Environmental Impact of Different Production Systems and Consumer Willingness to Pay for Chicken Meat Produced with a Higher Regard for the Environment

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Declaration

This thesis has been composed by myself and has not been submitted as part of any previous application for a degree. The work of which this is a record has been done by myself unless otherwise stated. All sources of information have been specifically acknowledged by means of referencing.

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Abstract

The aim of this study was to identify policy approaches to promote sustainable broiler production in Malaysia and this was addressed by three specific objectives namely to: i) estimate the environmental impact of different broiler production systems; ii) estimate consumers' willingness to pay (WTP) for chicken meat produced with a higher regard for the environment (chicken-HRE); iii) investigate potential policy changes which could be brought in to livestock production in Malaysia and assess their impact on the poultry industry from the perspective of various stakeholders including broiler producers, integrated broiler companies and the Government.

Evaluation of environmental impact was carried out using the Life Cycle Assessment method, with a functional unit of 1 tonne live weight of broiler chickens and a cradle to point of slaughter criterion as the system boundary. The environmental impact analysis used various sources to obtain foreground data on two broiler production systems, namely intensive closed house (CH) and open house (OH) systems. The CH system produced 6 to 7% lower environmental burdens but marginally greater use of energy than the OH system. Feed-related inputs (mainly raw materials and transportation) accounted for the greatest proportion of environmental burdens with, on average, 89.8% of energy use, 94.1% of greenhouse gas emissions, 76.8% of acidifying emissions and 86.8% of eutrophying emissions.

A Contingent Valuation Method was used in a survey of over 200 selected consumers across Peninsular Malaysia to ascertain the maximum WTP for chicken-HRE. Some 50% of respondents were willing to pay an increment of 10% above the existing market price. Using a mixed method approach, quantitative findings from the environmental assessment and the socio demographic and economic survey were integrated with qualitative results to explore the impact of potential policy approaches to promote sustainable broiler production in Malaysia. Even though the economic aspects explored in this study give only an indication of the likely societal attitudes to broiler chicken production, they nevertheless provide an indication of the growing stakeholder interest in methods of food production and implications for the level of environmental quality to be experienced by future generations.

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List of Abbreviations

AFTA	ASEAN Free Trade Area
AGR	Annual growth rate
ANOVA	Analysis of variance
AP	Acidification potential
API	Air Pollution Index
BOT	Balance of trade
CBA	Cost benefit analysis
CED	Cumulative Energy Demand
CH	Closed house
CH_4	Methane
Chicken-HRE	Chicken meat produced with higher regard for the environment
CO_2	Carbon dioxide
CPI	Consumer Price Index
CPO	Crude palm oil
CVM	Contingent valuation method
DEFRA	Department for Environment, Food and Rural Affairs
DM	Dry matter
DOC	Day-old chick
DOE	Department of Environment
DOS	Department of Statistics
DPSIR	Drive Force Pressure State Impact Response
DVS	Department of Veterinary Services
EBs	Environmental burdens
EnBs	Enumeration blocks
EFA	Ecological footprint analysis
EM	Effective micro-organism
EMA	Environmental Management for Agriculture
EP	Eutrophication potential
EPA	Environmental Protection Agency
EPs	Ecopoints
EPU	Economic Planning Unit
FAMA	Federal Agriculture Marketing Authority

FAO	Food and Agriculture Organisation
FAWC	Farm Animal Welfare Council
FCR	Food conversion ratio
FMD	Foot mouth disease
FU	Functional unit
GA	Green accounts
GAHP	Good animal husbandry production
GDP	Gross domestic products
GHGs	Greenhouse gases
GMP	Good manufacturing practice
GWP	Global warming potential
H5N1/HPAI	Highly pathogenic avian influenza virus of type A of subtype H5N1
HACCP	Hazard analysis and critical control point
H Cl	Hydrogen chloride
HFP	Halal food production
IFE	Incentive for export
IPCC	Intergovernmental Panel on Climate Change
IPT	Institute of Poultry Technology
ISO	International Standard Organisation
ITTO	International Tropical Timber Organisation
JAKIM	Department of Islamic Development Malaysia
K	Potassium
kWh	Kilowatt per hour
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LQs	Living quaters
LW	Live weight
MARDI	Malaysia Agriculture Research Development Institute
MGCCI	Malaysia-German Chamber of Commerce and Industry
MJ	Mega joule
MOA	Ministry of Agriculture and Agro-based Industry
MP	Malaysia Plan
MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysia Palm Oil Board

N	Nitrogen
N_2O	Nitrous oxide
NAP3	Third National Agriculture Policy
ND	Newcastle disease
NH_3	Ammonia
NH_4	Ammonium
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen oxides
OECD	The Organisation for Economic Co-operation and Development
OH	Open house
P	Phosphorus
PKC	Palm kernel cake
PKE	Palm kernel expeller
PO_4	Phosphate
PPI	Potential pareto improvement
RA	Reinvestment allowance
RM	Ringgit Malaysia
R&D	Research and development
SCAHAW	Scientific Committee on Animal Health and Animal Welfare
SDC	Sustainable Development Commission
SI	Semi-intensive system
SMTA-PGRFA	Standard Material Transfer Agreement on Plant Genetics Resources for Food and Agriculture
SO_2	Sulphur dioxide
SP	Stated preference
SPS	Sanitary and phytosanitary
SPSS	Statistical Package for the Social Science
t km	tonne kilometre
TKPA	Permanent chicken production park
TEV	Total economic value
TRQ	Tariff rate quota
WE	Welfare economics
WEPA	Water Environment Partnership in Asia

WTA	Willingness to accept
WTO	World Trade Organisation
WTP	Willingness to pay

Chapter 1. Introduction

1.1 Status of the Livestock Industry and Chicken Meat Products

In Malaysia, efforts to achieve greater self-sufficiency in livestock products have resulted in various plans to promote livestock production in specific zones of the country (MOA, 1998). Livestock products are divided into six categories; namely beef, mutton, poultry meat, pork, milk and eggs. Malaysia is self-sufficient in meeting the domestic demand for poultry meat and eggs with levels in 2009 of 122% and 115% respectively. Excess poultry products and eggs produced are exported, mainly to Singapore. Other livestock products have yet to fully meet the domestic demand and rely on imports.

Ex-farm value for chicken meat has recorded an increase from RM4.37 billion in 2005 to RM5.47 billion in 2009, representing an annual growth rate (AGR) of 5.7%. This value has contributed 53% of the overall value of livestock products in 2009. In terms of quantity, the production of chicken meat has increased from 0.98 million tonnes in 2005 to 1.20 million tonnes in 2009. The consumption had shown a similar trend, having increased from 0.79 million tonnes to 0.98 million tonnes over the same period. Over this duration, per-capita consumption has increased by 0.7% per year reaching 34.7 kg per year in 2009 (DVS, 2010).

The balance of trade (BOT) for live poultry and meat shows a surplus and positive trend for the period 2005-2009 with AGR of 12.3%, whilst the quantity produced showed an AGR of 5.3%. In 2005, the surplus BOT was RM280 million, which had increased to RM409 million in 2009 (MOA, 2010a). Strategies have been put in place to maintain the market share amongst common trading partner countries and at the same time penetrate new market destinations. The summary of production of chicken meat and trade status for poultry (live and meat) is illustrated in Table 1.

Table 1: Production, demand, ex-farm value, per-capita consumption of chicken meat, self-sufficiency level of poultry meat and eggs and balance of trade of poultry (live and meat) 2000-2009

Item	**2000**	**2004**	**2005**	**2009**	**Annual Growth Rate (%)**
					2005 - 2009
Production ('000 tonne)	714	927	980	1202	5.32
Demand ('000 tonne)	635	860	786	983	2.71
Ex farm value (RM million)	2,934	4,135	4,369	5,468	5.75
Per-capita Consumption (kg)	27	34	30	35	0.65
Self Sufficiency Level (%)	112	108	125	122	2.54
Balance of Trade (RM million)	198	229	280	409	12.32

1.2 Dichotomised Scenarios: Trade-Off between Environmental Impact versus Economic Expectation with Social Acceptance

Most chicken meat is consumed fresh; only 10% is used by the processing industries to manufacture products such as nuggets, burgers and other value added products especially for the fast food businesses.

In fact, this amount does not meet the demand from the downstream industry, as the industry has grown rapidly and received an increase in demand from the domestic and international markets. These value added products have successfully penetrated up to 25 international markets, mainly in the Middle East (Global Trade Information Service, 2010) and, to overcome the supply constraints, the industry has to import some raw materials from other countries. This encouraging scenario is able to generate higher economic returns and improve social prospects through the creation of employment opportunities. Moreover, since Malaysia has been categorised as non-endemic for bird influenza virus (H5N1), this gives advantages to create a conducive environment and promote more poultry production programmes (FAO, 2011a).

To achieve the target of production, set to be 1.49 million tonnes by 2020, the expansion of production through intensive vertically and horizontally integrated approaches has been identified as an effective solution (MOA, 2010b). In general, these approaches, especially the horizontal approach, are widely used in the broiler production in Malaysia, particularly on large and medium farms. In 2009, 22.9% of the farms were categorised as large-sized farms, with more than 50,000 broilers per cycle, while 26.2% were medium-scale farms ranging from 20,000 to 50,000 broilers per cycle. The remaining percentage was small farms with less than 20,000 broilers per cycle (DVS, 2011a). This intensive production system has two types of housing systems, namely closed and open house systems, which confine chickens inside the house at all times with commercial compounded feed and receiving scheduled treatments. The difference in the systems is the housing design; the former has a controlled internal environment, while the latter is of open air type, which is greatly influenced by ambient air. The detail of these systems will be explained in Chapter 2.

Even though there is a widespread belief that intensive animal production might be taxing to the environment, as larger production units may result in a higher quantity of unavoidable waste products such as faeces, urine, respiration and gaseous pollutants when compared to conventional systems, recent research suggests that intensive (housed) broiler production may have a lesser impact on the environment and greenhouse effects per unit of output product. These findings indicated that less intensive systems, such as organic production, are less efficient and have a higher feed conversion ratio (gram feed/gram gain; FCR) and a longer growing period for the heavier chickens that are produced, resulting in a net increase in energy requirement and, consequently, giving higher environmental burdens even though the waste can be used to substitute the application of synthetic fertilisers in crop production (Leinonen *et al.*, 2012). Clearly there is some difference between perception and actual impact of intensive broiler production system when compared to low input ones.

1.2.1 Problem statement

Despite the fact that intensive production, particularly the closed house system, offers much promise of environmental and economic advantages, if viewed at the macro level, including social components such as the readiness to accept and wellbeing of consumers and animal welfare, it requires a very careful evaluation. More intensive systems are perceived to be less animal welfare friendly and the issue of the trade-off between environmental impact and animal welfare has been raised (Rose, 1997; Turner *et al.*, 2003; Siegford *et al.*, 2008). In addition, modern approaches such as the application of a closed house system with full automation of feeding and watering will require higher initial investment which, unless there are savings (e.g. improved efficiency), may lead to a higher cost of production (including basic infrastructure such as access road and building design) which ultimately will be absorbed at consumer level by increase in the market price. This dichotomised scenario requires a more detailed assessment, so that a balanced broiler chicken production in Malaysia can be achieved.

1.3 Strengthening the Existing Approaches and Developing New Applications

There is an increasing trend for integrated studies, taking the approach of sustainable development, since the 1990s such as research on the effect of environmental factors (heat stress, ultraviolet B and ozone) which influence the health status (immune level) of poultry and their impact on the production (Dietert *et al.,* 1994). However, to date, there has been no specific research conducted in Malaysia in the widest context of sustainability, which takes account of all three major elements of sustainable development namely environmental impacts, social characteristics and economic aspects (Brundtland, 1987; Lawrence *et al.*, 2010). An appropriate integration tool of these three major elements is needed to evaluate the current position of broiler production and so identify opportunities to move towards even more sustainable production.

Absence of any previous studies investigating the sustainability of broiler production in Malaysia is the primary motivation for this study. The current study plans to estimate the value of environmental burdens (EBs) of different broiler production systems, to estimate the value that consumers in Malaysia might be prepared to place on chicken meat which is produced by more sustainable means, and to examine the attitude of various stakeholders including consumers, producers, integrators and the Government to more sustainable poultry production. Any policy directions which could be implemented to promote sustainable development of the poultry industry in Malaysia are in accordance with the current demand and requirements of domestic and international standards.

1.4 Objectives of the Study

Therefore, the objectives of this study are to i) estimate the environmental impact of different broiler production systems in Malaysia; ii) estimate consumers' willingness to pay (WTP) for chicken meat produced with a higher regard for the environment (chicken-HRE); and iii) investigate potential policy changes which could be brought in to livestock production in Malaysia and assess their impact on the poultry industry from the perspective of various stakeholders including broiler producers, integrated broiler companies and the Government. The objectives will be addressed by applying quantitative and qualitative approaches.

Chapter 2 provides an introduction to the global and domestic poultry industries and a detailed literature review of the development of sustainable animal production as well as various theories behind the three main elements of sustainability.

To find out whether different broiler production systems produce different levels of environmental burdens, quantitative measures will be applied in Chapter 3. A recognised environmental tool, namely Life Cycle Assessment (LCA), is employed which compiles the impacts of all the inputs and outputs of broiler production up to the point of slaughter.

To estimate the value that consumers are prepared to place on more sustainably-produced chicken meat, Chapter 4 outlines a structured survey using a Contingent Valuation Method (CVM) as a tool to estimate consumers' willingness to pay (WTP) for chicken-HRE. Estimates of WTP values can provide an indication of consumers' readiness to contribute towards good environmental practice and will represent the values of environmental goods, in this case favourable environmental quality. In addition, the relationship between selected socio-demographic characteristics of consumers with their stated WTP will be explored as a means of extrapolating the results to the Malaysian society.

To investigate potential policy changes which could be brought in to promote more sustainable forms of broiler production in Malaysia, the opinions/perspectives of various stakeholders including producers, integrators and the Government are described in Chapter 5. The producers' questionnaire is designed to explore their attitudes towards sustainable broiler production and motives that govern them in engaging in an industry which is capital intensive and heavily reliant on import of raw materials. The integrators' questionnaire aims to understand the challenges facing these large-scale businesses and their expectations for the future of their industry. Participation from the Government is crucial for a viable and sustainable industry; therefore the opinion of various Government departments is reported. Government sets the strategies and priorities for economic activities in both medium and long term planning, along with ensuring that these policies are implemented and enforced. All these qualitative findings will then be integrated with previous quantitative findings of LCA and CVM using a mixed method approach which aims to take a holistic perspective towards sustainable poultry development.

Finally, in a general discussion in Chapter 6, the main findings are drawn together and different policy recommendations which might strengthen and support moves towards more sustainable broiler production in Malaysia are explored.

Chapter 2. Literature Review

2.1 Sustainable Development

Sustainable development is a visionary development paradigm that officially received global endorsement in 1992. The Oxford Dictionary (Hornby and Wehmeier, 2000) defines sustainable as '*the use of natural products and in a way that does not harm the environment and can be continued for a long time'*. The concept of sustainable development thus recognises the negative impacts on the environment from the development of human activities, and received attention and commitment from most national governments during the Conference on Environment and Development in Rio de Janeiro on 3-14 June 1992. Sustainable development is a concept without a clear definition so that, after 20 years, various definitions have emerged and individual countries have come out with different interpretations and programmes of implementation. As a result, the impact of actual achievement of sustainable development at a global level is difficult to measure (Drexhage and Murphy, 2010) and indeed some argue that the actual achievement of sustainable development has been rather slow (Michel, 2008).

Sustainable development is a concept that has gone through a long process of debate and in fact has been practised for a long time. As far back as 1970 Herman Daly, through his well-known theory of A Steady-State of Economy, indicated that the earth is approximately a stable size where the inflow and outflow of energy as a result of human activities is roughly equal and allows for qualitative development rather than quantitative growth. To maintain the steady-state, Daly (1970) argued that the maximum human activities should remain at or below the capacity that the environment can sustain indefinitely.

Brown *et al.* (1988) suggested that the concept of sustainability is strongly dependent on the context of what exactly one is referring to, whether it applies to environment, economic or social perspectives. Even though a general concept of sustainable development which integrates the three commonly recognised pillars of economic development, environmental protection and social equity is accepted globally, the implementation remains an elusive challenge (Brown *et al.*, 1988; Liverman *et al.*, 1988; Pretty, 2005; Drexhage and Murphy, 2010). Sustainable development is often compartmentalised as an environmental issue whilst the measurement of development is still purely based on economic growth. Issues such as trade and financial liberalisation, together with fiscal and monetary policies, significantly influence the national development policy and have been used as indicators to determine the economic growth and stability of the development status. Thus, the term development has been viewed as sustaining economic development rather than sustaining global development. This situation has implied sustainable development as a subset to an economic paradigm (Drexhage and Murphy, 2010).

Drexhage and Murphy (2010) also argued that the lack of achievement in implementation of sustainable development is also, in part, due to the failure by governments to have a greater influence on policy. They also highlighted that the economic agenda has always had a greater impact on the mainstream of policy direction and gained significant political interest compared to other issues. The difficulties in getting an equal level of attention on economic and environmental issues from governments means that sustainable development remains as a single concept, with only climate change issues being the de facto proxy to augment the entry points of other pillars, even though it is realised that the level of acceptance on the climate change issue by member states in climate change negotiation varies. For example, the United States of America did not ratify the international environmental treaty of the Intergovernmental Panel on Climate Change (IPCC), while Canada and China, which recently reviewed their commitment to the IPCC, might hamper the impact of the whole complex interaction (McCright and Dunlap, 2003; Drexhage and Murphy, 2010; Vidal and Harvey, 2011).

2.2 Food Security and Food Sustainability

Food security is a flexible concept which has gone through the evolution of various definitions. In 1996, at the World Food Summit, the first agreed definition of food security was adopted as '*when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life*'. Food security and food sustainability are two aspects that complement each other and affect every human being.

For many years people have faced the challenges of balancing food production with consumption needs and, at the same time, protecting the environment. The debate on the profitability of sustainable farming systems with the adequacy of food production is still an on-going issue (Schaller, 1993). The concept of food security has been enhanced and strengthened by the interaction of these two aspects. Thus, a widely recognised definition of the term food security is that it '*exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary need and food preferences for an active and healthy life in a way that does not compromise future generations' ability to feed themselves sustainably and healthily*' (FAO, 2008; SDC, 2008).

The Food and Agriculture Organisation (FAO, 2009a and 2011b) identified the reason behind the increased importance of food security as mainly due to changes in socio economic factors, i.e. increasing population growth, the trend toward urbanization and rising income. With regards to the first two factors, world population is expected to reach nearly 9.15 billion people in the middle of this century and by then more than 70% of the population will be urban. This will bring the challenge to meet the global demand for food, since this scenario will bring changes in life styles and consumption patterns. The third factor highlighted in these studies is related to normal food types such as grains, vegetables, fruits and coffee which have shown a positive income elasticity trend, i.e. as income rises, so does the demand for these products. Several countries, especially the developing countries, recorded a similar relationship for the consumption of livestock products. With rising income, accompanied by urbanisation and westernisation of diets, there has been increasing demand not only for meat but also for diversified dairy products such as pasteurised milk, ice cream and chocolate.

Following the encouraging developments in the livestock industry, and to meet the increasing demand for livestock products as mentioned earlier, FAO in two studies (FAO, 2009a; 2011b) highlighted three strategies to increase livestock production, provided adequate resources are available and there is widespread adoption of technologies, such as mechanization of feeding and milking systems that offer potential solutions towards the problem of reducing resources such as land and labour. Firstly, increased investment in developing countries who are set to experience the highest increase in population (by at least 60% over current level in 2009), through mutual cooperation between public (including positive incentives to farmers) with private resources. Much of the increased supply of livestock will come from large-scale intensive systems, in which the private sector is the main player not only in the production stage but also in managing wastes and improving efficiency of the supply chain. These studies argued that public finance is still vital to provide basic infrastructure and research development. On the other hand smallholders and livestock-dependent societies experience difficulties in penetrating the market and thus have very limited prospects to increase their income due to competition with the large scale producers. This sector could be assisted by a combination of private and public finance efforts, such as developing and adopting livestock integration approaches and applying more efficient water management. Equally, the efficient management of the government and international aid is required, especially in managing issues such as a food crisis which is actually the result of inefficient implementation of food distribution mechanisms.

The second strategy proposed by FAO (2011b) to sustain the increase in livestock productivity is enhancing global investment in research and development (R&D). The potential improvement ranges from common issues such as improving the feeding practices, development of better breeds and enhancing animal health, up to the emerging issues such as finding ways to manage the issue of negative externalities derived from livestock production and its downstream activities. Negative externalities occur when the production imposes external costs for which no appropriate compensation is paid. Examples of negative externalities derived from livestock production include the potential environmental damage caused by the emission of hazardous gases from manure as a result of intensive production, and the external costs of feed miles of raw materials transport from field (local or imported) to the producers and the food transport from producers to consumers. Downstream activities in this context refers to the processing industries which produce value added products from the primary production as a strategy to obtain high sale values, besides creating job opportunities for people. Sausages, dried meat, and burger patties are some examples of products from livestock downstream activities.

At international level, strategies such as ‘sharing mechanism’ can be adapted to absorb the cost of R&D and implementation of development programmes. Approaches such as the Standard Material Transfer Agreement on Plant Genetics Resources for Food and Agriculture (SMTA-PGRFA) can be used as a model for livestock R&D. SMTA-PGRFA is an international treaty under FAO with the objective to conserve the use of plant genetic resources in a sustainable way besides equity sharing of the benefits arising from their use for sustainable agriculture and food security. The unique feature of this Treaty is the ability to ensure the sharing of benefits from the use of these genetic materials with the countries of origin. In order to achieve the objective, the multilateral system of access and benefit sharing of the plant genetic materials between farmers, plant breeders and scientists was established and provided with a funding strategy for the implementation of the Treaty (FAO, 2009b). Through this platform, the innovation and latest technologies are able to be shared and disseminated amongst member countries.

The final strategy is improving the effectiveness of food distribution systems, especially to poor countries (FAO, 2009a). Although the global supply of livestock products exceeds the needs of the human population, the level of production growth is not the same in all regions. Livestock production has been expanding rapidly in East and Southeast Asia and Latin America but has been very slow in sub-Saharan Africa. Even though FAO (2011b) reported that there is sufficient food for everyone, concerns regarding the socio-economic factors, as mentioned above, maintain the importance of increasing the world food production and finding the solution to food access. An effective information sharing mechanism between countries could help in detecting any food shortages and formulating contingency plans.

Based on all the above strategies, the target of food security seems achievable. However, the opposite scenario could occur, based on the current situation of increased competition between food and energy commodities which require more resource use and potentially lead to greater negative impacts on the environment. FAO (2009a) reported that increased energy commodities production for biofuel represents a major risk for long-term food security and climate change. In 2007-2008, 10% of 1,100 million tonnes of global coarse grains production was used for ethanol production, mainly as biofuel. This increased use of food crops for biofuel production could have serious implications for food security, mainly the issue of undernourished pre-school children in Africa and South Asia. This would worsen the situation by accelerating the rise in food prices observed in recent years, which gives a clear sign of reduced food availability as an outcome of declining growth in productivity due to natural disasters and environmental degradation (Lawrence *et al.*, 2010). These events have sharpened the awareness of policy makers and the public on exactly how fragile is the global food system, which has to be translated into more effective and resilient plans for implementation against unexpected risk in the future (FAO, 2009a). According to Lang (2010), food security can only exist when the food systems are sustainable.

Thus, sustainable development and food security go beyond the classic integration of simply economic development, environmental protection and social equity, and need to incorporate a good governance aspect, including direct participation of governance in all levels of society which will stimulate and engage people's creativity and diversity (Lang, 2010).

2.3 Livestock Revolution and Overview of the Global Poultry Industry

Over the last four decades there has been rapid growth in global livestock production. Population growth, urbanization and income growth are fuelling a massive global increase in demand for food of animal origin (Delgado *et al.*, 1999). Among livestock sectors, poultry has had the fastest growth rate of all livestock sectors in both developing and developed countries (Delgado *et al.*, 1999; FAO, 2006; Narrod *et al.*, 2008; McLeod *et al.*, 2009). Meanwhile, FAO, in their recent report, stated that from 1967 until 2007 there was a striking increase in the production of poultry meat by a factor of 7.0, the highest among livestock products (FAO, 2011b). Development of poultry production is characterised by a highly dynamic market, but has consolidated and continues to expand, even though it constantly faces price fluctuation of raw materials and public health concerns.

According to FAO (2012), world poultry meat production in 2010 was 98 million tonnes and is expected to reach 122.5 million tonnes by 2020 (Best, 2011) to satisfy the demand of the projected human population of 9.15 billion. It is estimated that 59% of this increase of poultry meat production will come from developing countries, where the consumption of poultry meat is growing more rapidly than all other meats (FAO, 2006; McMichael *et al.*, 2007; McLeod *et al.*, 2009). Narrod *et al*. (2008) stated that globally poultry will remain the highest expenditure category of livestock products for the next few decades.

Besides demand factors which have stimulated the growth of the global poultry industry, the supply side factors have also had a significant impact. Technology changes such as improved animal nutrition, breeding programmes and processing techniques have contributed to the development and growth. In addition, a major structural change in the poultry industry is the implementation of large scale vertically and horizontally integrated production chains which are typically focused on intensive housing systems. This strategy allows the industry to absorb any shock in input and output prices, reducing transaction costs and giving control over product quality and safety at all levels (Narrod *et al.*, 2008).

