene of species Priorities crop Add more value to crop e.g. Cocoa Diversification of crop Maintain the gene pool Production of cocoa is decreasing because of pod borers and lack of R&D to resolve this problem				
Information and communication technologies (ict) **Precision agriculture**	Ict for the farm level Systems approach to solve the problems Role of msc to be adapted in ict of agriculture Lack of enabling of ict in agriculture Lack of the continuous development in ict Accessibility of the data Knowledge	Poor value-chain Lack knowledge of applications of bio-informatics information	Integration between two different agencies Immediate accessibility to data e.g. Topo map and soil maps in digital format Updated data e.g. Satellite images , maps Better market information management Continue enhancement of existing system for futures' market e.g. For the	Agencies to have discussion on traceability and data sharing Use ict for improving agriculture marketing e.g. E-business Ict for improving value-chain Leverage the broadband initiative e.g. Portal of the moa such as agric bazaar Bio-informatics Making available quality criteria information for	Develop a policy for accessibility and data sharing Develop a policy for traceability mechanism Institutional programs/projects Develop the training program Adopt bio-informatics

Current status	Issues and challenges	Gaps in knowledge	Future needs	Proposed recommendations/ action plans	Strategies
Information and communication technologies (ict) **(contd.)**	management Centralised data knowledge repository Traceability system. E.g. Rfid Nano-technology		price of the fruit, flower and vegetable Real time data exchange Availability of data and services in real time for research agency	agriculture products in a portal e.g. In fama or moa For nano-tech-targeted delivery drugs and vaccine for crop, fishery and livestock (time control delivery)	
Resources constraint	**Land**				
	Converting coco to oil palm			Add value to the present crop	
	Agroforestry				
	Lack of policy to produce agriculture products in forest Expand the participation of the local community in forest community To bring the nature cycle-loop system to the agriculture sector e.g. Wild honey production in sarawak Identification of resin	Knowledge sharing Indigenous knowledge /research for bio-prospecting Improving the technology of harvesting for the agar wood (gaharu) from *karas* tree More models for the agroforestry	Bring the nature ecosystems More R&D for enhance biodiversity ecosystem	Capitalize the bio-diversity and indigenous knowledge linked to the sandt Undertake collaborative studies for agroforestry models	More resources for the R&D More collaboration platform between forestry and agriculture e.g. In education, medical
Resources constraint	**Fisheries**				
	Marin environment Lack of policy				

Current status	Issues and challenges	Gaps in knowledge	Future needs	Proposed recommendations/ action plans	Strategies
(contd.)	for develop aquaculture species Over fishing in west coast area Heavy threat for fresh water and riverine fishery from industrial pollution from poor river management				
	– Research and development funding				
	R&D institutes being diverted from core areas of R&D to showing income and profits Fund need to go to the high impact sector Slack in R&D procedures for funding and identification of focussed areas	–	–	–	–
	– **Energy**				
Resources constraint **(contd.)**	Reuse the displaced resource of the oil palm trunk to be by product of timber Competing for the same resources e.g. Oil palm trunk for wood versus for fertilizer				

Current status	Issues and challenges	Gaps in knowledge	Future needs	Proposed recommendations/ action plans	Strategies
Nutritional needs	Lack of the knowledge healthy food from agriculture to health sector No health survey for the status of national food basket Allocation of the research Refine the fast food category as a daily diet Agriculture product should base on the nutritional recommendation	The nutrition needs base on the genetic make up Do not have national food data consumption	Nutri-genomic study A study on the use of nutrition for preventing the diseases Adjust the food basket Biotech on the legumes and plants for improve antioxidant	Follow the latest of suggested food plan Nutritional research strategy to create a policy Meet the diet of the people according to the food pyramid and Run the food production as proposed in the food pyramid Put the lower price for the recommended food via mass production Design of the food base on the health	Matching the nutrition to the lifestyle

10 CONCLUSION

The developments in the region and the world, with regard to agriculture, were carefully analysed in the report. The significance of science and technology in the formulation and selection of strategies by the government and industry for the development of the agricultural sector was given emphasis. Some preliminary suggestions for investments in the subsector are also provided. The key conclusions from the study are outlined as follows:

With few exceptions, notably that of rubber, oil palm, cocoa, poultry and pork there is a lack of integration of applications of ST&I between the production segment with the subsequent downstream segments of many crops, livestock, fisheries and agroforestry.

There is a lack of integration and consistency in the policies, strategies and programmes in the agricultural sector and ST&I is used and managed in a 'diffused' manner by a plethora of agencies under the numerous ministries.

There is a serious lack of consistent data on the applications of ST&I along supply chains and trading networks as well as gaps on data on nutrition.

Although there is emphasis on 'New Agriculture' in the 9th Malaysia Plan, there is still a lack of proper understanding of the rational of this (re)emphasis on agriculture and how agriculture will contribute to the sustainable growth, wellbeing of the populace towards 2020 and beyond towards 2050 - towards a sustainable, inclusive and high income economy as envisioned in the New Economic Model.

In arriving at the characteristics and objectives of Malaysia's Agriculture towards 2050 the following conclusions are drawn.

The key strategic thrusts should be to ensure food security and safety; sustainable agriculture; intelligent/precision agriculture; and high-value agriculture via increasingly comprehensive and interconnected supply chains and trading networks.

For the next 40 years, the focus will be on food and agricultural product quality, food safety, improved food nutrition and functions, modernized agriculture via ICT, nanotechnology, biotechnology, digitization and precise technologies; and high-value ecological, multifunctional and sustainable agriculture. These are to be firmly established, in tandem with developments in the other sectors in WEHAB, of water, energy, health, and biodiversity.

Advances in biotechnology, ICT, nanotechnology as well as innovative ways of conducting business in Agriculture will further increase the efficiency, competitiveness and sustainability of the identified strategic crops, livestock, and fisheries as we move more confidently, as a nation, into the more challenging, globalizing and interdependent environment towards 2050.

The promises of the emerging technologies will, however, not guarantee contributions to improved Malaysia Agriculture if the nation fails to adopt appropriate policies; understand the importance of cross sector and discipline linkages; develop the critical mass of human resources needed through the whole value chain; participate actively in R&D; provide adequate funds; change mindset; and be sensitive to the welfare of the total environment.

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12 APPENDIX

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