2.4 Environmental and Economic Aspects of Livestock Production

As livestock production intensifies, there is an increase in unavoidable waste products including faeces and urine. These wastes return to the environment in the form of manure and can be termed as valuable wastes which contain a considerable amount of nutrients, especially nitrogen, phosphorus and potassium (respectively N, P and K). Nevertheless, the increment of these valuable wastes has been associated with an increase of animal concentrations that are out of balance with waste absorption capacity and land availability. Consequently, nutrient excess has the potential to degrade environmental quality through deterioration of natural resources such as groundwater and aquatic ecosystems (Delgado *et al*., 1999). These findings align with those of Stern (2006), who asserted that climate change will eventually impede economic growth. Thus, according to Stern, the prompt action to reduce greenhouse gas (GHG) emissions is vital since the stabilisation of GHG concentrations in the atmosphere is feasible to lower the rate of climate change impacts. His review also made a conclusion, from a number of different techniques to assess costs and risks related to climate change impacts, that the benefits of strong and early action far outweigh the economic costs of not acting. For example, using formal economic models, it is estimated that if we do not act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever; in contrast, with actions the cost can be limited to around 1% of global GDP each year (Stern, 2006).

In general, approximately 35% of GHG emissions derive from agriculture and land use. Of this, 18% comes from livestock production which involves numerous activities throughout the product life cycles such as deforestation for grazing land and animal-feed cultivation, energy use for processing and transporting of feed and finished products, and the on-farm inputs used during the production cycle. It is estimated that the livestock sector accounts for about 9% of anthropogenic carbon dioxide (CO_2) emissions, 37% of anthropogenic methane (CH_4) from enteric fermentation of ruminants and 65% of anthropogenic nitrous oxide (N_2O) (mainly the manure), beside 64% of anthropogenic of ammonia (NH_3) emissions (FAO, 2006; McMichael *et al.*, 2007). Anthropogenic refers to human activities that impact the environment, such as impacts on biodiversity, biophysical and other resources. Even though there are inconsistent findings regarding energy used and GHG emissions between different livestock production systems, recent findings showed that, by using modern production systems, it is possible to achieve more efficient conversion of actual food energy into animal products and so the total GHG emissions can be much lower (McMichael *et al.*, 2007; Leinonen *et al.*, 2012).

However, Pretty (2005) drew attention to the impact of agricultural activities on the environment in the context of environmental externalities, an emerging issue in livestock R&D. As mentioned previously, the overuse of natural resources as inputs for animal production makes them a sink for pollution. This has created another problem of so-called negative externalities or external costs, the concept introduced by Athur Pigou in 1912 which refers to costs and benefits which cannot be accounted and transmitted to the actual price, and spill over and may affect large populations (Davies, 2010). Thus, the potential to overproduce products and increase the negative externalities is higher, since the producer does not take into account, and is not responsible for, the external costs when producing the products. Pretty (2005) concluded that, even though there have been great successes with industrialised agriculture, there is little agreement on the economic cost of externalities which are not well accounted for and may be grossly underestimated. FAO (2011b) also highlighted the issue of external costs through water pollution and emission of hazardous gases, which do not currently have to be accounted for but have received attention from the economists. Coupled with other factors, such as scarcity of water resources and increasing price of crops and fuel, these have a strong possibility to increase the price of livestock products (FAO, 2011b).

This scenario is reflected in poultry production, since production has changed from small flocks to large scale intensive production which has resulted in an increased potential for pollution. The pollutants emitted to the air and into water are NH_3 and CH_4 from the chicken production, while CH_4, NH_3, N_2O, nitrogen oxides (NO_x) and nitrate (NO_3) are emitted from the manure storage.

Poultry manure includes both faecal excreta and urine and, if properly handled, will become the most valuable of all manure produced by livestock, especially for its N which is mainly in the form of inorganic ammonium that can be directly taken up by the plant (Mitchell and Donald, 1999; Steinfeld *et al.*, 2006). In the past, manure was predominantly used as fertilizer. However the geographical landscape has changed so that the competition for land use for other activities, such as residential and industrial purposes, has increased and, as a result, land availability for agricultural activities becomes more scare. The volume of manure generated, especially from intensive poultry production, may become a major obstacle if it is not properly managed and controlled. A detailed explanation of gaseous pollutants from poultry production is presented in Chapter 3.

Besides demand and supply factors which are driving the livestock revolution, another aspect which is highly relevant to modern sustainable livestock production is that of animal welfare. Animal welfare plays an increasing role in affecting both animal production and the consumption pattern of livestock products. Even though animal welfare was not identified as one of the main pillars of sustainable development, it is nevertheless accepted that high levels of animal welfare are integral to reduce animal disease risk, increase livestock production and respond to environmental degradation (Thornton, 2010). The following section provides information about animal welfare and how it is linked to broiler production.

2.4.1 Animal welfare

In general animal welfare refers to the state of physical and mental well-being in which an animal is in harmony with its environment (Brambell, 1965). The principles of the five freedoms are commonly used to outline the various components necessary to ensure good animal welfare, i.e. freedom from i) hunger and thirst, ii) discomfort; iii) pain, injury, infestation or disease; iv) fear and distress; and v) freedom to express normal behaviour (Brambell, 1965; FAWC, 1992; DEFRA, 2002).

Improved animal welfare is not a new issue, but nowadays in many countries, particularly relatively affluent ones, it is being expressed with greater force and has led to some degree of political influence. Thus animal welfare is a complex issue that can affect many aspects of the production chain and is for many people an emotional topic. It is involves scientific and technical data and also the everyday observations and practices of people in the industry (Seng and Laporte, 2005). In the EU, the European Commission through the EconWelfare project identified five maturity stages of animal welfare development, namely compliance legislation, raising awareness, product development, marketing and integrating with other related issues. These milestones require different abatement measures and target groups. For example the basic prerequisite in animal welfare development is to comply with the legal minimum requirements, with a specific target group of farmers which may be achieved through sharing best practices to improve animal welfare (Spoolder *et al.*, 2011).

Even though, in general, attention and understanding of the concept and assessment techniques of animal welfare have increased, some industries have not been very vocal about this issue, particularly in developing countries where the focus of animal production has been on economic aspects to ensure long-term business survival. In some cases the belief is that implementation of welfare regulations will reduce animal performance. Thus, some studies have suggested alternative pragmatic approach to improving animal welfare, such as the setting of standards and provision of guidance of good practice, rather than a regulations and enforcement approach which may not suitable in all cases and may create a lack interest from industry players. The most important factor would be to ensure sufficient adequately trained qualified personnel who are responsible for providing a certain degree of animal comfort whilst maintaining productivity (Seng and Laporte, 2005).

In broiler production systems which entail a degree of confinement and restriction of natural behaviour, and in intensive systems particularly, it is alleged that animal welfare is poor and inherently linked with environmental degradation (Rose, 1997; Siegford *et al.*, 2008). Nevertheless several studies in recent years have shown contradictory findings, at least in respect of environmental impact; through a detailed environmental assessment analysis, Williams *et al.* (2006) and Leinonen *et al.* (2012) showed that low input and typically extensive or semi-intensive production systems actually produced higher burdens to the environment than intensive systems.

In Malaysia, although welfare on farms is considered by a number of government departments (e.g. Department of Veterinary Services - DVS), there are as yet no laws or codes relating to animal welfare. However, a large number of producers adopt Good Animal Husbandry Production (GAHP) methods, which are designed to cover the well-being of farm animals. GAHP requires producers to ensure animals are farmed to meet certain quality requirements including biosecurity, they must have an efficient heard health management plan and complete a GAHP checklist annually and then update this every two years. GAHP also requires producers to meet certain food safety aspects, such as identification and track all animals which received veterinary treatment and maintain medication and treatment records (DVS, 2001). Given that broilers which are healthy will grow faster and be more efficient than unhealthy birds, it might therefore be expected that freedom from injury and disease is addressed to some degree in Malaysian broiler production.

2.5 Broiler Production in Malaysia

Poultry production in Malaysia is important in providing both a high quality and low-cost source of protein for direct consumption, besides raw material for the downstream poultry meat processing industry. The growth of this sector is very encouraging, with the quantity of production increasing by 5.3% annually for the period of 2005-2009, due to active participation from the private sector (DVS, 2010 and 2011b). In general, the poultry sector has been transformed into a commercial and large scale industry with strong linkages with other industries, such as processing, and with efficient transportation and storage systems.

According to the DVS report in 2009, there were 3,239 broiler farms in operation in Malaysia, carrying a standing population of nearly 1.20 million broiler chickens. Of these birds, 22.9% were from large farms with more than 50,000 broilers per cycle while 26.2% were from medium scale farms ranging between 20,000 to 50,000 broilers per cycle, and the rest were from small farms with less than 20,000 broilers per cycle. The states of Johor, Sarawak and Perak are the major broiler producers, accounting for 52% of total national production and recent developments of growing demand from the population in Borneo Island (Sabah, Sarawak, Brunei and Kalimantan, Indonesia) have led to an expansion of broiler production in Sarawak. Between the years 2000 to 2009, average annual broiler meat output grew from 0.71 million tonnes to 1.20 million tonnes.

Integrators, who supply the intermediate inputs and own the output, are the major players in providing working capital and movable stocks in the farm. Producers, who provide the primary inputs in the production process, receive a guaranteed wage or growing fee for each live bird based on its live weight, according to conditions that are predetermined and agreed upon through contractual obligation. Integrator companies and producers have their responsibilities and agreement throughout this period as summarised in Table 2.1.

Table 2.1: Standard responsibilities of broiler chicken producers and integrators in Malaysia

Producer	**Integrator**
Requirements:	**Provides:**
Skills (or by training)	Breeders / Hatchery / Day old chicks
Capital (or loan application) for:	Processing Plant / Cooling Room
House	Feed Supply
Utilities	Veterinary Services / Research
Electric generators	Transport
Land (own or rent)	
Bedding material	
Workers to look after birds and clean between each batch	

Figure 2.1 shows the flowchart of how producers and integrators interact, which is vital to ensure that the quality of chicken meets the requirements and, at the same time, that the producers can make a profit.

Generally there are three different poultry housing systems used in Malaysia. Firstly, extensive systems which include free range and backyard systems. The free range system allows poultry to scavenge over a wide area and normally uses no specific poultry houses. The poultry do not necessarily have access to shelter and may roost outside, usually in trees. For backyard systems, the poultry are housed at night. The food resources for extensive systems are home-produced grains and household waste on a small scale. They involve 12,000 farmers, mainly for subsistence purposes.

The second system is the semi-intensive system, which is special for indigenous cross breed chickens, and involves 80 commercial and semi-commercial farms. The poultry are confined to a certain area with access to shelter. There are various types of housing used, from modern houses to simple housing made from locally available materials.

For both extensive and semi-intensive production systems, the level of disease control and nature of any poultry health programmes varies considerably. Some small scale semi-intensive producers get advice on disease control and health programmes from the Government extension department, while extensive producers use their experience, such as separating infected chickens and proper spacing arrangements, to overcome any disease problems.

The third system is the intensive system, which consists of two main types of broiler housing system, namely closed house (CH) and open house (OH) systems, both of which are found at large and medium scales. These systems contribute more than 90% of broiler production in Malaysia. Even though there is no exact ratio figure of these housing systems according to farm size mentioned earlier, the DVS and Malaysia Agriculture Research Development Institute (MARDI) as implementation agencies related to broiler production agreed that the estimated ratio of the OH and CH systems for national production is approximately 60:40. In addition to that, Serin *et al.* (2011b) indicated that 31% of 189 farms in their survey used the CH system in their production. The following section will focus on a description of the typical layout of these housing systems.

2.5.1 Development of farm and facilities

i. Location: Location of the housing system should not be within an area under structural planning of the district or one which is to be developed for public use, i.e. at least 0.2 kilometres from developed areas such as residential, industrial, tourist attractions or public places. The site should be provided with good basic facilities such as road access, a drainage system and electricity supply.

ii. Floor systems: There are two types of floor, namely deep litter and raised floors. The deep litter system normally comprises a cement or concrete floor which is covered with wood shavings 5-8 cm thick as a form of bedding. The raised floor system consists of a perforated floor which is suspended about 0.9 m above the ground and is made from wood or hard wire which is arranged in a slatted shape (spacing of approximately 2.54 x 2.54 cm) to allow excreta to pass through to the earth.

iii. Housing design: The CH system is generally of a modern design, with concrete walls and a controlled internal environment. The OH system which typically has a slatted floor, open walls with wire netting and moveable curtains, while the temperature, humidity and air circulation are controlled manually by opening/closing the curtains. Both closed and open housing systems can have single or double levels. Table 2.2 shows the typical dimensions for the CH and OH systems. Deep litter and raised floor houses also refer to the CH and OH systems respectively. The floor space in CH and OH systems is approximately 0.09 m^2 and 0.12 m^2 per bird respectively. Feed provided for both housing systems is generally a commercially compounded ration.

Table 2.2: Housing design measurements for closed and open houses

	Closed House	**Open House**
Width (m)	5.5 – 12.0	5.5 – 12.0
Length (m)	depending on need	depending on need
Floor to roof height (m)	at least 3.6	at least 3.6
Floor to ceiling height (m)	2.5 - 3.0	2.5 - 3.0
Ground to floor height (m)	-	0.9
Length of roof side (m)	1.5	1.5
Roof gradient (°)	at least 1-20	at least 1-20

The long axis should be located in an east-west direction to reduce the effects of direct sunlight on the birds. Examples of all housing systems, as well as for broiler breeders (which are also kept in a CH system condition with a deep litter shed), are shown in Figures 2.2 to 2.5.

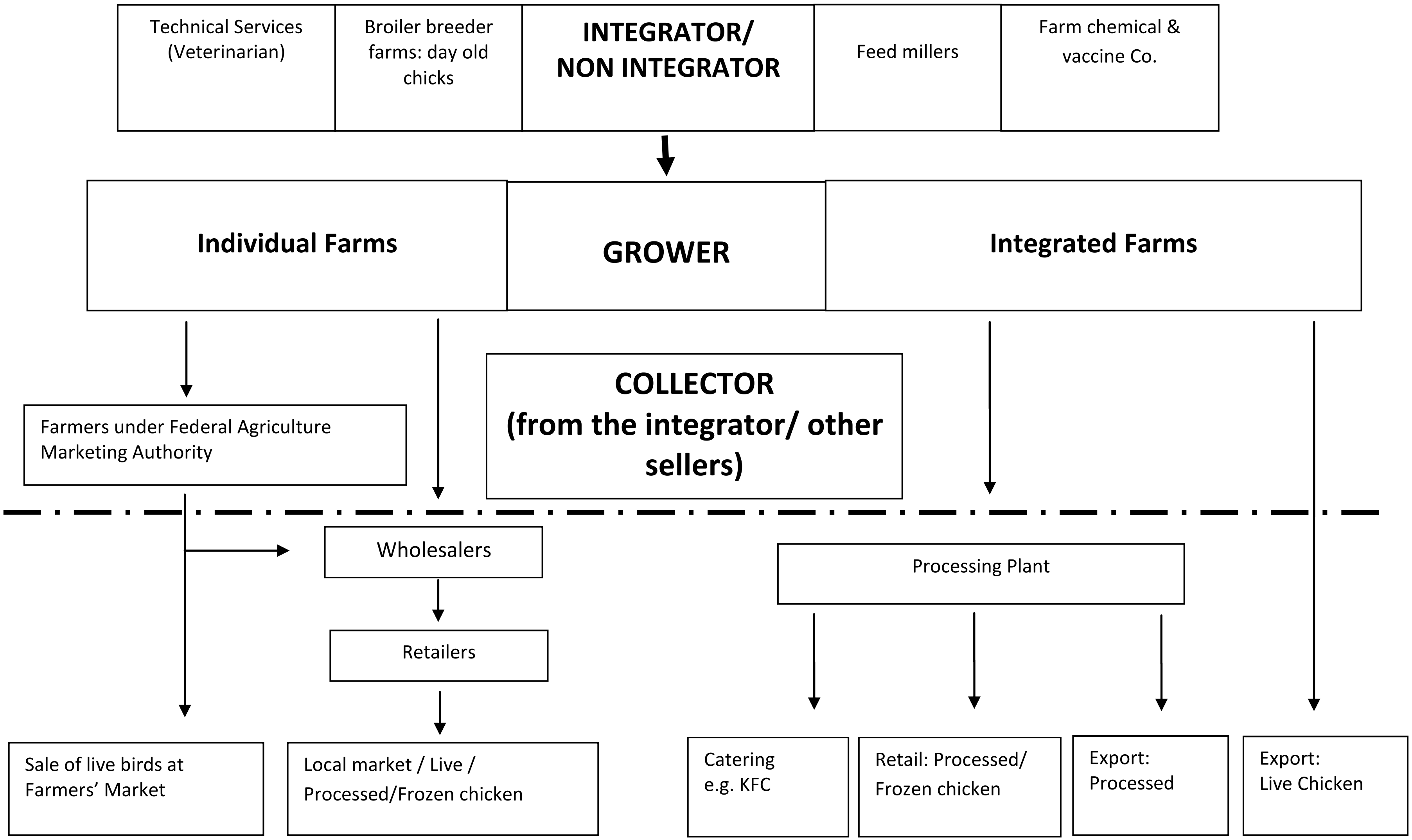


Figure 2.1: Broiler production supply chain in Malaysia (modified after DVS, Malaysia Report, 2011)

Figure 2.2: Intensive closed house system for broilers using the Ross/Cobb genotype (external/internal views)

Figure 2.3: Intensive open house system for broilers using the Ross/Cobb genotype (external/internal views)

Figure 2.4: Semi-intensive housing system of broiler production using local breeds – the Naked Neck breed (external/internal views)

Figure 2.5: Breeder production with views inside/outside the house

iv. Preparation for brooding stage: The brooding period occupies a significant part of the life of broiler chickens, typically 17 days. There are two systems of brooding broiler chicks, namely spot brooding and whole house brooding and the majority of Malaysian producers use the former method. Temporary barriers (brooder surrounds, made out of cardboard, plywood or wire with a height and diameter of about 45 cm and 214 cm respectively) are used to confine the chicks to the desired areas of heat and in which water and feed are made readily available. Besides that, the thickness of bedding in the brooding area is increased to approximately 8-10 cm. A correct temperature is indicated by the chicks being evenly spread throughout the brooding area.

2.5.2 Other selected factors along the broiler production chain

This sub-section is created to facilitate understanding of the current situation of broiler production in Malaysia and its integration within the food production system. It will outline some important information about the background, current status and future prospects of broiler production. The selected factors are divided into three phases, namely prior to production, after production and other external factors.

Before exploring the selected factors mentioned above, an important guideline, namely the Poultry Farming Enactment 2005, needs to be introduced. The enactment acts as an umbrella to all activities related to broiler production systems and provides comprehensive instructions which cover administration, licensing and offences as well as enforcement and prosecution elements. In addition, the enactment is also able to create a more organized and environmentally-friendly poultry farming system through the enforcement of licensing and regulation of poultry farming and poultry related activities.

1. Prior to production: Rationalisation of land use through a zoning approach

As mentioned in Section 1.1, one of the efforts used to increase livestock production in Malaysia is through promoting livestock production in specific geographical zones within the country. For the poultry industry, the approach requires producers to raise broiler chickens in designated areas through the development of a Permanent Chicken

Production Park (TKPA). TKPA concept involves cooperation of the State Government, Federal Government and producers as follows: -

a. Since land is a state matter pursuant to the Federal Constitution, thus the State Government has agreed to designate specific area for poultry production.
b. The Federal Government is responsible for providing the basic infrastructure, i.e. a design and layout plan, site preparation, drainage, perimeter fence and farm roads.
c. Producers and private companies can invest in broiler production through lease of land at attractive rates within the TKPA area for a specific period. Preparation of a business plan is a prerequisite of application to ensure the project is viable and can meet the production target.

The zoning approach is also intended to establish a disease free status within the designated area and to ensure biosecurity management; disease status and surveillance activities can be closely monitored. To date a total of 11 TKPA areas covering 1,685 ha and 800 ha has been identified and developed respectively.

ii. Horizontal and vertical integration production chains

In Section 2.3 it was stated that a positive change in the global poultry industry was due to greater acceptance of vertically and horizontally integrated production chains. Typical poultry farm arrangements in Malaysia are in the form of horizontal integration, which integration involves relationships between farms at the same production process. For example, a large company-owned broiler farm could be horizontally integrated with a small operation owned and operated by an independent producer. However, the trend towards vertically integrated production chains has been increasingly practiced by the integrators (Serin *et al.,* 2011b). The vertical integration refers to a single company which is involved in different parts of the production chain (e.g. the company may own and operate broiler and breeder farms, the hatchery, feed mills, slaughter and processing plants) and which can produce complementary products and services more profitably than a number of farms. In so doing transaction costs (including exchange rate) are reduced, and there is potential to improve product quality and homogeneity and also facilitate dissemination of technology amongst the subsidiaries. Thus balancing the well-established horizontally integrated approach with the new vertically-integrated approach is needed to ensure the true potential of the poultry industry can be achieved. FAO reported that vertical integration is likely to become even more important in the coming decades in most developing countries of the Asia-Pacific region (FAO, 2002).

2. After production stage:

i. Market and ceiling (or maximum) prices

Besides paddy (rice) cultivation, which as a staple food for the population has price policy instruments such as a guaranteed minimum price, price control, price and input subsidies, the prices of other food products in Malaysia, are generally determined by the interaction of supply and demand. However, there can be some exceptions this. Some food products are subject to the Price Control and Anti-Profiteering Act 2011 (formerly Price Control Act 1946), an act to control the price of goods and charges for services and to prohibit profiteering. This Act defines price-controlled goods as goods in respect of which minimum or maximum or fixed prices have been determined which may include charges for any service in relation to the supply, delivery, repair, maintenance, packing, carriage or storage of such goods. Currently three food items are considered as controlled goods, namely refined sugar (coarse and fine), flour and cooking oil (pure and blended palm oil). Previously, chicken meat was considered as control item; however it was repealed in 2008.

Another relevant piece of legislation is the Festive Season Price-Controlled Scheme which has been implemented in 2000 under the abovementioned Act. Under this scheme, six major festive seasons and a number of essential festive season goods are identified as price-controlled goods and the ceiling selling price will be determined according to areas and districts for a specified period. Again the main objective of this legislation is to protect consumers against profiteering. Chicken meat is one of the identified products.

Regarding animal feed which is contribute approximately 60-70% of cost of broiler production, the feed manufacturers need a consistence supply of raw materials to meet standard nutrient for chicken development. However small-scale animal feed manufacturers face challenges in getting supplies of raw materials, particularly maize, soybean and palm kernel cake (PKC), at competitive prices which made them difficult to compete with large-scale manufacturers in terms of price and quality of products. Thus the Government interventions are required to assist and support the growth of small-scale feed manufacturers (DVS, 2011b).

ii. Grading, packaging and labelling of agricultural products

In order to enhance the efficiency of marketing local produce and to maintain competitiveness of market share for both domestic and overseas markets, a Regulation of Grading, Packaging and Labelling of Agricultural Produce 2008 was enforced in 2011. This regulation requires that all agricultural produce is graded, packaged and labelled before they are marketed (whether for domestic, export or import). To date only seven agricultural products are covered by this regulation, namely fresh vegetables, fresh fruit, fresh cut flowers, groundnuts, coconuts, coffee beans and sugar cane stem. Crop products are considered as established agricultural sub-sector and currently no livestock products covered under this regulation. Since the implementation is considered new, there is a need to see the impact of this legislation on the industry and consumers before it might be extended to other food products.

iii. Sanitary and Phytosanitary Measures

Besides grading, packaging and labelling aspects, Malaysia who signing the Uruguay Round Agreement needs to ensure the existing relevant laws and regulations, namely the Plant Quarantine Act 1976 and the Rules of Plant Quarantine 1981; the Animal Ordinance 1953 (revised 2006) and related rules and orders; Fisheries Act 1993; and Food Act 1983 as well as Food Regulations 1985 are conformed to the Agreement on Sanitary and Phytosanitary Measures. To be specific for animal, sanitary measures are vital to protect livestock and products from diseases-causing organisms, additives and toxin. These measures which are based on scientific evidence and risk assessment including product criteria, quarantine, processing requirements, certifications, inspection, testing and health-related labelling, are able to facilitate and strengthen marketing strategy. Moreover, since these measures are able to avoid any sort of unjustified barriers, they may have a direct or indirect impact on international trade. Three groups are benefited from these measures, namely consumers, exporters and importers in the form of six advantages area as follows:-

i. Consumers: being supplied with safe livestock products to eat according to the appropriate standards;
ii. Exporter: Safety regulations are not being used as an excuse for protection of domestic producers;
iii. Exporter: Eliminate the unnecessary and unjustified trade barriers;
iv. Exporter: Create positive international competition among producers regarding safer and healthier food production;
v. Consumer/Exporters: increased the amount of available information as a results of greater transparency in governmental producer; and
vi. Importers: increase the amount of available information unjustified measures.

iv. Halal products for local and international markets

Production of meat specifically for Muslim people is an important issue in Malaysia. Halal chickens, which refers to slaughtering techniques according to Sharia Law, is an important issue among consumers, since 60% of the Malaysian population is Muslim (MOA, 2010b). At the same time, with proper planning and strategies in handling this issue, Malaysia can take an advantage of being a Muslim country to promote and expand the marketing of halal products at the global market which is estimated to be US$547 billion a year (MGCCI, 2011). The potential to promote halal chicken-based products in the international market will be elaborated in Chapter 5 of this thesis.

Currently the certification of halal-related matters in Malaysia is undertaken by the State Government, since religion-related matters are under state jurisdiction includes monitoring slaughter plants. Meanwhile at a Federal level, certification of halal matters is coordinated by JAKIM (Malaysia Department of Islamic Development) with wider functions including monitoring overseas abattoirs and active collaboration with other agencies in promoting Malaysian halal products. The development of halal products has become an increasingly important sector especially with increasing demand mainly from the Middle East countries with total export of 5,413 tonnes in 2007 (MOA, 2010b).

v. Other aspects of differentiation and labelling

Currently there is no difference price between the chicken meat from the CH and OH systems and labelling of meat products including the information related to GAHP activities have yet to be implemented under the existing regulation, i.e. Regulation of Grading, Packaging and Labelling of Agricultural Produce 2008.

Nevertheless since majority of Malaysia population is Muslim, most manufacturers take an additional step as a marketing strategy to use of label Halal to indicate meat as permissible to be consumed by Muslim. The manufacturers need to comply specific requirements before their product could be labelled as Halal and subjected with the Trade Description Act (Use of the term 'HALAL') 1975.

3. Other external factors:

i. Dependence on foreign labour

Structural changes in the economy from agriculture-based to manufacturing and services have resulted in the formation of dualism in the labour markets in Malaysia, namely primary and secondary labour markets (Ismail *et al.*, 2003). The primary labour market (especially in manufacturing and service sectors) is characterised as stable, with relatively high wages and a pleasant working environment, whilst the secondary labour market is characterised by irregular employment, low wages and unpleasant and risky employment conditions. As a result, Malaysian people are more interested in jobs in the primary market, while the secondary market tends to be filled by foreign workers.

The involvement of foreign workers in the agro-food sector (excluding plantations) in Malaysia has increased from 124,000 in 2006 to 191,000 in 2009 and is expected to increase to 294,000 in 2015 if there is no intervention by the Government. At the same time, recruitment of foreign workers must comply with the guidelines and regulations as stipulated in Policy and Practice in the Employment of Foreign Workers by the Ministry of Home Affairs and the Ministry of Human Resources. These regulations cover factors such as having a work permit, facilities and security which sometimes lead to problems retaining trained workers.

ii. Tax Incentives

Even though the broiler industry in Malaysia is private-sector driven, the government still has a role in providing an annual allocation of the national budget for a poultry development program to cover extension services, disease control and prevention, control of imports and exports of live chickens and chicken products. In addition the Government has also provided several tax incentives to stimulate growth of the poultry industry in the form of both direct and indirect tax incentives.

a. Direct tax incentives

The direct tax incentives are designed to grant partial or total relief from the payment of income tax or in the form of an allowance for a limited period of time under the Income Tax Act 1967. Currently, the Incentive for Modernization of Chicken and Duck Production has been provided for the sub-sector poultry.

In addition, there are several incentives which may indirectly benefit poultry producers such as the Incentive for Halal Food Production and the Incentive for Export. The former incentive entitles companies producing halal food to Investment Tax Allowance of 100% for qualifying capital expenditure incurred within a period of 5 years. The latter incentive is to promote export thus the eligible companies qualify for a tax exemption on statutory income equivalent to 10-15% of the value of increased exports.

Although it is no longer available, a previous government incentive called the Reinvestment Allowance (RA) under the Income Tax scheme was established for the period 2003-2010 with the objective of promoting producers to convert from OH to CH systems in the same location or alternatively construction of new CH systems in new areas. On qualifying, RA was eligible for 60% of the capital expenditure incurred by the producer. This incentive understandably received a positive reaction from broiler producers and integrators. In total the Government allocated RM595 million worth of investment and 46 poultry farms have benefited from the implementation of this incentive.

Since direct incentives are generally designed for a limited period of time, whether or not they will be reintroduced will depend upon national financial capability.

b. Indirect tax incentive

The indirect tax incentives are given in the form of exemptions from import duty under the Customs Act 1967. Currently import duties are paid by importers for certain goods at a specific rate. In relation to broiler production, to construct a CH system requires some imported materials such as machinery parts; implementation of this incentive in the form of indirect tax will have a positive impact especially to reduce cost of production.

iii. Equitable nation economic distribution

In the tenth Malaysia Plan (10^{th} MP), a blueprint for the development programmes of Malaysia between 2011 and 2015, there are five key thrusts. One of these thrusts is moving towards inclusive socio-economic development with the objective to enable equitable opportunities for all Malaysians. This is to ensure all ethnicities are able to participate in and benefit from economic growth and includes enhancing the economic participation of Bumiputera (an indigenous race of Malaysia) to address imbalances represented in employment, in ownership of assets such as property and corporate equity, and in high value-added activities. Since the target of attaining at least 30% Bumiputera equity ownership at a macro level has yet to be achieved, this will continue to be a major thrust of Malaysia's economic policy with improvement in strategies such as strengthening Bumiputera entrepreneurship to help create competitive businesses in high impact sectors (EPU, 2010).

The thrust towards inclusive socio-economic development is very relevant to the agriculture sector since approximately 62% of Bumiputera are involved in this sector, mainly in small scale production (Osman, 2009). A similar trend is seen in the broiler industry, where 52% of contract farmers are Bumiputera (Serin *et al.,* 2011b). Thus recommendations to stimulate and promote Bumiputera participation at an advanced level will be explored subsequently in this thesis.

2.6 Importance of Housing Systems in the Poultry Industry and Their Role for Sustainable Production

The selection of a particular housing system and implementation of good management are essential components of poultry production. The importance of these factors has been emphasised by Moreng and Avens (1991) and Rose (1997), who stated that housing and suitable equipment should be designed to create a comfortable environment with minimum stress for optimal egg or meat production. The relationship between selection and management of a housing system with the level of productivity and cost of production is very significant (Moreng and Avens, 1991; Rose, 1997). In relation to environmental concerns, selection of the housing system not only determines the level of productivity, but also affects the ability to collect manure which then can be processed into valuable products such as fertilizer, soil amendments, animal feed (when mixed with feed grain, especially for cattle and fish) or used as fuel source to produce heat energy (Bolan *et al*., 2010).

Havenstein *et al.* (2003) stated that the improvement in commercial broiler performance started from the 1950s, arising from selection of genetically superior birds, improvement in poultry nutrition and enhancement of the climatic environment through housing design. Winchell (2001) identified some requirements for broiler production, such as good location, e.g. zoning areas that are accessible for transportation with good water source and a well-insulated building equipped with proper ventilation, heating, lighting, feeding and watering systems, which are able to contribute to high production. These are the basic requirements in all types of poultry housing system, although the type of houses may differ greatly in size, appearance and arrangement (Winchell, 2001). Sainsbury (1992) emphasised the importance of good feeding routine, excellent management of the litter, fine control of the environment, constant and careful care of the chicken as being necessary to achieve satisfactory output of production. At higher production levels, poultry will become more sensitive to the climatic condition inside the house which finally influences the level of wellbeing and health of the chickens (Hulzebosch, 2004).

Environmental temperature is a major factor influencing the climate conditions inside the poultry house. Poultry species are ectothermic, i.e. they rely primarily on internal sources of heat to maintain their body temperature at a relatively constant level, regardless of the ambient temperature. The poultry body temperature is usually greater than the ambient temperature, thus heat will continually be lost to the environment through two categories encompassing four mechanisms, namely sensible heat losses (through convection, conduction and radiation mechanisms) and insensible heat loss (through water evaporation mechanism) (Rose, 1997).

Newly hatched chicks are unable to control their body temperature and so must be provided with an initial ambient temperature of 33-37°C. The temperature should than be reduced by 3°C per week and maintained at 21-24°C in week three (Moreng and Avens, 1991). At the post-brooding stage, the housing temperature should be maintained at the average of 32-34°C, 30°C, 26°C, 22°C and 20°C for first day, first, second, third and fourth week respectively. Therefore excessively high ambient temperatures coupled with high humidity can be devastating to the chickens and consequently lower productive efficiency (Butcher and Miles, 1996). The management of optimal temperature varies, depending on climatic factors. Yalcin *et al.* (1997) stated that the production methods used in tropical regions may result in economic losses to producers in temperate regions, with increased cost of production due to increases in energy input cost to achieve the required ambient temperature (Yalcin *et al.*, 1997). In contrast, in tropical regions such as Malaysia, often the ambient temperature is such that little extra energy is needed to keep chickens warm. Instead efforts can often be concentrated in ensuring adequate ventilation so that birds do not develop hyperthermia as a result of exposure to heat stress. Sainsbury (1992) indicated that all changes in temperature in the house should be made steadily and regularly to avoid stress to chickens.

Another important aspect to consider in order to provide a comfortable environment for broilers is the ventilation system, which is the process of supplying fresh air to, and getting rid of polluted air from, the poultry house. Good ventilation is able to control temperature and humidity, create a comfortable environment for the birds and increase efficiency of food conversion ratio (FCR), healthy growth and low mortality rate. Ventilation plays a crucial role in bird performance and income. Blakely (2008) stated that bodyweight and feed conversion efficiency can be impaired by improper management of ventilation, which ultimately will lead to significant financial loss to the grower and integrator. Thus, good agricultural practice to maintain an optimal environment in the house is crucial through proper management of ventilation. This is not only able to minimise flock weight differences, but also can maximise profit for both the grower and integrator.

Given the general characteristics of the domestic poultry industry and the transformation of global food demand, which witnessed the most dramatic increases in per-capita consumption of any animal food products, coupled with the essential links between the global food security and sustainability, there are two imperatives for action: firstly to ensure secure supplies of food for future generations and secondly to achieve sustainable food production. Based on the current scenario of poultry production as mentioned above, the challenges to meet food security and food sustainability can be divided into two major aspects, namely unsustainable use of resources i.e. exploiting global resources much faster than they are being replenished, and ineffective food distribution systems which have failed to end hunger. Therefore, the aim of the current study, which is based on three objectives as stated in Chapter 1, is to find the best practice in poultry production with optimal use of resources and able to achieve economic expectations without compromising the social acceptance.

The following sections will focus on the background of the two aspects mentioned above, regarding environmental and economic assessments, and how these will influence the public wellbeing and policy directions on the future of the broiler industry in Malaysia. This will include the theoretical basis used in this study and how these two aspects are interconnected, the concept, the related previous studies and the application. Chapter 3 will focus on environmental burdens emerging from different poultry housing systems and measure the impact values for each system, while Chapter 4 will estimate the willingness of consumers in Malaysia to pay more for chicken meat produced with a higher regard for the environment with the consideration of longer term benefits to the environment. In order to secure an equal level of attention from government concerning the relevance of environmental issues for the sustainability of any development programme, it is important to incorporate producers' and integrators' views which can subsequently be translated into feasible strategic interventions in policy implementation, which will be described in Chapter 5.

2.7 Introduction to Environmental Assessment

2.7.1 Environmental assessment tools

Halberg *et al.* (2005) argued that many different environmental assessment tools have been developed in order to determine the environmental impact of various agricultural enterprises and systems. However, the relationship between agricultural activities and their environmental impact usually cannot be directly measured because of the emissions characteristics, i.e. the particles can move past one another easily due to free space between particles, thus are spreading out in all directions. Therefore, indicators are used to give estimates of environmental impact which are derived from selected parameters according to specific objectives; the whole idea in using indicators is to simplify this complex phenomenon (Halberg *et al.*, 2005). Normally, most agro-environment indicators use land and process-based approaches, such as nutrient requirement per hectare, as a scale to measure the environmental impact. But there is an increasing interest to assess the impact beyond the process level, which is to include the product-based approach with its life cycle, meaning that the impact will comprise other activities in the production cycle including the process of cultivating of crops, the use of product and other inputs at all levels.

For example, in 1999 the European Environmental Agency introduced agri-environmental assessment based on Drive Force – Pressure – State – Impact - Response (DPSIR) methodology. In this method the driving forces are identified, arising from either internal or external sources such as financial policies and market demand. This is followed by pressure which acts on the system such as welfare issues. Figure 2.6

illustrates how the method has been used to assess the environmental impact of broiler production in Brazil. Here the production size of the farm and number of farms can be defined as parameters in the present state of the system. The combined effects from other factors of driving forces, pressures, impacts and responses will be aggregated to give an impact for the system and finally it is possible to identify how the system tries to respond in order to remain efficient and productive. Figure 2.6 provides an example of DPSIR methodology as used for poultry production by Bonaudo *et al.* (2010).

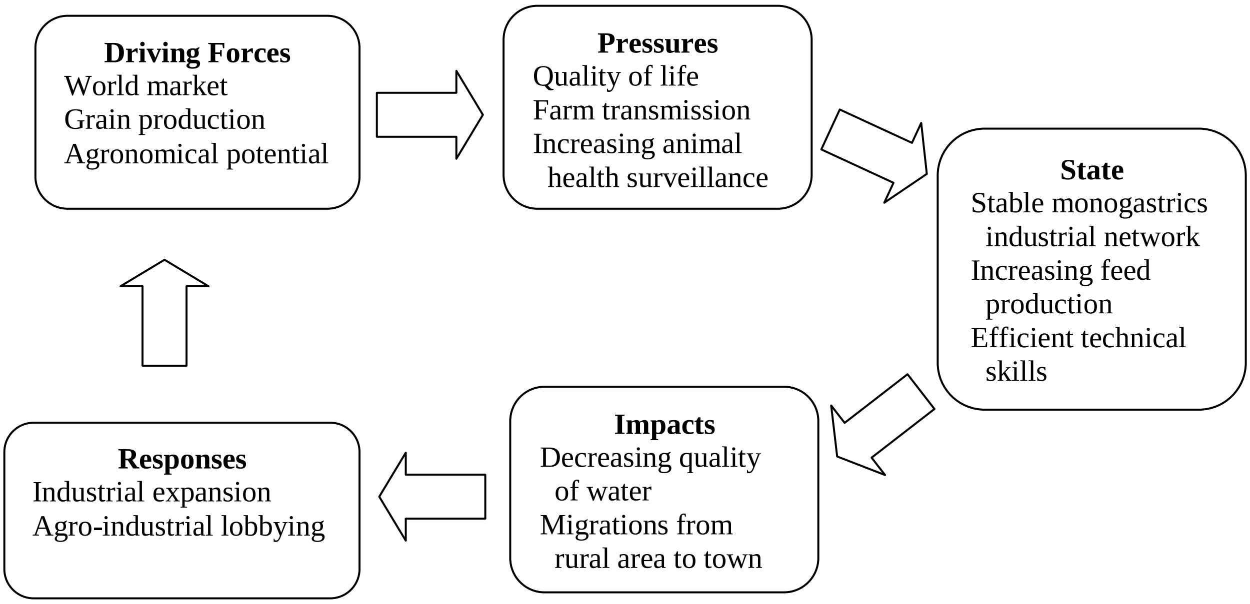


Figure 2.6: DPSIR methodology used in broiler production at Rio Verde, Brazil (Bonaudo *et al.*, 2010)

The DPSIR methodology, which was initially proposed by The Organisation for Economic Co-operation and Development (OECD) has been applied to various assessment tools such as Green Accounts (GA), Ecopoints (EPs), Environmental Management for Agriculture (EMA), Life Cycle Analysis (LCA) and Ecological Footprint Analysis (EFA). All environmental assessment tools are meant for voluntary use and vary, i.e. have no rigid conditions and depend on the environmental issues and type of indicators used, such as the use of direct non-renewable energy, soil erosion, and emission of nitrogen or natural biodiversity. The appropriate assessment tool should be able to link with the planning of the production, which requires participation at farm level, since the objective of the assessment is to improve the environmental performance on the particular farm (Halberg *et al.*, 2005; Bonaudo *et al.*, 2010).

All arguments on the strengths and weaknesses of each environmental tool are based on Halberg *et al.* (2005) study. They argued that GA and EFA tools are focussed on pressure indicators while other tools are based on driving forces and changes in the state. EPs and EMA only focus on individual farmer practices and management, such as Good Agriculture Practices, which are able to give a fast indication of environmental awareness at farm level but are not appropriate for identifying important impacts that can be used for potential improvement of methods on the farm. GA, EMA, LCA and EFA apply input use indicators as the driving force to indicate the potential pressure on the environment, thus comparison between farms can be conducted.

Input-output indicators such as nutrient surplus, coupled with estimates on emission indicators, were used by GA, EMA and LCA. The former indicator, such as P surplus per hectare, could generate a better proxy for environmental impact than the two indicators mentioned earlier, i.e. cropping practices and resource use. Input-output indicators are easy to assess and more practical, especially to explain to farmers by using classical parameters such as feed conversion ratio (FCR), and are very useful for a benchmarking process between farms. The latter indicator reflects efficiency of resource use which is useful to measure the specific emission impact to the environment, nevertheless the constraint to obtain the precise information about certain gases is still a continuing problem and, most of the time, the estimation may depend on the use of complex models. The weaknesses of using models are the differences of method used between countries, and lead to the difficulty of comparing the impacts level.

Even though all tools are facing difficulty when dealing with emission indicators, LCA provided an additional feature of aggregation of several emissions indicators into impact categories per selected functional unit of the product. Aggregated impact categories have several advantages and will be elaborated in detail in Section 2.8. Due to advantages and weakness of each tool aforementioned, LCA was chosen as the most appropriate tool to obtain a holistic evaluation of the environmental impact of different broiler production systems.

2.7.2 Life Cycle Analysis (LCA)

LCA is the most developed, product-oriented assessment tool for various agri-enterprises and systems (Halberg *et al.,* 2005). Xin *et al.* (2011) stated that LCA is a unique method of analysing the complete inventory and flow of raw materials, energy and waste products during the production and life cycle of a product. LCA has been used since the 1970s for manufacturing and some environmental studies and, more recently, it has been applied within food systems in a way that allows all food production stakeholders (farmers, producers, and manufacturers) to perform a complete spatial and quantitative analyses of the impact of the food production on the surrounding environment, which can lead to the creation of efficient mitigation strategies (Xin *et al.,* 2011).

LCA includes a carbon footprint, which measures the impact that our activities have on the environment and refers to the amount of carbon and other GHGs emitted individually in any one-year period in our day-to-day lives such as through burning fossil fuels for electricity, heating and transportation. For carbon, the units are tonnes (or kg) of carbon dioxide equivalent (Wiedmann and Minx, 2008). In addition, other environmental impacts can also be considered, such as eutrophication potential, as will be discussed in Section 2.8.3.

2.8 Structure and Components of the LCA

LCA is one of the possible tools to assess the environmental impacts associated with the production of goods and services by identifying materials and energy used, as well as waste released to the environment (de Vries and de Boer, 2010). LCA measures the environmental impact from CO_2 through burning fossil fuels for electricity, heating and transportation, including any burdens from the consumption of resources at production until the end of the product’s life. In fact, LCA includes other environmental impact categories such as eutrophication potential, acidification potential, energy use, abiotic resource use and ozone depletion.

The first LCA was conducted in 1969 on beverage containers; the objective of the analysis was to determine which type of container had the least effect on natural resources and the environment (LeVan, 1995). Since then, LCA has been improved to achieve the standard impact assessment of the application. LCA has received International Standard (ISO) recognition through ISO 14040 (Principle and Framework) and ISO 14044 (Requirements and Guidelines) which consists of four categories, namely i) goal and scope definition; ii) inventory analysis; iii) life cycle impact assessment; and iv) life cycle interpretation (ISO, 2006). LCA has been used for decades to assess the environmental impact of the production of industrial products (Dalgaard, 2007).

According to ISO 14040, LCA is defined as a compilation and evaluation of the inputs and outputs and the potential environmental impacts from the product system through its life cycle and consists of four interrelated phases as illustrated in Figure 2.7.

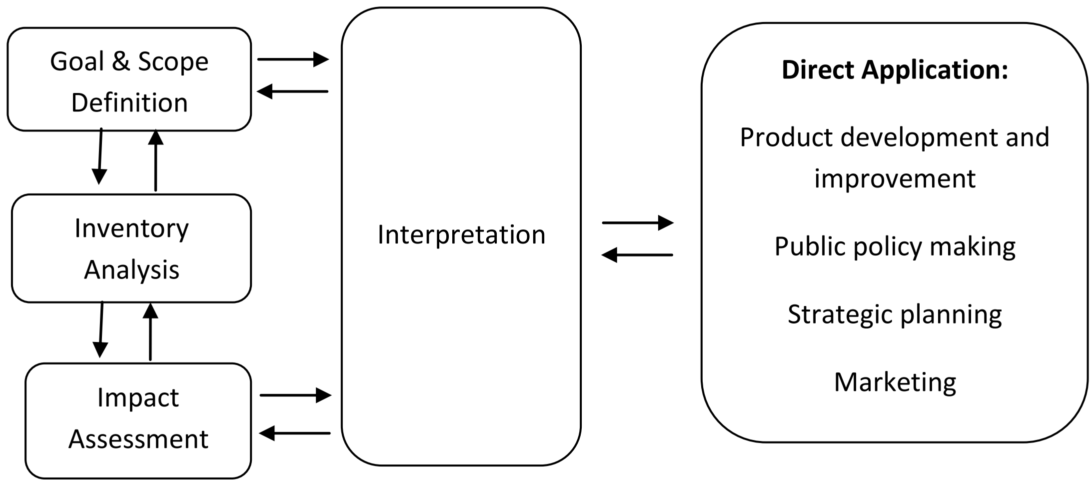


Figure 2.7: Phases and application of the LCA (ISO, 2006)

2.8.1 Goal and scope definition

The first phase of the LCA is the goal and scope definition which provides a plan of application, justification of assessment, a description of the product and its production system. There are two ways of performing the LCA model, using either a consequential or an attributional approach. The consequential approach model is applicable when there are changes in demand for the product and a method is needed to quantify the potential changes to the environment. The attributional approach is suitable for the situation in the Malaysian poultry meat production sector, where the aim is to quantify the relative environmental impact of the two main broiler housing systems.

For those products which produce more than one output, e.g. a forest tree which produces timber, sawdust and bark as the outputs, a description is needed to allocate the products over the different functions and outputs. There are three types of allocations provided, namely system expansion, physical (mass) and economic allocations (de Vries and de Boer, 2010). System expansion refers to the creation of additional functional units for co-products such as animal feed and human food, therefore the system itself can be easily expanded and comparable outputs can be measured. The second type of allocation exists when there are efforts to separate the products according to a physical relationship, e.g. the outputs from a forest tree mentioned earlier which are produced in varying amounts for each output. The third method of allocation refers to the proportion that can be established by partitioning the exchanges of product which reflects some other relationship between them, e.g. the timber produced from a forest tree is estimated to be worth 80% of the total economic value of all outputs with the remaining 20% derived from the sale of sawdust, whilst bark is normally left as waste (Pre Consultants, 2010).

Other elements in the Goal and Scope phase are a description of the system boundaries and the functional unit (FU), the basic element of the product which allows for the comparison of alternative systems of production. A FU can be, for example, one kg chicken meat produced or one tonne of edible carcass meat. However, some products such as livestock animals, a cow for example, may have more than one FU such as either one tonne of live weight, one kg of protein meat, one kg bone-fat-free meat or one kg milk (de Vries and de Boer, 2010).

2.8.2 Inventory analysis

The most demanding task in performing LCA is data collection, the main element of the Inventory Analysis phase. This involves the compilation and quantification of all inputs and outputs required to produce a FU, including both input consumption of resources and waste emission to the environment (Dalgaard, 2007). Data are divided into two categories; first, the foreground data which are needed to model a particular product. In the case of LCA for agricultural products such data have to be collected from farms or companies, frequently by the use of one or more questionnaires. The second type of data are background data, also known as generic data, e.g. type and method of transport, energy consumption, the quantity of manure and amount of gases emitted; such data can be obtained from literature and databases. The ability to collect these comprehensive data is strongly dependent on the time and financial budget available (Pre Consultants, 2010).

2.8.3 Impact assessment

The third phase of the LCA is the Life Cycle Impact Assessment (LCIA). The aim of this phase is to provide fundamental indicators for evaluating the magnitude and significance of potential impacts from the extraction of resources and emissions from the production system. Two types of indicators are distinguished according to their position in the environmental mechanism relationship between emissions and impacts (cause and effect chain), namely midpoint and endpoint indicators. Midpoint indicators are considered to be a point of a particular impact category, prior to the endpoint, which reflects the relative importance of an emission or extraction in a LCIA. Midpoint indicator categories include global warming potential, acidification potential, eutrophication potential, destruction of ozone layer potential and primary energy use. In a midpoint approach, the environmental relevance is generally presented in the form of quantitative relationships and statistics to reflect the relative importance of emissions involved in the lifecycle (Bare *et al*., 2000; Pre Consultants, 2010).

The Environmental Protection Agency (EPA, 2009) refers to global warming as a gradual increase in the overall temperature of the earth's atmosphere and oceans due to increased levels of CO_2, CH_4 and N_2O emissions. The atmospheric consequences of these emissions are predicted to cause a rise in sea levels, increasing severity of storms (such as hurricanes and cyclones), massive crop failure, widespread extinction of species and effects on the human population. Acidification is the process of releasing acidifying pollutants such as sulphur dioxide (SO_2), hydrogen chloride (HCl), NO, and NH_3. Acidification can have severe impacts such as mortality of aquatic life and damage to forests and buildings. Eutrophication is the situation when excessively high levels of nutrients occur which lead to increases in biological productivity, especially in water bodies. Ultimately this reduces the levels of oxygen in water and destroys aquatic ecosystems (Solomon *et al.*, 2007; EPA, 2009).

The second type of impact indicator is an endpoint indicator which is performed to assess the aggregation across impact categories, such as human health, destruction of ecosystem and extinction of species. Extinction of species, for example, is a result of the burdens of multiple midpoint indicators such as land-use, eutrophication and eco-toxicity to the environment. However, the endpoint indicator approach could bring the potential for significant uncertainty since only a small part of the environmental mechanism needs to be modelled (Goedkoop and Spriensma, 2000; Goedkoop *et al.,* 2009; Bare *et al.,* 2000). Endpoint indicators are appropriate to apply when there is a trade-off between products (Rebitzer *et al.* 2004). This means that, the selection of the end points as a point of comparison must be practical and realistic by comparing benefits of the information with the costs of collection (Segnestam, 1999). An example of a trade-off situation is the effort to prevent destruction of ecosystems, such as swamp areas, which require equipment such as remote sensing compared to examining the conditions of the habitat which need a comprehensive preparation. This example shows the comparison of the practicality of the methodology and the cost involved with the benefit gained for society. According to Pre Consultants (2010) even though there are some weaknesses in using endpoint indicators, as mentioned earlier, they have a higher relevance and are much easier to interpret by decision makers for public understanding. The graphic summary to distinguish these impact categories is illustrated in Figure 2.8.

2.8.4 Interpretation phase

According to ISO 14044 (ISO, 2006), the interpretation phase of LCA is the phase where validity and robustness of the assumptions made and results generated are evaluated, including the consistency and sufficiency of the results and sensitivity on representativeness of the model, which then finally draws the conclusions of the whole production system (Goedkoop *et al.,* 2009). The conclusions can be developed either purely based on LCIA values or aggregated impact categories as mentioned earlier. Since endpoint indicators refer to wider impacts, Pennington *et al.* (2004) drew attention to the fact that the decisions from LCA are not only based on natural science but rely heavily on social science and economics.

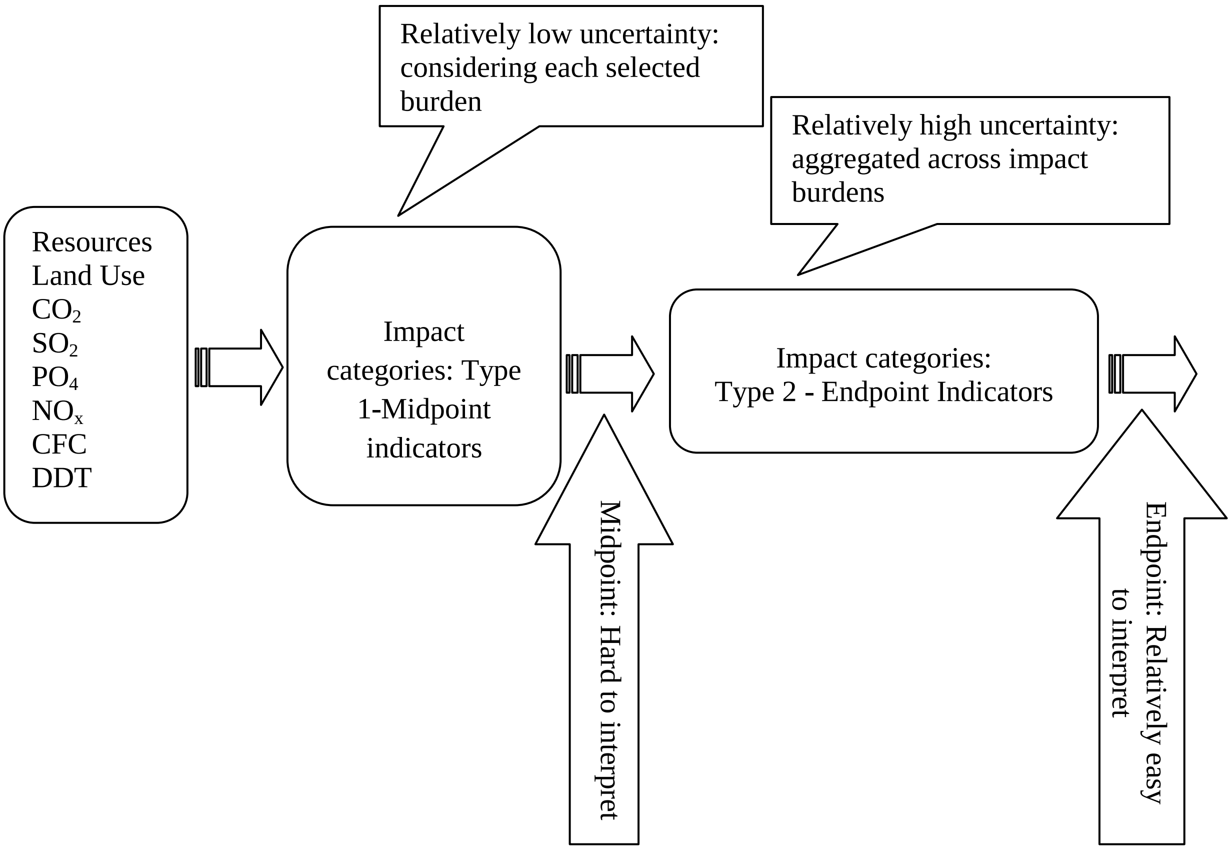


Figure 2.8: Structure of the environmental assessment mechanisms including the inputs of resources used, potential burdens generated which then produce a number of impact categories and their linkages to method of interpretation (modified from ISO, 2006)

2.9 Previous LCA Studies on Livestock Production

Several studies have been conducted to assess the environmental impact from livestock production. The most recent review by de Vries and de Boer (2010) involved 16 peer-reviewed articles, including the production of chicken, beef, pork, milk and eggs. This study identified five criteria, including type of allocation and methodology used as well as the definition of system boundary. Five impact categories were selected to compare the impacts of different systems, namely GWP, AP, EP, Land and Energy Use. This review only covered the studies in OECD countries. Of the 16 studies included, three studies involved broiler chickens as a subject, i.e. broiler chickens from conventional and free range systems in the United Kingdom (U.K), which used 1 tonne dead weight as a functional unit (Williams *et al.*, 2006); and broiler chicken from conventional production system in Finland, which used 1 tonne processed product as a functional unit

(Katajajuuri, 2008). There have been other recent LCA studies conducted to predict environmental burdens of broiler production systems, including some outside OECD countries; two studies used the same FU of 1 tonne live weight of broiler chicken in the United States of America (U.S.A) (Pelletier, 2008) and Italy (Boggia *et al.,* 2010), meanwhile recently Leinonen *et al.* (2012) conducted a study to predict the environmental burdens of the U.K broiler production systems by using 1 tonne of expected edible carcass weight as a functional unit. These three studies used additional environmental impacts than those mentioned above, including ozone depletion. Comparison of the impact value needs to be done with caution, as these studies used different functional unit and impact assessment values. For example, Boggia *et al.* (2010) used normalization scores for impact values, while Leinonen *et al.* (2012) and Pelletier (2008) used the absolute values. Even though the last two studies employed similar absolute values to describe the findings, the data must be interpreted with caution due to dissimilarity of functional unit, besides different sources contributing to selected impact categories. Further details of the comparison with the current study will be elaborated in Chapter 3 of this thesis.

2.10 The Concept of Valuing Environmental Goods

A value in economics has a precise definition - it is the price individuals are willing to pay in order to obtain a good or service. However, according to Asafu (2005) certain goods, especially public goods which are non-rival and non-exclusive in consumption, have zero marginal cost, i.e. the change in total cost that arises when the quantity produced changes by one unit, and are not traded in the market. This creates difficulties to place a value on a good for which no obvious price exists. This is called a Market Failure, which is a basis of environmental economics. In the past, valuations of environmental goods were considered to be zero due to difficulties in assigning economic values. However, nowadays, it is realised that the failure to assign the price means the good is not allocating efficiently and has been contributing to environmental degradation, i.e. pollution, deforestation and ecosystem destruction, due to the tendency for under-pricing the good, which leads to excess demand (Asafu, 2005; Mitchell and Carson, 2005). Thus the failure to consider both benefit and cost in the decision making could lead to underestimation of the contribution of the subject to total welfare economics (WE) (Mitchell and Carson, 2005).

Note that this concept of welfare is different to the well-being of animals discussed previously, rather WE is a theory which allows the comparison of outcomes in terms of their contribution to the utility of the population according to a utilitarian approach. A utilitarian approach refers to the sum of the utility (or welfare) of the society for the production of different combinations of goods. Thus, to put WE into practice, Pareto introduced the concept of Pareto Improvement; this is defined as any policy changes which make at least one person better off without making anyone worse off should be undertaken, and this criterion is referred to as the efficiency of resource allocation. However, in reality, it is difficult to find a way of resource allocation which does not impose costs to someone, and almost all development projects can cause at least one loser. Therefore, Kaldor & Hicks in the 1930s proposed a new principle known as The Potential Pareto Improvement (PPI). The important word here is 'potential', which applies the principle of asking 'Could the gainer compensate the loser, but still be better off'. Another way of stating the PPI is 'are aggregated benefits bigger than aggregated costs'. This is how the PPI criterion provides the link between WE as a theory with cost benefit analysis (CBA) as a practice. CBA eventually emerged out of WE as a practical application to place monetary value on the gains and losses to those affected by policy changes (Hanley *et al.*, 2001). The CBA is one of the systematic processes to compare the benefits and costs of certain project in order to determine feasible projects for investment and implementation.

Since WE comprises the contribution of the goods to the utility of the society (to value the benefit), this involves consumer behaviour and demand as the main component. The demand curve for the good which is well-defined and exclusive consists of two main properties; namely i) diminishing marginal properties; and ii) the maximum price that consumers are willing to pay for a given quantity (Asafu, 2005). However for those goods which are not traded in the market, techniques to estimate the marginal benefit (utility) is by asking the maximum amount an individual is willing to pay (WTP) in order to obtain such goods, or the minimum amount an individual is willing to accept (WTA) as the compensation to go without such goods.

Before considering the detail of the divergence between two choices of welfare measures, namely WTP and WTA, an understanding of the types of economic value is crucial to determine the suitable evaluation methods. A total economic value (TEV) is a technique to assign value for the full array of environmental commodities and services which make up of the benefits of environmental goods into two broad categories, namely use value (instrumental) and non-use value (intrinsic). The former value derives directly or indirectly from the actual use of the goods which satisfy our need, while the latter value arises from the knowledge which is inherent in the goods but unassociated with actual use. The examples of the latter value, such as peoples' concern about the environmental quality or the respect to welfare issues, are often disregarded during the calculation of TEV. Kurtilla, in 1967, agreed with the idea that non-use values, also known as passive values, can be reliably measured and should be explicitly taken into account when he observed that many people value natural amenity and gained utility simply for their existence, and therefore society has a positive WTP for planning and managing the resources (Carson *et al.*, 2001).

Based on the above concept of TEV, which was introduced by Peterson and Sorg in 1987, the model of TEV benefits is conceptually summarized in Figure 2.9, which shows the potential benefits generated by the livestock industry that might be obtained from five categories of values.

Two benefit based approaches (also known as demand curve approaches) have been used to estimate the marginal benefits for passive values, i.e. revealed and stated preference methods. Three types of revealed techniques are commonly used, namely travel cost, hedonic price and benefit transfer methods. The contingent valuation method (CVM) and choice experiment are two types of established stated preference methods (Garrod and Willis 1999; Asafu, 2005).

- *Travel Cost Method* estimates the economic values associated with ecosystems or sites that are used for recreation. The basic assumption underlying the method is the cost for an individual to travel and visit the site as a proxy for WTP and the value of that site.

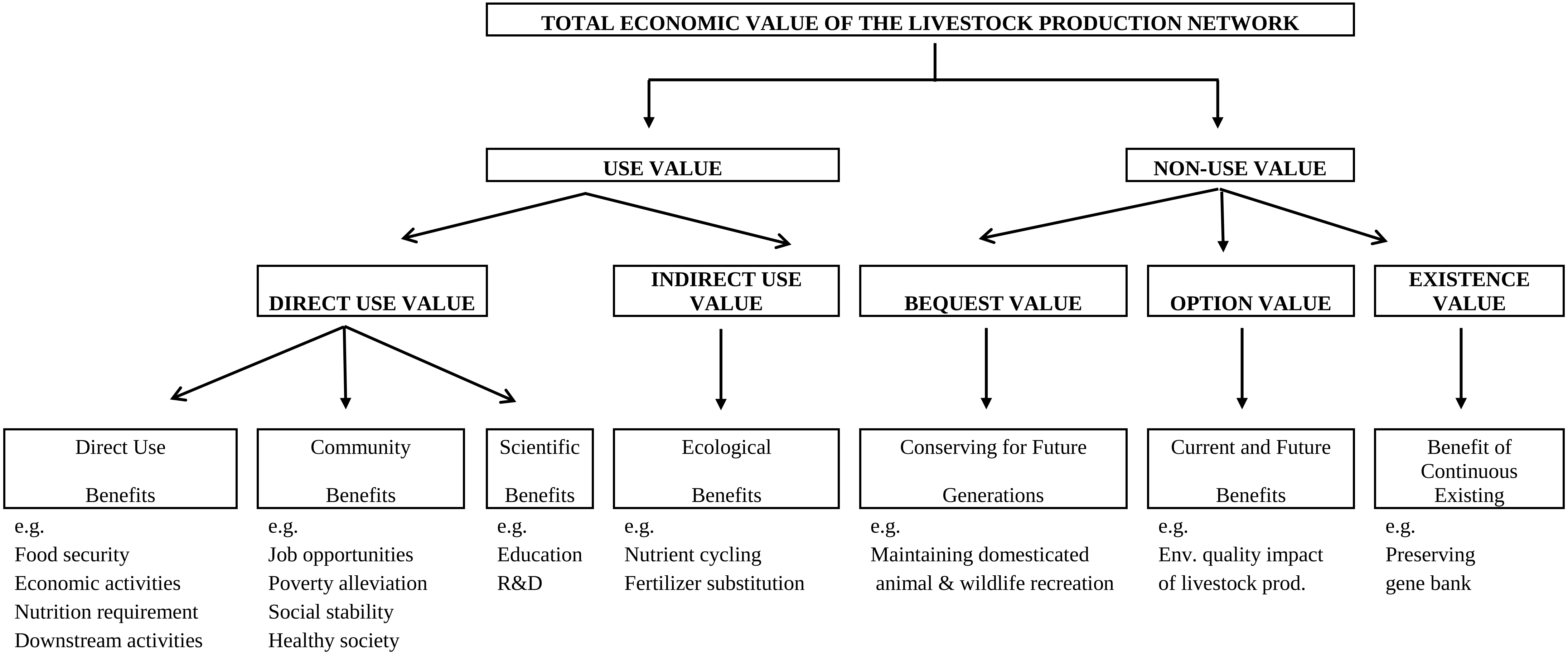


Figure 2.9: A total economic value framework for estimating potential utilities from livestock industry to the society based on five categories of values

- *Hedonic Pricing Method* estimates the economic values for ecosystem or environmental services by using information from the market prices as a close substitution. The classic example for this method is applied to variations in housing prices which are determined by various environmental attributes such as location, amenities and environmental quality. Thus, this method allows measuring the monetary value for a unit change in the housing attributes, i.e. marginal price.

- *Benefit Transfer Method* attempts to adopt the result from previous study to a new situation with similar resources and conditions such as similarity on demographic and physical characteristics; the population in both areas should be similar and the duration between both studies should be within a reasonable period due to preference change over time.

- *Contingent Valuation Method* is used to estimate economic values for virtually any ecosystem or environmental services. The most widely used method of a CVM is by asking people of their willingness to pay directly based on a hypothetical scenario. The detail of this method is elaborated in the following section.

- *Choice Modeling* is used to estimate the non-use value such as preserving a wilderness area by choosing the most preferred alternative uses of the resources such as size of area, number of rare species and accessibility aspects by using multinomial logit model.

2.11 Stated Preference: Contingent Valuation Method (CVM)

Stated Preference, and the CVM in particular, was used in academic research for the first time in 1963 by Robert Davis who examined and elicited directly the value of hunting and wilderness at a recreation area in Maine Woods, U.S.A. In fact, Loomis (2005) stated that only CVM or another related stated preference method could be used to assess most passive values. Since then, stated preference has become very popular and has been applied to a wide range of real world problems, from the issue of environmental quality, wilderness and wildlife conservation to health care and food safety. The most widely known application of CVM was the Exxon oil spill in Alaska in 1989, which ignited the interest in assessing natural resources damage dramatically. The massive oil spill due to grounding of the Valdez oil tanker in the Gulf of Alaska affected 1,300 kilometres of coastline and almost 23,000 birds were killed. The State of Alaska commissioned an interdisciplinary study to identify ecosystem and economic losses by implementing a national CVM to measure the loss of non-use values to the U.S.A citizens as a result of the oil spill. The study, coordinated by Richard Carson, applied a set of guideline by the National Oceanic and Atmospheric Administration Panel (NOAA) and estimated that the loss of non-use values resulting from the Exxon Valdez oil spill was USD2.8 billion (Randall, 1993; Carson *et al.*, 2003).

CVM was applied by Mehrara (2009) to estimate the value of environmental quality aspects, such as drinking water connection issues in Iran. Due to low annual average rainfall of only 250 mm annually, the degree of Government intervention is limited and therefore the study chose the demand-side approach by asking consumers their WTP for drinking from tap water connections. The findings showed that once drinking water taps are connected, the household WTP was approximately 2,399.70 Rials which was equal to 0.2 to 4.8% in addition to their monthly water charges. This additional amount was substantial, and equates to between 1.4 to 40% of average monthly income of the households.

Richardson and Loomis (2008) conducted a survey using CVM to evaluate the passive value in the area of biodiversity (i.e. issues concerning threatened and endangered species) in the U.S.A compared to the rest of world. The survey considered three aspects, namely i) the pattern of WTP values to conserve threatened and endangered species from different locations, ii) comparing the trend of WTP from developed and developing countries; and iii) comparing the choice of elicitation formats. Amongst the major findings in this study was that even though U.S.A respondents seemed on average more willing to pay for conservation than the rest of the world through lump sum payment, they were reluctant and pay less on a recurring scheme. Respondents from low income countries preferred longer payment periods which mean that budget constraints are less binding. These findings also showed that the payment mode played a significant role to maintain a respondent’s willingness participate in preserving biodiversity. In addition, respondents from developing countries showed a higher WTP to preserve national symbolic species. In terms of elicitation format, the study recorded that dichotomous choice gave higher average WTP values compared to an open ended format, and this is consistent with empirical evidence by NOAA which suggests open-ended format often produces lower mean WTP estimates than other formats.

Meanwhile, Glass *et al.* (2005) illustrated the usefulness of CVM as a tool in measuring the animal welfare values in Northern Ireland which should be taken into consideration in possible government policy initiatives. The general public in Northern Ireland were revealed to be willing to pay for a variety of pig welfare improvement methods, representing an increase of household food bill expenditure of 3.6 – 4.7%. Pig welfare improvement methods in this study related current modern ‘factory farming’ to better production methods, with increases in space allowance and provision of elements of environmental enrichment. The Glass *et al.* (2005) results showed that provision of straw bedding, for example, gave a similar significant WTP value to the approach of double the space allowance per pig which would require a massive investment. The information on the alternative options in the survey was considered a good approach which not only reduces the financial implications for pig farmers, but also could increase the understanding among the public regarding welfare issues in pig production.

Lastly, a well-known example of stated preference was the use of the CVM as a tool to evaluate the passive value in food safety issues designed by Fox *et al.* (2002). The study assessed the consumer responses about the potential benefits of irradiated poultry meat, which can reduce the probability of illness caused by salmonella. The survey found that 30% of respondents were willing to pay 10% premium for irradiated meat to reduce the risk of food-borne pathogens.

2.12 Structure and Components of Contingent Valuation Method

As mentioned above, the ultimate aim of any monetary evaluation approach to environmental good is to obtain particularly accurate estimates of the benefit of any changes in quality and quantity of the goods which can then be used in some form of policy and project appraisal. One such example is the established modern welfare economic method of cost-benefit analysis, which operationalized a variant of the Pareto improvement criterion (Mitchell and Carson, 2005). Therefore, in the current study, in order to measure the benefit changes which are represented by a demand curve, the CVM was chosen as a tool to estimate the WTP of consumers for chicken meat produced with a higher regard for the environment (chicken-HRE). A welfare economic measure of WTP was considered to be more appropriate than WTA due to substitution and property right characteristics of the good, which will be explained in detail in Section 2.12.2. The term 'contingent' in the phrase CVM is obtained from the nature of the method, namely that responses are sought as their action contingent on simulating a hypothetical market for the good. The most common approach in CVM is to ask an individual the maximum amount of money they are willing to pay for a given good. There are several procedures in the CVM process which are categorised into three main classes:

1. Description of the good being valued and the comprehensive hypothetical scenario.
2. Elicitation of the respondents' willingness to pay for the good being valued.
3. Socio-demographic and economic characteristics of the respondents.

Four prominent references have been used to explain the structure and components of CVM, namely Garrod and Willis (1999), Pearce *et al.* (2002), Asafu (2005) and Mitchell and Carson (2005). These papers and books have been the basis for the remainder of this section.

2.12.1 Description of the good being valued and the comprehensive hypothetical scenario

The most important element at this stage is the construction of the hypothetical market for the environmental good which is able to provide comprehensive and plausible information to ensure respondents understand the context and realise the potential consequences of the environmental changes. These elements are crucial so that the respondents have some knowledge and belief about the scenario; this aspect will also determine the ability of the respondents to participate and give realistic and truthful answers.

Information on the use of the good in question is also essential to distinguish the common users from non-users. It is also recommended to present sets of photographs or other visual aids about the scenario which will facilitate their understanding. Questions about respondents' attitude to general issues concerning the environmental good in question are also useful to obtain information on the level of awareness and understanding about general environmental issues. More detailed questions about the specific good being valued can then follow.

The second item in the hypothetical scenario stage is the payment vehicle, which describes the way in which the respondent is expected to pay for the good. The payment mode can be coercive, such as taxes or a price increase, or can be a voluntary basis such as donation to any trust fund. However each method has disadvantages, the former payment vehicle might create hostility and may lead to non-response answers, while the latter option invites free-riding behaviour. Pre-testing can explore if the respondents find the method of payment plausible.

2.12.2 Elicitation of respondents' willingness to pay for the good being valued

In this stage, the questions are designed to facilitate the valuation process and to draw out the welfare measure, i.e. peoples' maximum willingness to pay (WTP) or the minimum willingness to accept (WTA) without anchoring biases. The eliciting process involves three steps of procedures, namely i) choice of survey instrument; ii) sample design; and iii) choice of elicitation format. The survey instrument can be administered in a number of ways including by mail (though there is a high potential for non-response unless the hypothetical market is easily explained), telephone survey (which tend to yield incomplete information) or finally face-to-face interviews (an expensive method but allowing more scope in presenting the hypothetical scenario, clarifying respondents concerns and minimising non-responses).

A sufficient sample size is essential to determine the precision of the sample statistic, such as mean and median, which represents the population status. A larger sample means small variation of central tendency values as measured by standard error and described in confidence intervals. Even though mean values are most appropriate to represent the value of the good, when considering a key measure of the majority utility from the population, the median value can be used, and has much to recommend it since it is less affected by larger values and skewed data. The value of WTP median is almost always less than that of mean bids.

The most widely used elicitation formats are open-ended questions, payment cards, iterative bidding and referendum type-questions. Open-ended questions ask the respondents what would be their maximum WTP for any improvement of the good, or the minimum WTA as compensation for the decrease of the good. Payment cards offer a range of values on the card and respondents are requested to choose one. However the payment card method is believed to encourage people to pay lower value compared to the true value. In a bidding game, respondents are faced with several rounds of discrete questions which progressively ascend or descend from a specific starting point until it reaches the maximum WTP. There are two types of referendum questions, single and double dichotomous choices. The former type refers to 'yes' or 'no' to a single WTP amount, while the latter choice offers a lower amount for 'no' answer and higher bids for 'yes' answer. Different elicitation formats typically produce different estimates of welfare values. Some researchers add follow-up questions, which are also known as debriefing questions, in order to understand the motives behind answers given, especially when there was some form of protest or unwillingness to pay for the good in question.

2.12.3 Socio-demographic and economic characteristics

The final important component of the questionnaire asks for socio-demographic and economic characteristics of the respondents, such as age, gender, education, income as well as preferences for the good which may also be relevant to the issues being investigated. Such information is used to test whether the WTP answers conform to theoretical expectations.

2.13 Controversies of CVM

CVM has become a popular way to elicit people's preferences for environmental goods due to its flexibility and ability to estimate the total value; i.e. use and non-use value. However several controversies have emerged over the reliability of CVM due to continued criticism about risk of bias and inaccurate choices of welfare measures. Carson *et al*. (2001) stated that many of these alleged issues can be resolved by careful study design and implementation. Two of the main criticisms of CVM, biases and eliciting valuation options, are discussed below.

2.13.1 Biases

Although CVM has the advantages of being straightforward and not requiring any theoretical assumptions compared to revealed preference approaches, the method has a number of critics due to the possibility for bias at various stages of the survey implementation, including hypothetical, embedding, strategic, information, starting point and non-response biases. For this study, two potential biases could occur, namely embedding and strategic biases. In general, embedding bias normally occurs when the object of the survey is categorised as an inclusive good rather than private good and the respondents are aware on substitution availability of the good. In turn the respondents stated their WTP to get a good feel or warm glow effect of contributing to a good cause and did not represent their true determination. An additional step could be included in the elicitation format such as a verbal reminder of historical facts about the goods to facilitate the respondent to give a close estimate of the true WTP value. Strategic bias happens when the respondents state their bid with the purpose to influence the outcome. Respondents who do not favour conservation efforts, which they believe might impede economic growth, will state a lower bid to this type of survey question.

As for hypothetical bias, most suggestions to increase the reliability of the questionnaire are by adding images, statistics in the form of table or figures, and describing the potential consequences to the public using trained interviewers. Pre-test also helps in improving the setting of the hypothetical scenario. The use of non-technical questions also encourages respondents to participate. In addition to that, another bias i.e. starting point bias may occur for formats such as payment card and bidding games, which involve a start off with a certain amount and may be misinterpreted by the respondent.

2.13.2 Eliciting valuation: Divergence of WTP and WTA estimates

Both Hanemann (1991) and Carson *et al.* (2001) reported that Wiling (1976) stated that, from a theoretical perspective, WTP and WTA should be close together depending on the relationship between income and demand. However, if the good has no substitution, then we can expect quite large differences between values for WTA and WTP, whereas if close substitution exists, then they should not be that different. In addition to this, Hanemann (1991) and Carson *et al.* (2001), once again re-examined that the divergent choices of welfare measures arose from the issues of property right, together with the psychological point of view as demonstrated by Randall and Stoll in 1990. If people have the right to the good, then the best question is to ask the amount of compensation they would demand to agree to prevent the reduction in quality of those particular goods. But, if the status of the goods is public goods to which people have no right, then the question of the maximum willingness to pay to have an increase or to prevent a reduction can be asked. Therefore, since in the current study favourable environmental quality fulfils the characteristics of a public good and there is no substitution, then the welfare economic measure of WTP is considered to be the most appropriate to apply.

2.14 Integration of Quantitative and Qualitative Research

A variety of considerations are involved in the process of conducting research. Typically the research begins with setting some broad question(s) which are then narrowed down to focus on operationalization of data analysis through empirical or observation strategies. The results are then examined to draw conclusions and finally address the original question(s) posed. There are three elements underlying the philosophy of scientific research in physical and social sciences which need to be explored. These are the relationship between research and theory, epistemology and ontology considerations as shown in Figure 2.10.

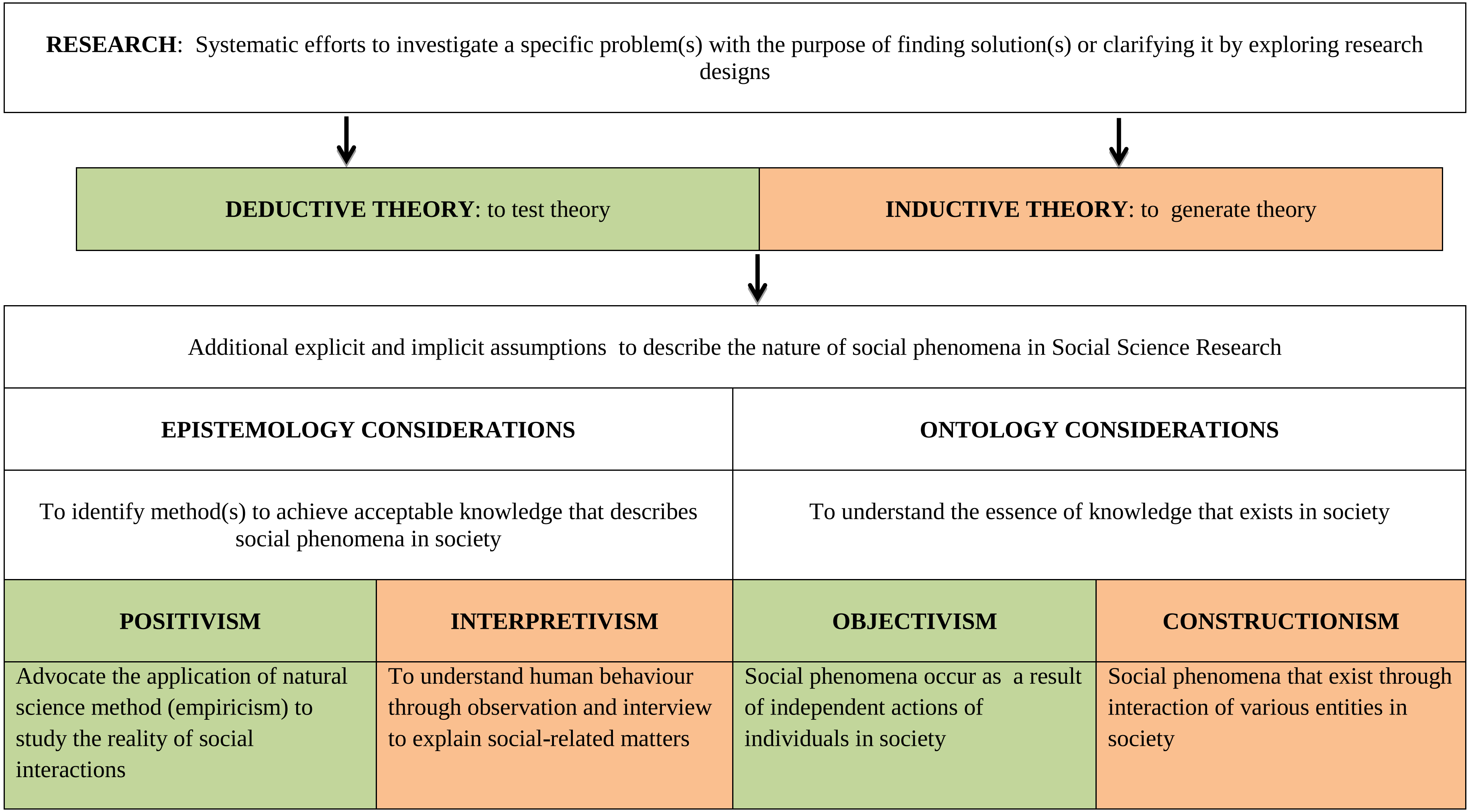


Figure 2.10: Elements underlying the philosophy of physical and social science research which entails the relationship of research and theory, epistemology and ontology considerations (modified after Burrell and Morgan, 1979; Bryman, 2008; Crumley, 2009; Freimuth, 2009)

The LCA and CVM analyses described previously (Section 2.7 and 2.10 respectively) both apply deductive theory (i.e. research that employs experimental methods) and are associated with quantitative research to answer the questions posed and to generate and test the hypotheses (Golafshani, 2003; Bryman, 2008). In other words, quantitative methods tend to be employed when a theory is already well developed and is just being confirmed. Besides the empirical approach employed in LCA and CVM analyses, the current study also has an interest in social aspects, i.e. stability and a healthy society through the environmentally friendly broiler production system, thus requiring considering of epistemology and ontology orientations.

Epistemology deals with the identification of acceptable knowledge including looking at the sources and conditions of the knowledge to describe phenomena that we experience (Crumley, 2009). Positivism is one of the two positions of epistemology that promotes the application of natural science methods in order to study the cause and effect of social phenomena. Positivism is incorporated in the practices and norms of natural scientific models and thus is applied for LCA and CVM analyses.

Meanwhile, there are two approaches to address the issue of ontological concerns, namely constructionism and objectivism. Constructionism is about social phenomena which are caused by the interaction of people, whereas objectivism is associated with social phenomena that we use in everyday discourse which are independent from the actors, and each person is considered as an objective entity (Bryman, 2008; Freimuth, 2009). In layman's terms, this means something that is not influenced by the researcher or instruments used during the experiment. This also means that social reality is viewed as an external. The constructionism is appropriate for qualitative questions while objectivism is constructed for quantitative research.

However, since the current study through LCA and CVM analyses will involve aspects of social science and have obligations to fulfil social interests, a situation where a holistic perspective to preserve the complexities of human behaviour and perspectives is a prerequisite of the research, a qualitative approach needs to be conducted (Black, 1994). Even though some researchers question the use of qualitative measures, claiming that qualitative study is less rigorous or objective than quantitative analyses and may not have a sufficiently large sample size for statistical analyses, Black (1994) contends this is a weak argument, since a quantitative approach is unable to answer certain questions such as "how often?". In layman's terms, qualitative research is adherence to an interpretivism perspective, i.e. another orientation of epistemology which is associated with qualitative methods. An interpretivism orientation refers to gaining an understanding of how individuals interpret the social world based on their own experiences. Measurement in qualitative research is more subjective, which means that researchers are able to interpret the meaning of certain results in different ways which can be advantage to understanding particular questions. In essence, qualitative research is helpful to understand the nature and strength of social interactions (Black, 1994; Bryman, 2008).

Thus, the apparent concern about the use of qualitative research methods confirms the importance of considering an integration of qualitative and quantitative methods into a single study. By combining the strengths of qualitative and quantitative approaches through a combined approach, such as mixed method, a more comprehensive study can be undertaken. In social science research, combining qualitative and quantitative approaches has been implemented for a long time, e.g. sociological study of community life was first used in the 1920s. Mixed method has been growing in popularity in the 1990s and is now considered as a third major approach of research design to add to quantitative and qualitative approaches (Bazeley, 2003).

2.15 Mixed Method Characteristics

The combination of quantitative and qualitative methods in the same study is referred to by different terms, such as integrated method, mixed method and multi strategy study. Selection of a particular method is strongly based on the particular research setting and purposes of the research being undertaken (Bazeley, 2012). According to Ginsburg (1996) and Yin (2006), mixed method should be conducted as an integrated study so that the component parts are linked as a single study (i.e. not decomposed).

Bryman (2008) classified 16 rationale schemes of combining quantitative and qualitative research, including the top three most adopted in practice. The rationale scheme represents the purpose of the integration, while practice is the actual use of the integration. Enhancement, triangulation and completeness schemes were recorded as the top three used in practice (121, 80 and 67 respectively). Enhancement was the most commonly used rationale scheme which is perhaps in part because it entails a reference to augmenting either quantitative or qualitative findings by gathering data using a qualitative or quantitative approach. Triangulation, also known as cross examination, deals with the case where the results originating from different methods lead to the same conclusion. Completeness allows the researcher to develop more comprehensive research questions by employing both quantitative and qualitative methods, which implies that the gaps left by one method can be filled by another.

2.16 Application of Mixed Method

Two previous studies on mixed method (represented by completeness and enhancement; and triangulation approaches) are described below as examples of how qualitative and quantitative methods have been used in practice to achieve comprehensive answers to research questions on certain issues.

The first case is the work by Poortinga *et al*. (2004) on the 2001 Foot and Mouth Disease (FMD) Crisis in Britain, which according to Bryman (2008) is an example that applied mixed method with completeness and an enhancement schemes. The study by Poortinga *et al*. (2004) comprised two stages of survey, namely a quantitative survey among people who experienced the disease outbreak (in the region of Norwich and Bude), and a qualitative focus group survey with selected respondents who had participated in the quantitative survey. In general, the results of the study suggested that the outbreak of the disease was considered a system failure (i.e. people blamed the outbreak on the ineffectiveness of the structure of the organisation) rather than something related to technical or individual causes. Both research approaches identified three interpretable factors as to the cause of the disease outbreak, namely blaming i) farming practices; ii) regulations; and iii) market forces. Thus, this study showed a completeness scheme since focus group (i.e. qualitative approach) provided valuable additional information behind the people understanding on the FMD issue (i.e. quantitative approach). In other words, the findings of the focus group reinforced those of the questionnaire regarding general concerns. However, Poortinga *et al*. (2004) then qualified that in the focus group (i.e. qualitative approach), these three factors were often used in combination and were seen as being highly connected which implies enhancement characteristic.

Another illustration of mixed method, but using a triangulation approach, is an investigation by Hughes *et al.* (1997) on the attitudes of young people to the consumption of designer drinks. Designer drinks refer to a new range of fortified fruit wines and strong white ciders that became popular in the U.K in the 1990s. The study was about the health concerns surrounding consumption of these drinks amongst young people (under the age of 18) and applied qualitative methods of discussion (with eight focus groups) and quantitative methods (using questionnaire of respondents aged between 12-17 years old). The qualitative findings showed a difference in attitude towards designer drinks. For example, people aged 14 and 15 years old thought of drinking as a means of having fun and being an important experience to share with others, while those aged 16 and 17 were mainly concerned with appearing mature and establishing relationships with the opposite gender. Since the function of triangulation is to cross examine the findings of one method, thus qualitative outputs were consistent and confirmed the quantitative evidence which showed that two thirds of 12-17 years old drank alcohol. Of this, more than half (51%) tried the designer drinks, while 42% had tried one of four brands of strong cider. The findings from both methods suggested that it was important to establish public debate concerning the demand for these drinks and the extent to which these drinks should be free marketed or control mechanisms should be enforced in the interests of the health of young people.

2.17 Conclusions from the Review and Research Approaches

The sustainability issue in any development programme comprises of three basic pillars, economic development, environmental protection and social equity, with the additional importance of finding political entry points to make real progress. Thus, the current study will explore the potential to move towards a sustainable broiler industry in Malaysia through integration of these four elements. The LCA approach is the best one to employ to estimate the burdens produced from different broiler housing systems, which ultimately will suggest the most environmentally friendly production system. Meanwhile, advantages of using this production system to achieve economic expectations must also be considered.

The ability to produce better environmental quality through environmentally friendly broiler production system depends on societal support. A CVM survey can evaluate the consumers' WTP for product obtained from improved systems, as a proxy to evaluate non-exclusive good, namely the favourable environmental quality which is intangible and does not have a market price. To place a value for this good is a vital initial step for any further economic analysis. The CVM also offers other values which can be used as indicators to represent any potential economic outcome from the survey. This approach is also able to reveal societal concerns towards food security and social stability.

In order to obtain comprehensive findings representing social elements, besides the interest of consumers, the roles and opinions of producers and integrators in this industry are crucial, particularly in relation to their commitment and readiness to accept any strategy directions. Since the social analysis involves the complexities of human behaviour, qualitative approaches are useful as a tool of analysis. Both quantitative results from farm performance and consumers' concerns, together with opinions and perspectives of producers, integrators and the Government on their acceptance and efforts, will be integrated in a qualitative approach of mixed method

Deeper understanding of the importance of security and sustainability issues in the broiler industry, through empirical and intangible findings, is essential and will facilitate future policy decisions.

Chapter 3. Environmental Assessment of Different Broiler Production Systems: Life Cycle Assessment

One of the objectives formulated in Section 1.4 was to estimate the environmental impacts of different broiler production systems in Malaysia by using an established environmental assessment tool. This objective was then divided into a number of questions as follows:

i. What are the environmental impact values of different broiler production systems?
ii. What is the relative contribution of each of the inputs for every stage of broiler production within the selected system boundary?

3.1 Materials and Methods

To evaluate the environmental impacts of different broiler production systems in Malaysia, a Life Cycle Assessment (LCA) was employed through the use of specialist software, namely SimaPro 7.3.2 (PRé Consultants, Amersfoort, Netherlands, 2010). The standard procedure of LCA, as described in Chapter 2, was applied and the environmental impacts analysis based on data from the two major broiler chicken production systems in Malaysia, namely intensive closed house (CH) and open house (OH) systems. Although the semi-intensive (SI) system would have made for a very interesting comparison, the limited contribution of this system to domestic chicken production (just 1%) meant that the SI system was not considered in this assessment.

3.2 Goal and Scope Definition

The framework of LCA ISO 14044 was used as a guideline to evaluate the environmental impacts of the two broiler production systems mentioned above, using a functional unit of one tonne live weight (LW) of broiler chickens and taking a cradle to point of slaughter criterion as the system boundary. Based on the two fundamental issues for modelling LCA, as described in Section 2.8, the decision was made to take an attributional approach, since the motivation of the current study is based on the technologies provided in different production systems. This study is focused on a single product output (no equivalent co-product); therefore allocation output does not need to be taken into consideration.

The assessment of environmental burdens from the production of raw materials (i.e. feed and feed additives), inputs to the broiler house (i.e. water, gas, bedding and electricity) and outputs of finished broiler, manure and any hazardous gases and substances which may have leached from the production site, i.e. nitrous oxide (N_2O), methane (CH_4), ammonia (NH_3) and nitrate (NO_3) were taken into account in the analysis. Burdens associated with transportation (i.e. by water and land arising from ocean and road transportation) were included for importing raw materials and conveying them to the feed mills, and subsequently transporting the manufactured feed to the farms (both breeder and broiler), delivery of day-old chicks (DOC) to the broiler farms, and finished broilers to the slaughter plants, and transport of manure to the plantation farms (typically oil palm plantations). The system boundary for this study is illustrated in Figure 3.1.

3.3 Life Cycle Inventory: Foreground and Background Information and Survey

In order to obtain the foreground data, including inputs, outputs and manure handling practices, several sources were employed in the current study as follows:-

i. Broiler chicken data at the production stage: derived from the study of 'Issue and impact in broiler contract farming in Peninsular Malaysia' by Serin *et al.* (2011b);
ii. Breeder information: an informal survey with one major poultry breeder company, namely Huat Lai Sdn. Bhd. on 23 - 24 June 2011;
iii. Hatchery data: information from hatchery at the Institute of Poultry Technology, Department of Veterinary Services (DVS) on 22 June 2011;
iv. Manure-related data: an informal survey with six farms (three from each system, the CH and OH systems). The selection of farms was based on advice from the DVS. The survey was conducted on 24- 25 April 2013 and

also involved collection and subsequent nutrient analysis of representative manure samples from each housing system;

v. All information on feed ingredients and formulation: supplied by the Malaysia Agriculture Research Development Institute (MARDI).

The study by Serin *et al.* (2011b) was chosen for the basis of physical performance parameters for the production of broiler chickens, including quantities of raw materials used, utilities required and transportation data. A total of 189 broiler chicken producers in Peninsular Malaysia were involved in this study, which collectively represent some 5% of the broiler producers registered by the DVS. Although the aim of the study by Serin *et al.* (2011b) was to investigate several socio-economic issues affecting the contract farming system of broiler production in Malaysia (such as contract agreements, effectiveness of extension services, risk of losses etc.), the study also provided the price of inputs, value of outputs and other technical performance information. However, since some of the required data did not directly appear in the publication, discussions with Serin and his team of researchers took place during the month of April 2013 to obtain the raw data of inputs and outputs from the farms and other technical parameters of broiler chicken production.

It was assumed that the same breeder farm could supply day old chicks (DOC) to both broiler production systems. Thus, discussion with management of a major breeder company, namely Huat Lai Sdn. Bhd., took place on 23 - 24 June 2011 to obtain the main parameters required for the breeding stage.

A typical broiler production system starts with activities at the breeding farm, where hens are housed in a deep litter shed and produce fertile eggs at a rate of approximately 93% of total lay per cycle. Fertile eggs are collected daily and transferred to the hatchery. Modern incubation hatcheries can routinely achieve hatching rates of 85% within 10-14 days. Batches of DOC are then delivered to the broiler farms where the chicks are reared on litter (wood shavings, 5-10 cm deep) with an optimum environmental temperature of 22^{o}C – 30^{o}C until the third week of age, when they are able to regulate their body temperature. Adequate feeders and drinkers are important in the early life of chicks. During the growing period, the chickens are given *ad libitum* access to water and feed with appropriate concentrations of the specific nutrients to promote fast growth.

The floor space provided varies with design of the housing system, normally 0.07 – 0.09 m^2 per bird up to 38 - 42 days of age when the finished weight is approximately 2.0 - 2.3 kg and the finished broilers are then caught and transported to the processing plant. Houses are left empty for 2 - 3 weeks to allow for cleaning and disinfection between each batch (Moreng and Avens, 1991; Sainsbury, 1992; Edwards and Daniel, 1992). In the case of the CH and OH systems in Malaysia, the floor space could be up to 0.09 m^2 and 0.12 m^2 per bird with a production cycle lasting 40 and 43 days respectively (Serin *et al.,* 2011b).

There are two types of poultry waste arising from broiler production which raise environmental concerns, namely the mixture of litter/manure and any dead birds. The former refers to the bedding materials used during the production cycle mixed with manure. Dead birds arise from birds which die during the course of finishing due to illness or were culled prematurely on welfare grounds. The birds are collected from the shed by farm workers and then disposed of in batches. The average mortality rate of chickens over the production cycle is between 4 to 6%. Handling of these wastes is either by composting, land application or biogas production or burial (for dead birds), potentially contaminating the environment through the emissions of hazardous gases or leaching of substances to water bodies.

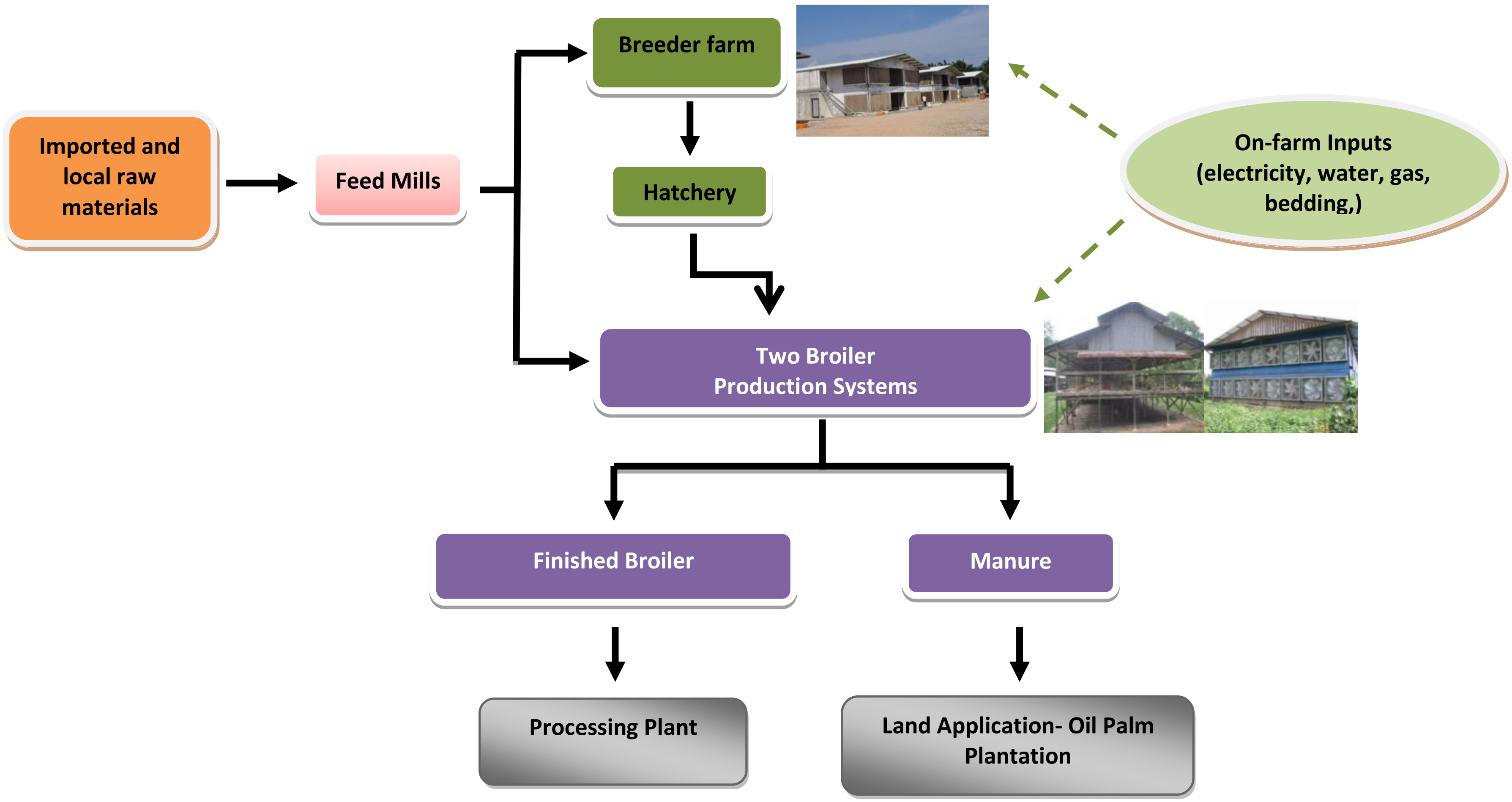
3.3.1 Foreground data

As described previously, foreground data of broiler chicken production were based on average data from 189 farms (Serin *et al.,* 2011b) whilst that for manure came from six farms. All inputs and sources of all foreground data categories which will be elaborated in the following sections are listed in Table 3.1. Quantities of the main inputs used to produce one tonne live weight of broiler chicken in each of the two different production systems are presented in Table 3.2.

3.3.1.1 Feed and water consumption

Approximately 90% of raw materials used in Malaysian broiler production are imported. Sea transportation (oceanic freight) is used to import cereals, namely maize and soya bean from Argentina and wheat from Japan. Crude Palm Oil (CPO), fishmeal and all minerals, vitamins and pure amino acids are produced locally. The feed formulation, including levels of added minerals, vitamins and pure amino acids, was supplied by MARDI for two phases, namely starter and grower rations. The starter feed is given from day 1 to 28 of age in the form of crumbs, with the main ingredients being maize and soya bean. The grower feed, fed from day 28 of age to slaughter comprises 70% of the total feed supplied to the birds and typically contains 13.18 MJ of energy and 20.09% of protein. The chemical composition for all raw materials, such as protein, lysine and methonine, was also provided by MARDI using current formulation data.

The amount of feed consumed by a broiler, together with water used for consumption and the cleaning process after each production system was obtained from the secondary data of Serin *et al.* (2011b) as mentioned above. Since the genotype of the broiler chickens was the same in both the CH and OH systems, (i.e. Ross 308), the same diet formulation was used for these systems. The feed for broiler chickens was divided into two types, namely starter and grower, supplied in the ratio of 30:70 of feed ingredients. The CH system produced a finished broiler weighing 2.18 kg live weight, with a feed conversion ratio (FCR) of 1.78 and total feed intake of 3.88 kg for each bird during the 40 days production cycle. The OH system required 43 days to complete one production cycle, and produced an average finished broiler weighing 2.12 kg with an FCR of 1.91 and a total feed intake of 4.05 kg for each bird. Thus, with different finished weights, the number of birds required for 1 tonne LW varied, with 459 and 472 for the CH and OH systems respectively.



*Different transportation modes were used for each stage along the production chain within the system boundary

Figure 3.1: System boundary and main components of broiler production in Malaysia

All activities for feed production, including growing the crop, harvesting and transportation of these raw materials to the feed mills, feed manufacture (crushing or milling of raw materials, heat treatment, mixing and pelleting), storage of the compound feed, water usage (consumption and wastewater treatment) and use of land related to the storage buildings, were based on the Ecoinvent 2.2 database (2010).

For breeder hens, some form of nutrient restriction was applied in their diet to prevent excess body weight gain. The requirements of breeders for energy and protein are much lower than broiler chickens, while the content of calcium and phosphorus is higher, since these minerals are important for egg production and to achieve optimal hatchability (NRC, 1994; MARDI, 2011). To produce 1 tonne LW of boiler chickens required approximately three breeder hens for both production systems. Each breeder hen needed a total period of 64 weeks and approximately 52 kg of feed to complete each production cycle, with a final live weight of 2.7 kg.

At the hatchery, an average of 93% of the eggs laid were fertilised and, with optimal incubation conditions, 85% of these eggs hatch. Given that each breeder hen laid 181 eggs as mentioned above, therefore, approximately 143 DOC were produced from each breeder hen for each cycle.

The details of the feed nutrient requirements for broiler and breeder chickens are shown in Tables 3.3 to 3.4. The values given in the tables are generally the minimum requirements that satisfy the productive activities for a specific age of bird.

The difference in length of the production cycle in the two housing systems is reflected in the amount of drinking water for each broiler chicken. Each broiler chicken in the CH and OH systems required 11 and 12 litres respectively for each production cycle, while breeder hens needed 139 litres for the 448 day production cycle.

Table 3.1: Sources of life cycle inventory data for broiler production in Malaysia

Type of Input	Description	Sources
Feed Ingredients : Imported Raw Materials	**Origin country**	
Maize	Argentina	MARDI (2011)
Soya bean meal	Argentina	MoA (2010a)
Wheat pollard	Japan	NRC* (1994)
Corn gluten meal	Argentina	
Feed Ingredients : Locally Produced	Locally produced and manufactured	
Crude Palm Oil		
Fish meal		
Other minerals, vitamins and pure amino acids (such as lysine, methionine, salt, limestone powder)		
Feed nutrient composition	Including all nutrients required	MARDI (2011)
Broiler & breeder	by broiler chickens and breeder hens	NRC* (1994)
Transportation related	To transport feed, DOC, finished broilers	Serin *et al.* (2011b)
Distance, amount of inputs, type of transport	and manure to farms, processing plants and crop plantations respectively	DVS (2011b)
Physical performance parameters	Parameters which are used to measure	Serin *et al.* (2011b)
No. of birds	nutrient requirements and burdens	DVS (2011b)
Start and finished weight	derived for/from the broiler chicken	Huat Lai (2011)

(cont.)

**NRC = National Research Council : Nutrient requirement of poultry*

Type of Input	Description	Sources
Physical performance parameters (cont.)		
Time to reach finished weight		
Feed Intake per bird and per FU		
Feed Conversion Ratio		
Mortality Rate		
Utilities related	Energy, water and bedding used during each production stage including cleaning and disinfection, at breeder and broiler houses	Serin *et al.* (2011b) DVS (2011b) Huat Lai (2011)
Electricity use		
Gas use		
Amount of water used for drinking		
Amount of water used for cleaning		
Amount of bedding used		
Gaseous emission	Multiple gases from animal and manure (storage and land application as fertilizer)	IPPC (2006) Williams *et al.* (2006)
Manure generated	Amount of manure to estimate nutrient content and then used for estimates of gases emitted	Producer (2013)** DVS (2011b)
Synthetic and organic fertilizer application	including main parameters in oil palm cultivation and fertilizer characteristics	MPOB** (2012)

***MPOB = Malaysia Palm Oil Board; Producer (2013) = interview with producers, as described in Section 3.3*

Table 3.2: Main parameters used in broiler and breeder production associated with production of the functional unit (FU) of one tonne live weight of broiler chickens

	Production System	
Parameter - Breeder Hen	**Closed House 1 tonne LW**	**Open House 1 tonne LW**
No. of broiler breeders to produce 1 FU	3	3
Mature weight (kg/bird)	2.7	2.7
Time length of laying cycle (weeks)	64	64
Total Feed Intake (kg/bird)	52	52
Total Feed Intake for 1 FU (kg)	156	156
Weight of starter feed for 1 FU (kg)	26.99	26.99
Weight of grower feed for 1 FU (kg)	129.01	129.01
Genotype	Ross 308	Ross 308
Parameter – Broilers		
No. of birds	459	472
Finished weight (kg/bird)	2.18	2.12
Time to reach finished weight (days)	40	43
Total Feed Intake (kg/bird)	3.88	4.05
Total Feed Intake for 1 FU (kg)	1,782.00	1,909.00
Weight of starter feed for 1 FU (kg)	535.00	573.00
Weight of grower feed for 1 FU (kg)	1,247.00	1,336.00
Feed Conversion Ratio	1.78	1.91
Mortality Rate (%)	3.60	6.08
Genotype	Ross 308	Ross 308

Table 3.3: Dietary and nutrient compositions of five different rations used for breeder hens, as a percentage of total ingredients or units of diet

Raw Materials	**Unit**	**Starter-1**	**Starter-2**	**Grower**	**Pre-Breeder**	**Breeder**
Maize	%	52.68	49.53	44.66	44.98	60.27
Soybean meal	%	28.00	28.00	17.82	22.07	20.41
Palm kernel expeller	%	6.00	6.00	7.00	6.00	6.00
Wheat pollard	%	7.18	12.09	26.39	21.42	4.43
Fishmeal	%	2.38	0.00	0.00	0.00	0.00
Crude palm oil	%	0.50	0.50	0.50	0.50	0.50
Methionine	%	0.22	0.14	0.06	0.05	0.08
Lysine	%	0.12	0.05	0.05	0.05	0.05
Salt	%	0.28	0.34	0.33	0.33	0.34
Dicalcium phosphate	%	1.43	2.00	1.50	1.77	1.43
Salinomycin	%	0.05	0.05	0.05	0.05	0.05
Choline chloride	%	0.10	0.10	0.10	0.10	0.10
Limestone powder	%	0.93	1.07	1.41	2.55	6.22
Mineral	%	0.10	0.10	0.10	0.10	0.10
Vitamin	%	0.03	0.03	0.03	0.03	0.03
Total		**100**	**100**	**100**	**100**	**100**
Energy and Nutrient Content						
ME	MJ/kg	11.50	11.50	11.50	11.50	11.50
	Kcal	2,748.92	2,748.92	2,748.92	2,748.92	2,748.92
Crude protein	%	20.00	18.00	14.00	15.00	15.00
Calcium	%	1.00	1.00	1.00	1.50	2.80
Available phosphorus	%	0.45	0.45	0.35	0.40	0.35
Sodium	%	0.16	0.16	0.16	0.16	0.16
Chloride	%	0.25	0.26	0.26	0.26	0.26
Lysine	%	1.12	0.94	0.70	0.78	0.75
Methionine	%	0.56	0.45	0.30	0.30	0.34
Methionine + Cystine	%	0.87	0.73	0.52	0.54	0.58
Threonine	%	0.80	0.72	0.55	0.60	0.61
Tryptophan	%	0.24	0.22	0.16	0.18	0.18
Arginine	%	1.34	1.24	0.95	1.03	1.03

Table 3.4: Dietary and nutrient compositions of starter and grower rations for broiler chickens in all production systems as a percentage of total ingredients or units of diet

Raw Materials	**Unit**	**Starter**	**Grower**
Maize	%	57.61	60.00
Soybean meal	%	28.62	27.21
Fish meal	%	1.00	1.00
Wheat pollard	%	2.77	3.05
Crude palm oil	%	2.00	3.56
Corn gluten meal	%	3.96	1.38
Minerals, vitamins and pure amino acids	%		
Lysine	%	0.28	0.22
Methionine	%	0.17	0.21
Salt	%	0.42	0.35
Choline chloride	%	0.10	0.10
Mineral mixture	%	0.10	0.10
Vitamin mixture	%	0.03	0.03
Dicalcium phosphate	%	1.46	1.36
Limestone powder	%	1.27	1.24
Others			
Chlortetracycline	%	0.15	0.15
Salinomycin	%	0.05	0.05
Total	%	**100.00**	**100.00**
Energy and Nutrient Content			
ME	MJ/kg	12.80	13.18
	Kcal	3,059.36	3,151.57
Protein	%	22.15	20.09
Lysine	%	1.30	1.19
Methionine	%	0.56	0.55
M+C	%	0.90	0.85
Arginine	%	1.37	1.27
digestible Lysine	%	1.16	1.06
digestible Methionine	%	0.51	0.51
digestible Methionine + Cystine	%	0.80	0.76
Calcium	%	0.97	0.93
Phosphorus	%	0.70	0.67
Available Phosphorus	%	0.41	0.39
Sodium	%	0.19	0.17
Choline chloride	%	0.05	0.05

3.3.1.2 Transportation

The distance from Argentina to Malaysia is approximately 16,812 km and from Japan to Malaysia is 5,767 km. The mass to transport one tonne of those raw materials from the countries of origin was expressed in tonne kilometres (tkm), where one tkm is the mass required to transport one tonne of raw materials over one kilometre. Imported raw materials together with locally-produced raw materials were then transported to feed mills which are approximately 135 km from the main harbour of Port Klang. It was assumed that a 40 tonne truck was used with a load factor of 50%, because the return trip to the port will be empty. Thus, to import raw materials from Argentina and Japan by ocean freight to make one tonne of feed required mass transport of 14,975 tkm and 171 tkm respectively and then to the feed mills needed another 124 tkm. The manufactured feed was then transported by lorry (capacity of 16 tonnes), initially to the storage centre (approximately 5 km from the feed mills), before subsequent transported to the broiler and breeder farms (located approximately 50 km from the storage centre). To deliver 1 tonne of feed to breeder and broiler farms thus required mass transport of 50.8 tkm and 48.1 tkm respectively.

Meanwhile, DOCs were brought from the hatchery to the broiler farm (using a 16 tonne lorry) an estimated distance of 20 km generating 0.0007 tkm of mass transport. At the end of the production cycle, finished chickens were transported by lorry to processing plants which were about 20 km away and required 0.04 tkm of mass transport. Another output at the end of the broiler production cycle was manure, which was used as an organic fertiliser at the oil palm plantation. An average distance to the plantation farm was 10 km and thus required 0.02 tkm of mass transport. Dead chickens were normally given free to aquaculture farmers who collected the dead birds from the production sites with their own transport. It was assumed that the distance from the production sites to the aquaculture farms was around 5 km.

All burdens from the manufacturing of the different transportation methods (ocean and land) including energy and emissions during the transport operation were provided by Ecoinvent 2.2. Average fuel consumption and emissions released were also included.

3.3.1.3 Electricity, gas, bedding and water for cleaning

The costs of energy from electricity (lighting and ventilation systems) and gas (during the brooding phase) for all broiler production systems were obtained from Serin *et al.* (2011b) and then converted into kilowatt hours based on the Medium Voltage Specification Agriculture Tariff category; this was RM0.30 per kilowatt hour, provided by the national energy agency, Tenaga Nasional Berhad (2011). Since the CH system provides a controlled environment by means of a ventilation system to maintain temperature and humidity, it requires a higher input of electricity than the OH (i.e. 0.4 kWh for each chicken per cycle in CH compared to 0.08 kWh for the OH system). Breeder hens were also kept in a CH system but, given the much longer production period for breeders, required a much greater electricity input (2.6 kWh for each breeder hen per cycle). Gas usage during the brooding phase (from the time chicks hatch until about 17 days of age, using a spot brooding system as mentioned in Section 2.5.1) was estimated to be 0.08 litres of gas per bird across both broiler and breeder production systems.

It was also estimated that water use for cleaning after each cycle was the same across both broiler production systems and the breeder hens (approximately 1.75 litres of water for each bird). The use of bedding for one broiler chicken in the CH and OH systems was estimated to be 0.29 kg and 0.04 kg respectively for each cycle due to the housing design (only minimal bedding in the OH system, as described in Section 2.5.1), while a breeder hen needed 4.2 kg for the production cycle of 1 year and 3 months.

3.3.1.4 Emissions and manure from broiler production

The amount of nutrients contained in the manure was estimated by following a number of steps. Using the mass balance principle, the amount of nutrients N, P and K (the main nutrients associated with pollution) in the manure was derived by calculating the difference between the amount of nutrients supplied in the feed intake minus the levels retained in the body. The process is described in detail as follows:-

a. Determine the total nutrient content in the feed which is derived from the specific nutrient content for each feed ingredient and the specific diet formulation (NRC, 1994; MARDI, 2011).

   i. **Amount of Feed-N, P, K = kg (N, P, K) per bird**

b. Obtain the total amount of N consumed by one broiler chicken by multiplying the nutrient content in the feed with the total amount of feed consumed per chicken. Taking N as an example:

   i. **Feed-N = (CP / 6.25) * ∑ F**

$$\text{Feed-N} = (CP / 6.25) * \sum F$$

Feed-N = Amount of Feed-N consumed by one broiler chicken, kg N $chicken^{-1}$

6.25 = Conversion factor from percentage Nitrogen to percentage total protein for feed material

CP = Crude protein content of feed consumed by a chicken at a specific stage, %

∑ F = Total amount of feed consumed by a chicken per cycle, kg $chicken^{-1}$

And for P and K:

   ii. **Feed-P or Feed-K = ∑ P or K nutrient * ∑ F**

Feed-P = Total amount of Feed-P consumed by one broiler chicken, kg P $chicken^{-1}$

Feed-K = Total amount of Feed-K consumed by one broiler chicken, kg K $chicken^{-1}$

∑ Total nutrient = P or K nutrient content in feed consumed by a chicken at a specific stage.

∑ F = Total amount of feed consumed by a chicken per cycle, kg $chicken^{-1}$

c. Total nutrient content retained in the body can be derived by multiplying the finished weight of the broiler with percentage nutrient carcass composition of chicken meat. In this study, the percentage of carcass compositions were derived from McGahan and Tucker (2003), i.e. 28.0 g N, 5.0 g P, 2.0 g K per kg of meat chicken respectively.

d. The differences of (b) – (c) will give the amount of nutrients excreted by chicken and released to manure.

Quantities of these three nutrients (particularly N) in the manure are essential for the calculation of various types of emissions of gasses and other pollution substances generated from the manure. The amount of N in the manure produced by each chicken was estimated to be 0.0715 and 0.0790 kg of N respectively for the CH and OH systems. Based on nutrient balance calculation, the estimated amounts of N in the feed, retained in the body and excreted are shown in Table 3.5.

Table 3.5: Estimated nitrogen balance for a single broiler chicken in each of two different production systems (amount of N offered in the feed, retained in the body and excreted)

	Closed House	**Open House**
	(kg of N/bird)	
N_{feed}	0.1316	0.1374
$N_{retention}$	0.0601	0.0584
$N_{excreted}$	0.0715	0.0790

The amount of N excreted was used as a basis to estimate the burdens for greenhouse gasses (GHGs) and other hazardous gaseous emissions of N_2O, NH_3, N_2 and nitrogen oxides (NO_x) by using formulae provided by the Intergovernmental Panel on Climate Change Guidelines (IPCC, 2006) and Williams *et al.* (2006). IPCC (2006) divided emissions from chicken production into two categories, namely i) direct and indirect N_2O, in the form of NH_3, NO_2 and CH_4 emissions from manure management; and ii). CH_4 emission from enteric fermentation

i. GHGs and other hazardous gaseous emissions from manure: N_2O, NH_3, and CH_4

The quantity of N_2O arising from manure production and storage is divided into two categories, namely direct and indirect emissions. Direct N_2O emissions occur during nitrification and denitrification of the N contained in the manure. The total amount of N emitted will depend on the amount of N in the manure as well as the duration of storage (if any) and whether any manure treatment was applied (in this study, there were no manure treatments in any production system). N_2O requires an initial aerobic reaction of nitrification, to convert ammonium (NH_4) to nitrite (NO_2) and nitrate (NO_3), and this is then followed by an anaerobic process of denitrification, which transforms NO_3 or NO_2 to N_2O and, in the presence of oxygen, some N_2O is transformed to N_2. Hence, dry and aerobic manure handling systems may encourage an environment more conducive for N_2O emissions. Meanwhile, indirect emissions from volatile N losses occur primarily in the form of NH_3. Organic N is mineralised to an inorganic form of ammonia nitrogen (NH_4), which can be absorbed by plants. However NH_4 is easily volatized in the environment as NH_3. A small portion of N is emitted into the atmosphere as NO_x (http://www.nitrogencycle.org/, 2010).

Even though CH_4 does not account for a significant proportion of gaseous pollutants from monogastric animals, particularly poultry, the potential for increasing emissions from manure is becoming an important issue, since the techniques in modern poultry production rely on an intensive approach, i.e. increased number of chickens per unit area and, as a result, an increase in the amount of manure in a particular area. The main factors affecting the quantity of gases emitted from manure are the amount of manure produced and the proportion that decomposes aerobically. Equations and derived formula to quantify emissions from the manure associated with one FU were based on IPCC (2006) and Williams *et al.* (2006).

i. Methane

$CH_{4\ (manure)} = \sum (EF_{(T)} * N_{(T)}) / 10^6$

where,

$CH_{4\ (manure)}$ = CH_4 emissions from manure management, for a defined population, Gg CH_4 $cycle^{-1}$

$EF_{(T)}$ = emissions factor for the defined livestock, kg CH_4 $head^{-1} cycle^{-1}$

$N_{(T)}$ = number of birds (thus n=1 to generate output per bird)

ii. Nitrous oxides

$N_2O_{(manure)} = [\sum (N_{(T)} * N_{ex(T)} * MS_{(T,S)}) * EF_{(S)}] * 44/28$

where,

$N_2O_{(manure)}$ = N_2O emissions from manure, kg N_2O $cycle^{-1}$

$N_{(T)}$ = number of birds (thus n=1 to generate output per bird)

$N_{ex\ (T)}$ = average N excretion per head, kg N $animal^{-1}$ $cycle^{-1}$

$MS_{(T,S)}$ = fraction of total nitrogen excretion for each livestock species that is managed in manure management system in the country

$EF_{(S)}$ = emission factor for direct N_2O emissions from manure management system, kg N_2O-N kg N^{-1}

44/28 = conversion of N_2O-N emissions to N_2O emission

iii. Ammonia

$NH_{3\ (manure)} = 0.081 * N$ excreted per bird

where,

$NH_{3\ (manure)}$ = Ammonia emissions from manure, for a defined livestock, kg $bird^{-1}$

N = Nitrogen released in the manure based on mass balance calculation, kg

ii. Other hazardous gas from animal: CH_4

In addition to the CH_4 emissions from manure mentioned above, CH_4 is also a by-product of enteric fermentation and depends mainly on the type of the animal's digestive system and the feed offered. IPCC (2006) guidelines do not provide an equation for CH_4 for poultry species. Previous studies have shown that monogastric livestock (i.e. pigs and poultry) have relatively low CH_4 emissions because, unlike ruminants, fermentation accounts for a very small part of their nutrient supply and thus less methane is produced in their digestive system. Therefore, an equation derived from the definition to assess gaseous emissions from chickens was based on Williams *et al*. (2006), as follows:

iv. Methane

CH_4 = 0.0000055 * live weight * time
where,
CH_4 = Methane emissions from the animal, for a defined livestock, kg bird^{-1}
Live weight = weight of finished broiler, kg
Time = duration of production cycle, days

The amount of various gasses associated with one broiler chicken from a complete of production cycle of the CH and OH production systems are presented in Table 3.6.

3.3.1.5 Land application: Emissions and credit for displaced synthetic fertiliser

i. Emissions from land application

Land application for growing crops has traditionally been the main fate of poultry manure. In Malaysia, organic fertilizer from either poultry manure or biomass (composting of oil palm by-products such as the branches) has been used alongside synthetic fertilizers for oil palm production in a ratio of 30:70 respectively (organic: synthetic fertilizer).

Utilization of poultry manure to the extent of 30% of fertilizer inputs seems to offer not only advantages for economic returns (since the synthetic fertilizer does not nurture the organic matter and microbial activity in the soil and therefore more synthetic fertilizer is needed in the long term), but also offers a valuable credit to the environment. However, excessive use of poultry manure as a fertilizer could lead to increasing environmental pollution, i.e. N_2O and CO_2 into the air and NO_3 into the ground water. N pollutants arising from the nitrification processes of managed soil lead to emissions of N_2O as well as volatilization of NH_3 and NO_x into the air. NO_3 which is not emitted as N_2O has the potential for leaching and runoff of N. Meanwhile, the use of synthetic fertilizer increases CO_2 emissions due to additional utilization of liming materials and urea-containing fertilizer (Webb *et al.*, 2010).

Due to complexity of the interaction between manure, soil and crop, quantification of emissions from land-spreading was based on the model established by Williams *et al.* (2006). In that study it was assumed that 40% of the available N in broiler manure is used as fertiliser, thus the remaining N is accounted for through several emissions, typically 2.5%, 49% and 32.5% of nitrogen losses were as N_2O, NO_3 and N_2 respectively. Thus the total amount of all gaseous emissions from the animal and their manure in the production site as well as manure from land spreading are presented in Table 3.6

Table 3.6: Methane, other gases and leaching substances emitted from the animal and their manure in the production site as well as manure from land spreading during one production cycle in two different broiler production systems

	Closed House	**Open House**
	kg of specific gasses bird^{-1} cycle^{-1}	
Methane (CH_4)	0.0027	0.0028
Nitrous oxide (N_2O)	0.0006	0.0007
Nitrate (NO_3)	0.0079	0.0085
Ammonia (NH_3)	0.0058	0.0064
Nitrogen (N_2)	0.0053	0.0056
Total N-based gases emitted	**0.0196**	**0.0211**

Subsequently, all the above amounts of specific gasses for each chicken were then translated into environmental impact values.

ii. Credit for displaced synthetic fertiliser

To estimate fertiliser saving from the use of manure in palm oil plantations, data on application rate of poultry manure as a fertilizer for oil palm crops were obtained from the Malaysia Palm Oil Board (MPOB). Manure samples were then collected from three different farms for each broiler production system. To obtain a representative sample of the manure (and bedding where appropriate) left behind inside the house and on the ground after depopulation, a point sampling technique was used whereby the technician walked in a zigzag manner through and below the house, stopping to collect a sample at various points (thus the edges and the middle of the building were included). At each sampling point, a spade was used to take a 3 to 9cm deep slice of manure which was then placed in a plastic bucket. The contents of the bucket were thoroughly mixed, placed in a plastic bag, labelled and then sent to the Agriculture Chemical Analysis Laboratory at MARDI for subsequent analysis to determine N, P and K content through the use of a flow injector analyser. Estimates of the quantity of manure generated (and bedding used) from each production system were obtained from producer records and showed that each bird in the CH and OH systems respectively produced 1.10 and 1.19 kg manure per cycle.

The total amount of NPK in the manure at the end of production cycle was obtained through laboratory analyses on a dry matter (DM) basis. Samples from the CH system contained on average 4.25%, 1.81% and 2.10% of NPK respectively, whilst samples from the OH system contained on average 4.22%, 1.94% and 2.65 % of NPK respectively. For the CH system, estimates of the quantity of nutrients in the manure took into consideration the percentage of manure content in 'material removed from the poultry house' (i.e. bedding/bedding combined) and thus accounted for bedding. For the OH system, as described in Section 3.3.1.3, the quantity of bedding used was very small (just 0.04 kg per bird per cycle) and thus was excluded from the analysis. These values were then multiplied with quantity of manure removed per chicken as shown in Table 3.7.

Table 3.7: Amount of nitrogen, phosphorus and potassium present in the manure of broiler chickens following one production cycle in two different production systems

Amount of nutrient present in the manure	**CH**	**OH**
	(kg/bird)	
Nitrogen (N)	0.0437	0.0465
Phosphorus (P)	0.0186	0.0214
Potassium (K)	0.0216	0.0292

Several steps were involved in estimating the amount of poultry manure needed to replace synthetic fertiliser in the production of oil palm.

a. With an estimation of the N, P and K ratio of synthetic fertiliser provided by the oil palm farmers, the amounts of N, P and K contained in the fertiliser were obtained.
b. By using the amount of nutrients (N, P and K) present in the manure of each bird (see Table 3.7), the amount of these nutrients in each tonne of manure was obtained.
c. Values from (a) and (b) were then used to estimate the environmental benefits obtained from the substitution of synthetic manure for poultry manure (i.e. how much less synthetic fertiliser was required).

Next, the amount of manure excreted from each chicken (as described above) was used to estimate the amount of manure production per cycle for each production system, i.e. 504.9 kg and 561.7 kg of manure per tonne LW of broiler chicken for CH and OH systems respectively. By applying the calculation based on the three steps above, with an assumption that one tonne synthetic fertiliser of 12:12:17 of N, P and K can be substituted with an equivalent amount of nutrients supplied from chicken manure, Table 3.8 presents the amount of each nutrient supplied from synthetic fertiliser and poultry manure. These values were then used to obtain the estimated credit values from the manure substitution.

Table 3.8: Absolute amount of nitrogen, phosphorus and potassium contained in one tonne of synthetic fertiliser or chicken manure

	Nutrient content of 1000 kg of synthetic fertiliser	**Nutrient content of 1000 kg of chicken manure from each housing system**	
		CH	**OH**
Amount of Nitrogen (kg)	120.0	39.7	38.7
Amount of Phosphorus (kg)	52.3	16.9	17.8
Amount of Potassium (kg)	141.1	20.6	22.5

3.3.2 Background data

Background data on generic information (i.e. feed production activities and processes, transportation elements, gases and manure properties) were obtained from the SimaPro 7.3.2 database where the descriptive data provided for each process or activity was useful to identify the appropriate process or activity for certain types of production in a particular country. SimaPro 7.3.2 contains two libraries for the background data based on the Ecoinvent 2.2 (2010) database covering over 4,100 unit processes of products and services from the energy, transport, building materials, chemicals, pulp and paper, waste treatment and agricultural sectors, and is integrated with several well-known databases such as ETH-ESU 96 and EPFL.

3.3.3 Data entering procedures for processes, waste treatment, waste scenario and a complete product lifecycle

For the purpose of entering data into SimaPro, all data were divided into two categories under the Process Inventory, namely Material and Waste. Under the term Material, three processes link together in the production of a finished broiler. These are breeder hen, broiler feed and breeder feed. Other-farm inputs (i.e. transportation, water, electricity, gas and bedding materials) were added at all processes stages. The detail of inter-linkages between processes is illustrated in Figure 3.2. For the term Waste, the amount of manure, together with all related gaseous and leaching substances (calculated based on selected nutrient contents) and transportation used were also estimated. Figure 3.3 provides an activity map for the exercise, and shows the main activities involved and all items, namely raw materials, on-farm inputs, transports, synthetic fertilisers and gaseous emissions which lead to the burdens which will be elaborated on in Section 3.6. Examples of the entering process for the above stages are illustrated in Figure 3.4 (i & ii).

3.4 Life Cycle Impact Assessment (LCIA)

The impact assessment phase of a LCA consists of the evaluation of potential environmental impacts arising from the extraction of resources, waste and emissions by using the results of the inventory analysis according to the selected impact categories. As mentioned in Section 2.8.3, two approaches can be applied to analyse the impacts, namely midpoint and endpoint impact assessments. The former is suitable for measuring the environmental impact consequences, while the latter is useful to understand the impact of the product on the wider perspectives.

Four midpoint impact categories were considered in the current study, namely Energy Use (MJ), Global Warming Potential (GWP, CO_2 equiv.), Acidification Potential (AP, SO_2 equiv.) and Eutrophication Potential (EP, PO_4 equiv.). Once the impact categories were determined, the classification step involved assigning each of the gases emitted during poultry production to one particular impact category. Thus, CO_2, N_2O and CH_4 were allocated to GWP, while SO_2, NO_x and NH_4 were allocated to the AP and NO_2, NH_3, NH_4 and PO_4 were allocated to the EP (EPA, 2001). The final step in LCIA is determining the characterisation factors for each category, in order to get consistent values from several types of gases. Since each category contains several gases, a specific factor was introduced to ensure the measurement was uniform. Thus, on a time scale of 100 years, the contribution of 1 kg CH_4 and 1 kg N_2O to global warming are 25 and 298 times respectively as high as the emissions of 1 kg CO_2, meaning the characterisation factor of CO_2 is 1, while for CH_4 and N_2O they are 25 and 298 respectively. For acidification impact, 1 kg of NO_x and NH_4 are 0.13 to 0.10 and 0.35 times respectively that of 1 kg of SO_2. Finally for eutrophication impact, the emission factor for NO_2, NH_3 and NH_4 are 0.70, 0.93 and 0.89 times respectively that of 1 kg of PO_4 (AEA Technology, 2009).

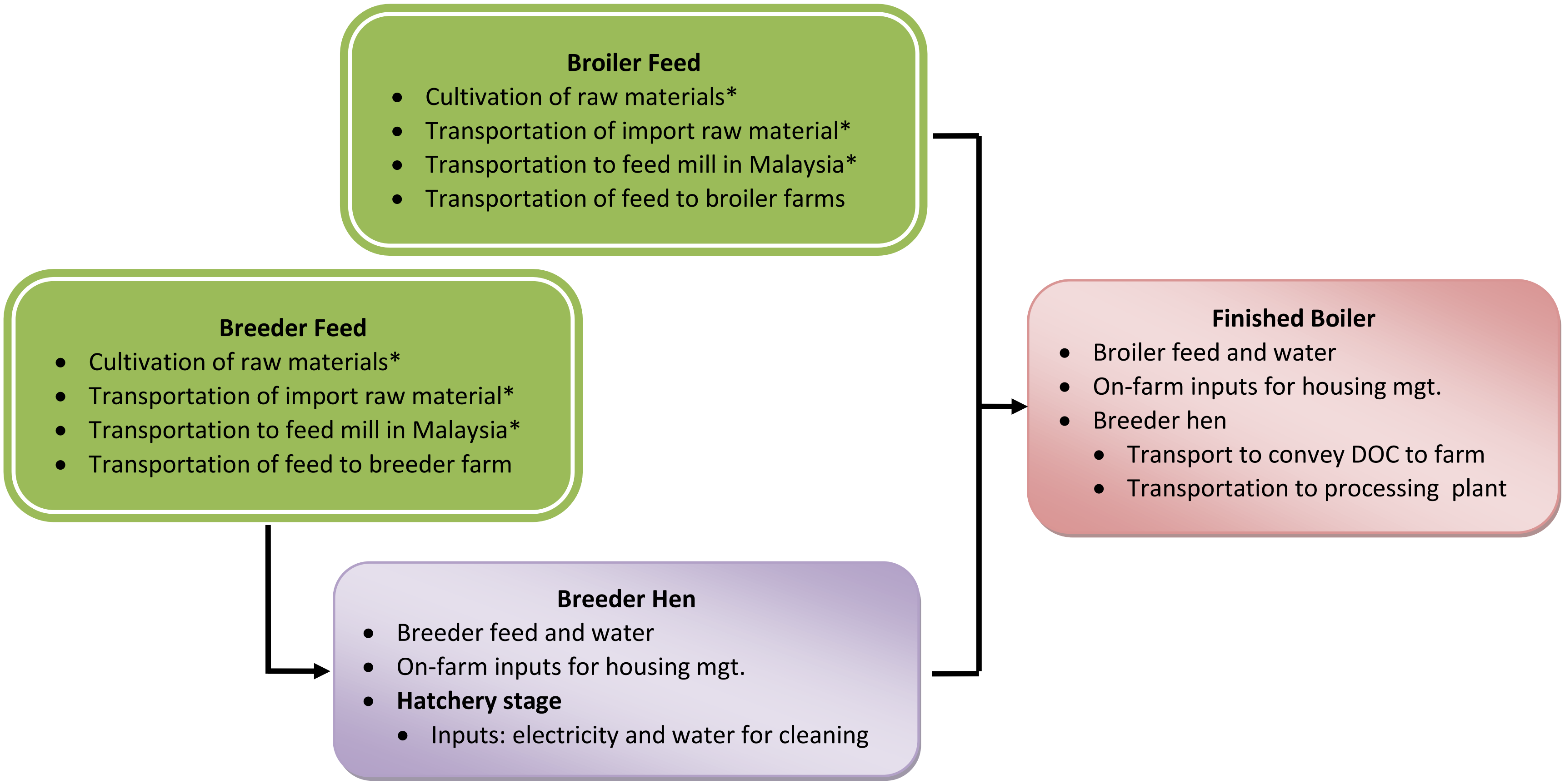


Figure 3.2: Inter-linkages between items under Material Inventory which involved three processes of breeder hen, broiler and breeder feed to produce a finished broiler and multiple on-farm inputs of transportation, water, electricity, gas and bedding materials, associated with production of one tonne live weight of broiler chickens

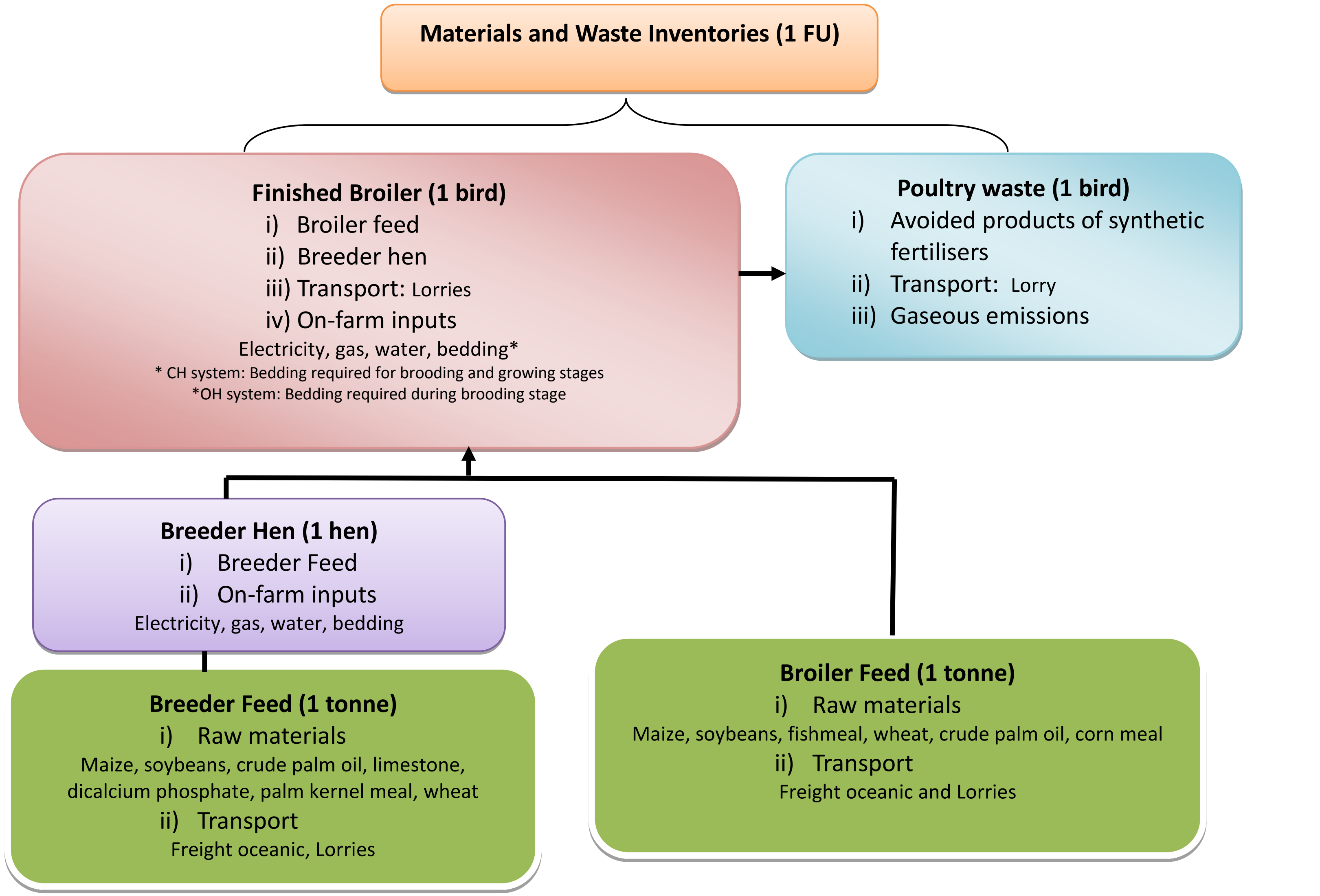


Figure 3.3: Activity map showing the three processes of Material Inventory and the single process of Waste Inventory associated with the production of one tonne live weight of broiler chickens (the actual amounts of each item in this activity map are subsequently specified in Sections 3.3.1.1 to 3.3.1.5).

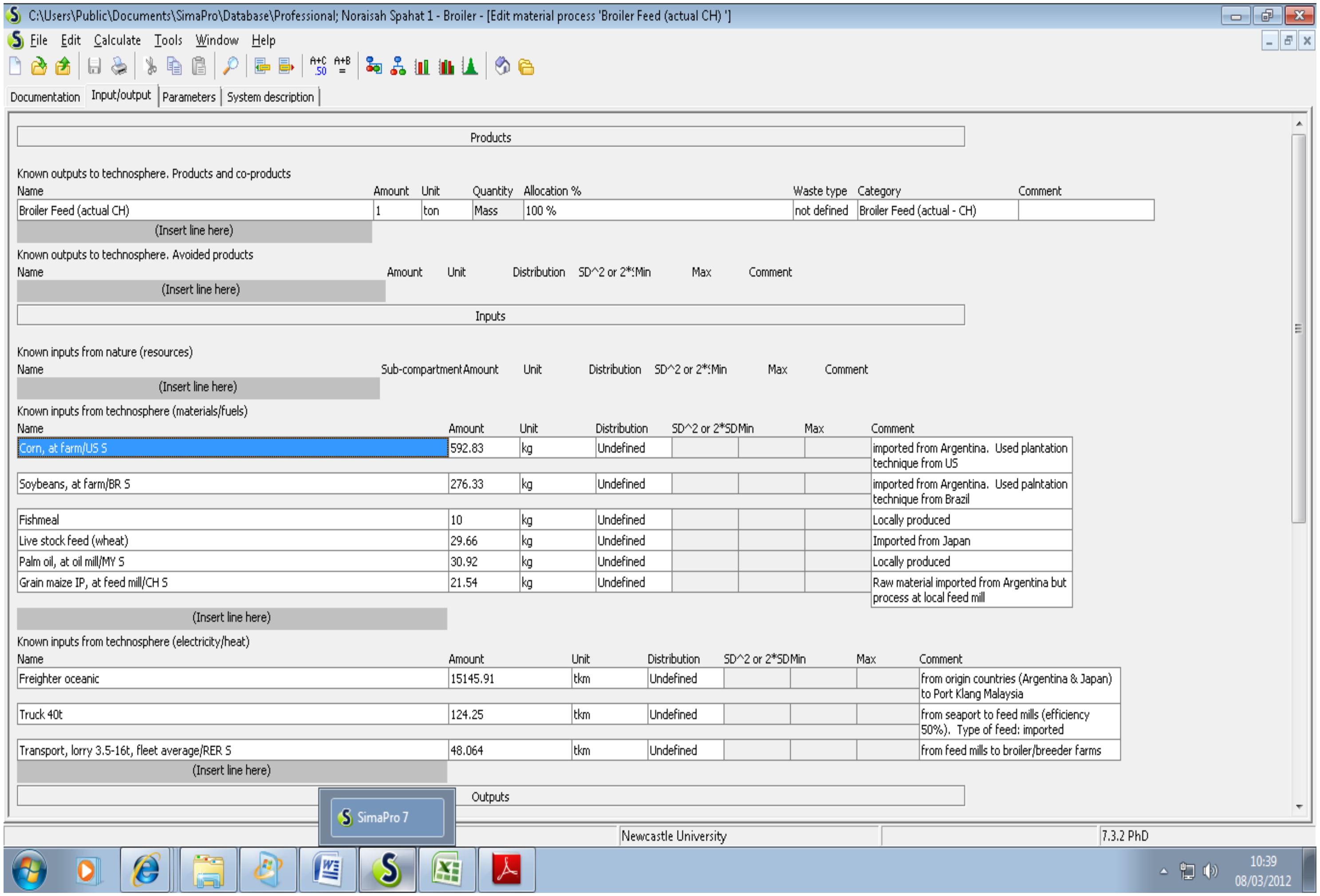


Figure 3.4 (i): Example of entering process of one tonne feed to produce broiler chickens

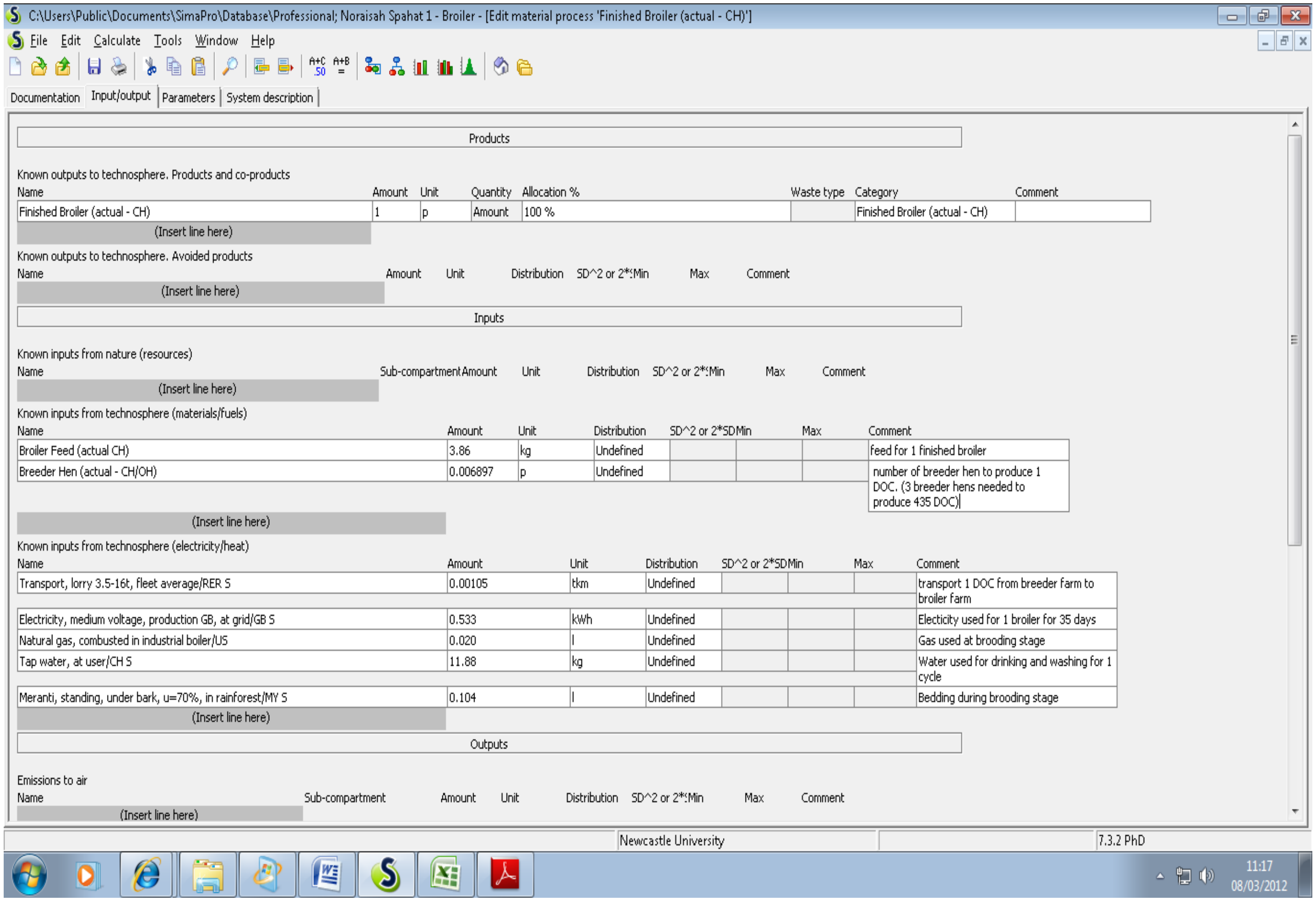


Figure 3.4 (ii): Example of entering process for output of one finished broiler by using input of broiler feed, breeder hen, transportation and a number of utilities elements

Global warming, acidification and eutrophication potentials were estimated using the CML 2 Baseline 2000 - version 2.02 (CML, 2001) method, which measures the potential environmental burdens included in the entire process until the final disposal using appropriate equivalence factors for several impact categories. The Cumulative Energy Demand (CED) LCA Food – version 1.02 (Ecoinvent Data, 2000) method was applied to estimate energy use to produce one tonne LW of broilers from different production systems.

3.5 Life Cycle Interpretation

The total contributions for each environmental impact category to produce one tonne LW of broiler chickens from each production system were calculated.

3.6 Results

As stated in Section 3.4, four midpoint impact categories were considered in the assessment of the potential environmental impacts associated with the production of one tonne LW of broiler chicken, namely energy use, GWP, AP and EP for three classes of burdens sources, i.e. broiler and breeder feed-related, other on-farm inputs (including transportation, electricity, gas, bedding, water for washing) and emissions for both breeder and broiler production, and fertilizer credit. Table 3.9 shows the four mid-point impact categories of a cradle to point of slaughter life cycle of one tonne LW of broiler chicken. In general, after considering the offset value from manure as fertilizer, the OH system recorded greater impacts produced for GWP, AP and EP, typically 6 to 7 % higher than for the CH system. However the CH system produced a greater burden for energy use, some 1.3% higher than for the OH system.

The impact values for various stages of the CH and OH systems are shown in Appendix 1 and 2 respectively. The decision was made to present the environmental burdens in the form of an impact assessment characterisation table instead of a network diagram, an approach which was considered to be more user-friendly since each stage of impact value can easily compared to the next impact stage.

Table 3.9: Life cycle impact assessment of category of energy use, global warming potential, acidification potential and eutrophication potential associated with the production of one tonne live weight of broiler chickens from two different production systems

Impact Category	Closed House	%*	Open House	%*
Energy Use (MJ)				
Broiler Feed-related	**9,482.03**	***78.1***	**10,175.35**	***85.5***
Breeder Feed-related	**952.95**	***7.8***	**979.92**	***8.2***
Other-farm inputs/emissions	**1,709.85**	***14.1***	**749.64**	***6.3***
Transportation	*223.68*	*13.1*	*242.11*	*32.3*
*Other inputs***	*1,486.17*	*86.9*	*507.53*	*67.7*
Electricity	*1,463.95*	*98.5*	*501.79*	*98.9*
Gas	*1.63*	*0.1*	*1.68*	*0.3*
Water	*1.15*	*0.1*	*1.19*	*0.2*
Bedding	*19.44*	*1.3*	*2.87*	*0.6*
Emissions	*0.00*	*0.0*	*0.00*	*0.0*
Sub-total	**12,144.83**		**11,904.91**	
Manure ***	- 3,732.14		- 3,600.50	
TOTAL	**8,412.69**		**8,304.41**	
Global Warming Potential (kg CO_2 equiv.)				
Broiler-related	**1,699.19**	***84.5***	**1,823.45**	***88.1***
Breeder-related	**157.16**	***7.8***	**161.61**	***7.8***
On-farm inputs/emissions	**154.64**	***7.7***	**84.92**	***4.1***
Transportation	14.86	*9.6*	16.10	*19.0*
*Other inputs***	139.78	*72.2*	68.82	*44.9*
Electricity	110.03	*98.6*	37.72	*98.9*
Gas	0.09	*0.1*	0.09	*0.2*
Water	0.11	*0.1*	0.11	*0.3*
Bedding	1.37	*1.0*	0.20	*0.5*
Emissions	28.18	*18.2*	30.70	*36.2*
Sub-total	**2,010.99**		**2,069.98**	
Manure ***	-690.24		-665.90	
TOTAL	**1,320.74**		**1,404.08**	

Impact Category	Closed House	%*	Open House	%*
Acidification Potential (kg SO_2 equiv.)				
Broiler-related	**13.57**	***69.6***	**14.56**	***70.5***
Breeder-related	**1.33**	***6.8***	**1.37**	***6.6***
Other-farm inputs/emissions	**4.58**	***23.5***	**4.71**	***22.8***
Transportation	0.07	*1.5*	0.07	*1.5*
*Other inputs***	4.52	*8.4*	4.64	*2.8*
Electricity	0.38	*97.8*	0.13	*98.2*
Gas	0.00	*0.2*	0.00	*0.7*
Water	0.00	*0.1*	0.00	*0.4*
Bedding	0.01	*1.8*	0.00	*0.8*
Emissions	4.13	*90.2*	4.51	*95.8*
Sub-total	**19.48**		**20.64**	
Manure ***	-2.08		-2.01	
TOTAL	**17.40**		**18.63**	
Eutrophication Potential (kg PO_4 equiv.)				
Broiler-related	**8.39**	***79.2***	**9.01**	***79.9***
Breeder-related	**0.78**	***7.4***	**0.80**	***7.1***
Other-farm inputs/emissions	**1.42**	***13.4***	**1.46**	***12.9***
Transportation	0.02	*1.4*	0.02	*1.4*
*Other inputs***	1.40	*9.0*	1.44	*3.0*
Electricity	0.13	*97.9*	0.04	*98.6*
Gas	0.00	*0.0*	0.00	*0.0*
Water	0.00	*0.2*	0.00	*0.6*
Bedding	0.00	*1.9*	0.00	*0.8*
Emissions	1.27	*89.6*	1.39	*95.6*
Sub-total	**10.60**		**11.27**	
Manure ***	-0.34		-0.33	
TOTAL	**10.25**		**10.94**	

**% refers to the percentage of impact at the production stage*
***other inputs including electricity, gas, bedding and water for washing*
****Negative values indicate the credit gained from using the manure as a fertiliser in oil palm production, thus reducing burdens of using synthetic fertiliser*

3.6.1 Broiler and breeder feed-related and other on-farm inputs

For both broiler production systems, broiler feed-related impacts accounted for the greatest proportion of each of the four mid-point impact categories. Taking into consideration the trade-off from manure that substitutes the use of synthetic fertiliser through fertiliser credit, the broiler feed-related category contributed between 70 to 85% and 71 to 88% of impacts for the CH and OH systems respectively. In contrast, breeder feed-related impacts had a relatively minor contribution, accounting for approximately 6.6 to 8.2% of burdens.

Other-farm inputs were divided into three classes, namely transport, other inputs and emissions from birds and manure. Other inputs comprise electricity, gas, bedding and water for washing the houses after each cycle for broiler production. When comparing within systems, both systems showed the same trend, i.e. other inputs were the major element contributing to the impacts for energy use and GW. Thus in the case of energy use, other inputs accounted for 87% and 68% the total burdens from other-farm inputs in the CH and OH systems respectively. In contrast, emissions from chickens and manure made a greater contribution to the impact for acidification and eutrophication categories, and were thus within the range of 90 to 96% of the total burdens from other-farm inputs.

When comparing between systems, other-farm inputs in the CH system produced a burden for energy use that was approximately 2.3 times more that of the OH system, largely due to its heating and ventilation systems (in absolute terms the CH system uses approximately three times more electricity than the OH system).

3.6.2 Manure as a fertilizer credit for oil palm production

Based on the assumption that the substitution between synthetic fertiliser and organic fertiliser nutrients, i.e. by replacing one tonne of synthetic fertiliser with a ratio of 12:12:17 of N, P and K with an equivalent amount of chicken manure, as stated in Section 3.3.1.5 (ii), burdens associated with synthetic fertiliser production and utilisation could be reduced. This practice offset approximately 43 to 44 % of total energy use, 47 to 52% of total GWP emission, 11 to 12% of total AP emissions and 3% of total EP emissions. The detail of offset values as a percentage of all impacts categories is shown in Figure 3.5 whilst the absolute values are shown in Table 3.9.

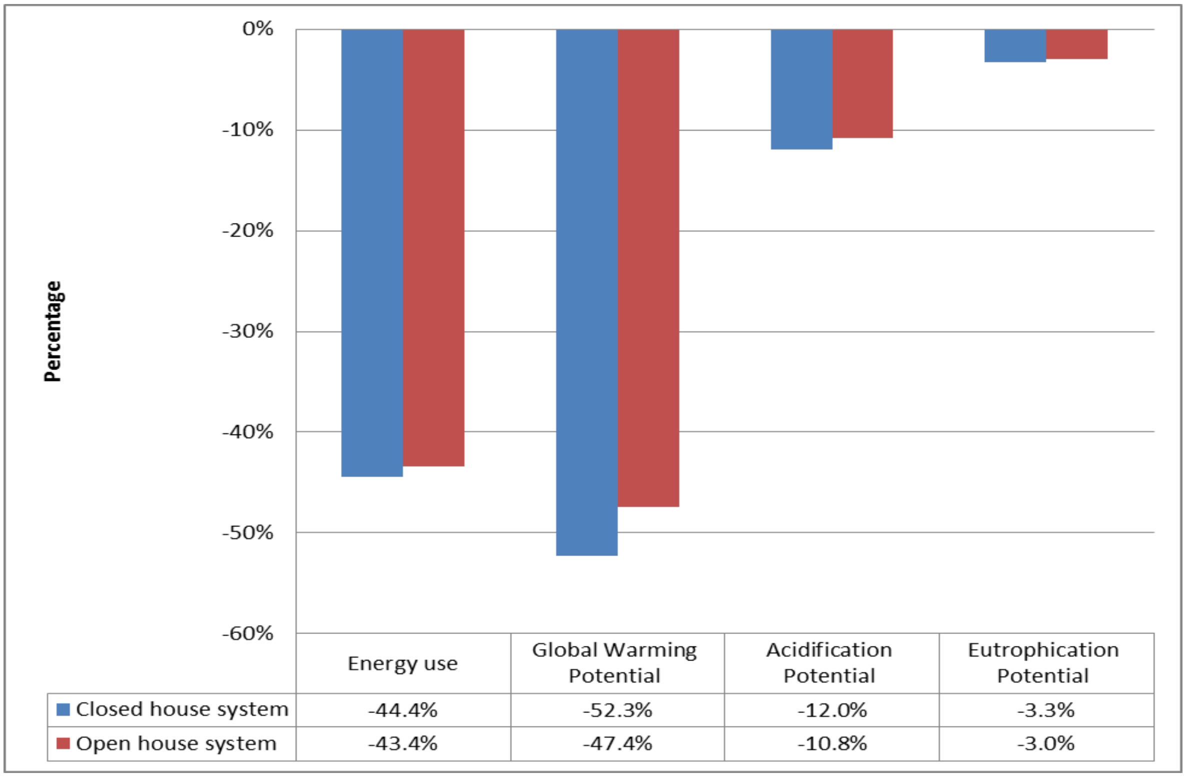
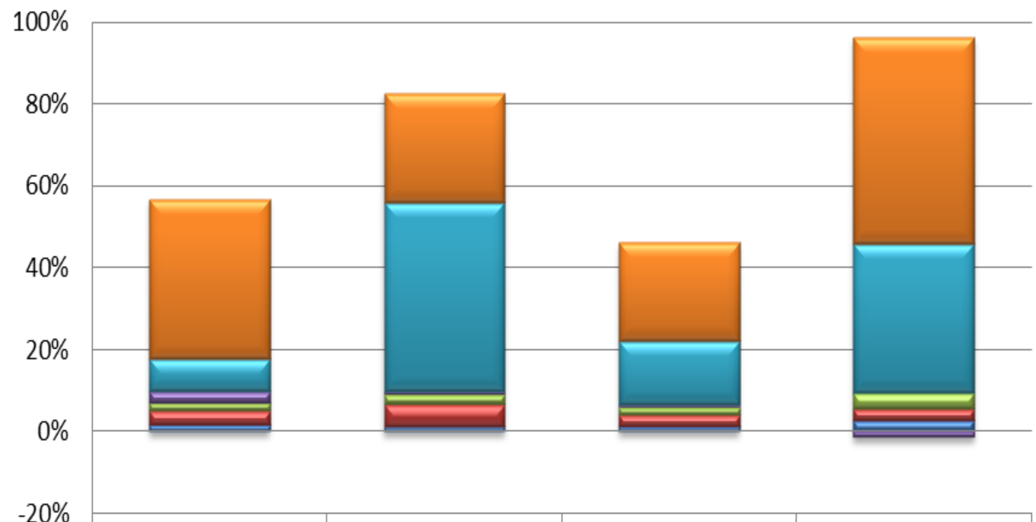


Figure 3.5: Relative contribution of poultry manure as an organic fertiliser for oil palm cultivation for energy use, global warming potential, acidification potential and eutrophication potential associated with production of one tonne LW of broiler chickens

3.6.3 Broiler and breeder feed as a major contributor of environmental inputs

Given the fact that feed used for both broiler and breeder production dominated the contributions for all mid-point impact categories, it is useful to examine the background of the feed production system in detail. The contribution of feed-related input comprises two main elements, namely raw materials and transportation. On average, raw materials accounted for approximately 70.1% and 70.4% of all impact categories for broiler and breeder feed respectively, whereas the equivalent values for transportation (freight oceanic and land transportation) were 29.9% and 29.6%.

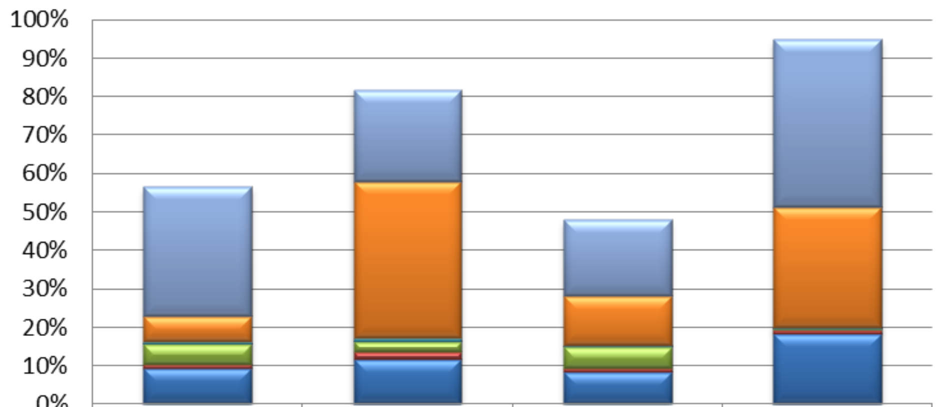
For boiler feed, maize, soybean and palm oil accounted for a substantial part of the total impacts, while soybean, wheat pollard, maize and dicalcium phosphate recorded significant environmental impact in the breeder feed. Maize, which comprises approximately 59% by mass of the ingredients, contributed on average 35% of the impacts associated with the production of one tonne LW of broiler chickens, while soybean, which makes up approximately 28% of broiler feed, contributed on average 27% of impacts. Figure 3.6 shows the percentage impacts of broiler feed consumed to produce 1 FU of broiler chickens.



	Energy Use	Global Warming Potential	Acidification Potential	Eutrophication Potential
Maize	39.0%	26.8%	24.0%	50.5%
Soybeans	7.9%	46.1%	15.8%	36.4%
Fishmeal	2.9%	0.7%	0.4%	-1.4%
Wheat	1.9%	2.3%	1.8%	3.8%
Palm oil	3.3%	5.4%	2.9%	2.8%
Maize gluten	1.7%	1.3%	1.3%	2.8%

Figure 3.6: Relative contribution of raw materials used (including crop cultivation and feed processing) to produce one tonne of broiler feed to energy use, global warming, acidification and eutrophication impacts associated with production of one tonne live weight of broiler chickens

Meanwhile, for breeder production, the feed requirements for both production systems were similar, not least because a similar numbers of breeder hens (approximately three) were required per FU. Maize was a major ingredient, accounting for approximately 50% by mass, yet it contributed on average 30% of the impacts, while soybean and wheat pollard, which comprised approximately 23% and 14.3% of the ration by mass, produced on average 23% and 12% of the impacts respectively. The detail of impacts produced from one tonne of breeder feed in percentage values can be seen in Figure 3.7



	Energy Use	Global Warming Potential	Acidification Potential	Eutrophication Potential
Maize	33.4%	23.9%	19.7%	43.6%
Soybeans	6.7%	40.7%	12.9%	31.1%
Palm Oil	0.5%	0.9%	0.5%	0.5%
Limestone	0.0%	0.0%	0.0%	0.0%
Dicalcium Phosphate	5.3%	2.7%	5.5%	0.1%
Palm Kernel	1.1%	2.0%	1.0%	1.0%
Wheat Pollard	9.4%	11.7%	8.4%	18.5%

Figure 3.7: Relative contribution of raw materials used (including crop cultivation and feed processing) to produce one tonne of breeder feed to energy use, global warming, acidification and eutrophication impacts associated with production of one tonne live weight of broiler chickens

3.7 Sensitivity Analysis

As described in Section 3.3.1, foreground and background data collected during the Life Cycle Inventory phase were derived from various sources, namely industry, previous LCA studies, interviews with researchers in Malaysia and direct from producers. In subsequently generating the impact values, a series of assumptions and calculations were made based on the best available advice. However, it can be argued that any model of a system is only as good as the data on which it is based and therefore we should test how sensitive the results are to small changes in the input data. The importance of any potential error in input values can be assessed by completing sensitivity or uncertainty analyses. EPA (2001) defines sensitivity analysis as a procedure to identify and measure the extent to which changes in key data and assumptions made during the Lifecycle Inventory (LCI) phase and characterization models affect the impact values. On the other hand, uncertainty analysis describes the variability of the Lifecycle Impact Assessment (LCIA) data to determine the significance of the impact indicator values. Sensitivity and uncertainty both deal with the variability of data but at different LCA stages, namely LCI and LCIA respectively. Hence due to multiple sources and techniques used to obtain the foreground data as described previously, in the present study we chose to employ sensitivity analysis due to multiple sources and techniques used to obtain the foreground data as mentioned earlier.

Thus each parameter in the sensitivity analysis was changed independently of all others, so that the magnitude of its effect on the calculated value for the each production system could be assessed. Some parameters used have a relatively high degree of accuracy and these can remain fixed throughout the analysis, however other parameters or assumptions may have some inherent degree of ambiguity and are the ones to be varied. The useful discipline in sensitivity analysis is to set a target variation of results from adjustments in selected parameters, by altering the value in turn by ±5%, ±10% and ±20% (CMHC, 2004).

The model established in the current study employed total feed intake of the broiler chicken and other on-farm inputs as key parameters during the Lifecycle Assessment. Since feed-related inputs contributed the highest percentage of overall impact values, this indicates that the sensitivity analysis should be focussed more on aspects related to feed than to other on-farm inputs. Thus three main feed-related parameters which were important, and at the same time carried some degree of uncertainty, were chosen as alternative parameters, namely FCR, finished weight and length of production cycle. Ideally, different types of raw materials could be used as the alternative parameters, but since the majority of feed ingredients are imported, the macro level of feed-related parameters was chosen for sensitivity tests. Even though these alternative parameters are specific for this study, the basis of arguments can be applied to general broiler production in Malaysia, since more than three quarters of broiler production systems are in the integrated form. Table 3.10 shows how the production parameters were varied for the CH system to assess the extent to which values for those parameters are important to the life cycle of broiler production.

Table 3.10: Adjustment of alternative main parameters of finished weight, length of production cycle and food conversion ratio to assess the extent to which selected parameters are important in the lifecycle of closed house broiler production

Main Parameter	**Baseline value**	**Variation adjustment of main parameters**					
		Finished weight		**Length of production cycle**		**Food Conversion Ratio**	
		(+10%)	**(-10%)**	**(+5%)**	**(-5%)**	**(-5%)**	**(+5%)**
Finished weight	2.18	2.40	1.96				
Length per cycle (days)	40			42	38		
FCR	1.78	1.78	1.78	1.78	1.78	1.69	1.87
Feed intake (kg/bird)	3.88	4.27	3.49	4.08	3.69	3.69	4.08
Number of birds (for 1FU)	459	417	510	437	482	459	459

In this study, ambiguity of data accuracy may occur for finished weight and length of production cycle parameters which were derived from the Serin *et al.* (2011b) survey. Finished weight, for example, is a parameter used as a basis for the FCR calculation which later becomes the most important parameter to measure the production efficiency, while length of production is a crucial factor to determine the amount of manure generated which brings significant burdens to the environment. Thus, two classes of sensitivity analyses were conducted to measure to what extent the adjustment of these parameters produce changes from baseline impact values. Firstly, the changes of impact values as a result of

FCR adjustment with finished weight as a constant value were evaluated, while a second analysis chose adjustment of finished weight and length of production cycle parameters with the assumption that the value of FCR is a constant. The positive numbers in the results indicate a percentage increase while the negative numbers signify a decreased contribution of impacts. The next sections show changes from baseline impact values after the adjustment of these three parameters.

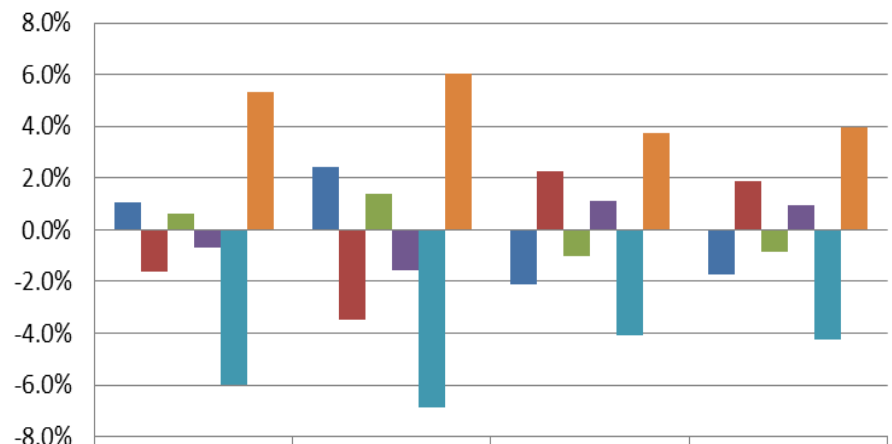
3.7.1 Closed house system

Figure 3.8 shows the influence of percentage adjustment of ±5% and ±10% for four impact categories in the CH system.

Both finished weight and length of production produced similar impact changes for both variations. For example, with an adjustment of +10% of finished weight, a FU of birds produced positive impact changes for energy use and global warming of 1.0% and 2.4% respectively, while a reduction of 10% generated changes of -1.6% and -3.5% respectively. For the adjustments of +10% and -10%, 417 and 510 birds were required to achieve one tonne live weight of broiler chickens in comparison with the baseline of 459 birds.

However, impacts for acidification and eutrophication showed the opposite trends. For example when the adjustment was +10% of finished weight, the impacts showed negative changes per FU of 2.1% and 1.7% for AP and EP respectively. The lower number of birds required (i.e. 417 instead of 459) led to the lower impact compared to baseline values. A similar scenario explained the positive changes for a reduction of 10%, which required an additional 51 birds per FU. A variation of ±5% for finished weight and length of production recorded approximately half of the change in values from ±10% for all impact categories.

Meanwhile, the adjustment of FCR with finished weight as a constant parameter showed that with a reduction of only 5%, the impact values for GWP at a FU unit level can be reduced by 6.9%.



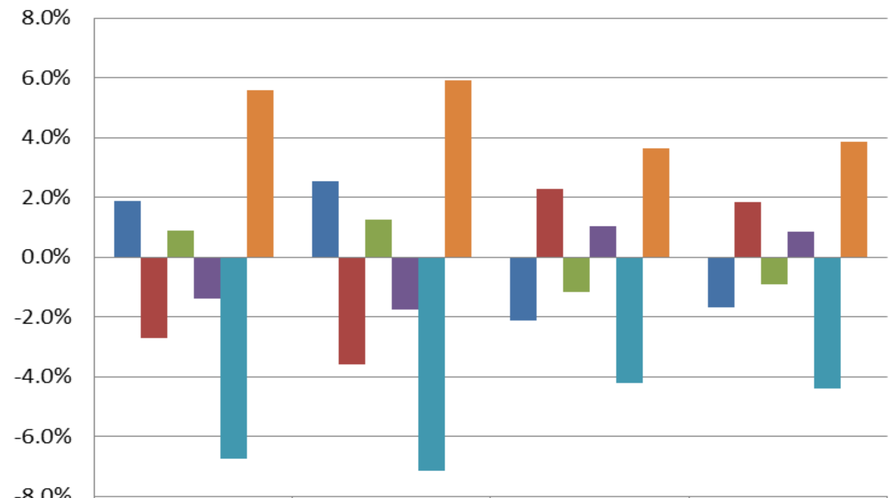
	Energy Use	GWP	AP	EP
Finished weight (+10%)	1.0%	2.4%	-2.1%	-1.7%
Finished weight (-10%)	-1.6%	-3.5%	2.3%	1.9%
Length of production (+5%)	0.6%	1.4%	-1.0%	-0.8%
Length of production (-5%)	-0.7%	-1.6%	1.1%	0.9%
FCR (-5%)	-6.0%	-6.9%	-4.1%	-4.3%
FCR (+5%)	5.3%	6.1%	3.8%	3.9%

Figure 3.8: Influence of changing finished weight, length of production cycle and feed conversion ratio (FCR) at ±5% and ±10% for the closed house system on total energy use, global warming potential, acidification potential and eutrophication potential impacts categories associated with production of one tonne live weight of broiler chickens

3.7.2 Open house system

Similar trends of impact values to those in the CH system were recorded for the OH system. Figure 3.9 shows the variation in percentage changes for four impact categories for a FU produced in the OH system as a result of adjustments of the three selected parameters at ±5% and ±10%.

With an adjustment of +10% in finished weight or length of production parameters, the burdens produced for energy use and global warming were increased by 1.9% and 2.5% respectively, while for a -10% adjustment the burdens were reduced by 2.7% and 3.6%. For acidification and eutrophication impacts, +10% adjustments showed reductions in impact of 2.1% and 1.7% respectively, while -10% adjustments recorded the opposite trend with increased impact of approximately the same magnitude. For FCR, the reduction of 5% produced less burdens for all categories, of 4.2 to 7.2% from baseline values, while a +5% change in FCR recorded an increase in burdens of approximately 4 to 6%.



	Energy Use	GWP	AP	EP
Finished weight (+10%)	1.9%	2.5%	-2.1%	-1.7%
Finished weight (-10%)	-2.7%	-3.6%	2.3%	1.9%
Length of production (+5%)	0.9%	1.3%	-1.2%	-0.9%
Length of production (-5%)	-1.4%	-1.8%	1.0%	0.8%
FCR (-5%)	-6.7%	-7.2%	-4.2%	-4.4%
FCR (+5%)	5.6%	5.9%	3.6%	3.9%

Figure 3.9: Influence of changing finished weight, length of production cycle and feed conversion ratio (FCR) at ±5% and ±10% for the open house system on total energy use, global warming potential, acidification potential and eutrophication potential impact categories associated with the production of one tonne live weight of broiler chickens

3.7.3 Conclusion of sensitivity analyses

Detailed sensitivity analyses of all impact categories in each housing system revealed that the FCR was the most important parameter to reduce environmental burdens by improving the production efficiency. Since the other parameters, i.e. finished weight and length of production cycle were determined by the integrator, these factors could easily be adjusted to give the optimal FCR value. By improving FCR by only 5%, burdens can be reduced by an average of 5.5% which represents a significant opportunity to reduce impacts. In contrast, changes in finished weight and length of production (with constant FCR), even at a -10% parameter adjustment of finished weight, resulted in only very minor reductions in burdens (on average just 0.4%).

3.8 Discussion

3.8.1 Introduction

Environmental assessment tools have been developed to determine the environmental impacts of human activities in the provision of the goods and services and thus to assist in developing more sustainable systems (Rebitzer *et al.*, 2004; Roy *et al.*, 2009). Even though there are various types of environmental assessment tools, as described in Chapter 2, in the present study LCA was chosen with the objective of evaluating the environmental burdens associated with the production of broiler chickens by identifying the resources and energy use as well as waste released to the environment. This method allows identification of the main sources of pollution along the supply chain at a farm level (Halberg *et al.*, 2005).

The current study was modelled on the function of the product (i.e. finished broiler chickens) that satisfies societies' demand and economic expectations from the different types of production systems. Previous studies have used different scenarios as the basis for the LCA, such as issues in manure handling and potential benefits from regulation changes (Dalgaard, 2007), changes in farm management (Pelletier, 2008), comparison of approaches in performing LCA (Thomassen *et al.*, 2008), comparison of contrasting environments (Olea *et al.*, 2009) and differences between production systems (Williams *et al.*, 2006; Boggia *et al.*, 2010; Xin *et al.*, 2011; Leinonen *et al.*, 2012). Therefore, selection of the functional unit (FU) and the choice of system boundary were also based on the function of the product. The FU of 1 tonne LW of broiler chickens was chosen since the majority of the economic value of the broiler chicken comes from the production of meat and therefore the environmental impact should be fully allocated to the meat. Even though there is an increasing interest in the use of a particular FU which focuses on the human body's need for nutrition (e.g. de Vries and de Boer, 2010, reported the used a FU of 1 kg of protein), the lack of comprehensive foreground data about post-slaughter processing of broiler chickens in Malaysia meant that the current study chose a cradle to point of slaughter approach and opted for a FU of one tonne LW of broiler chickens.

Ideally, LCA assesses the environmental burdens over a product's entire lifecycle, from cradle to grave in effect. However, the current study concentrated on the environmental impacts associated with the production of broiler chickens on farm, and thus excluded the subsequent stages of processing, retail outlets and consumer markets. The justification for this focus on the production stage lies in the objective of this study, which was to find out whether different broiler production systems produce different levels of EBs. Therefore a cradle to point of slaughter system boundary was considered appropriate to estimate values of selected categories of environmental impact for different production systems.

Discussion about the results of four selected impact categories will be considered in three areas:

i) Comparison of impact of a typical Malaysian broiler production system with other studies;
ii) Comparison of the total impact of burdens across the two different broiler housing systems; and
iii) The relative contribution of different inputs in the system boundary to total environmental impacts.

3.8.2 Comparison analysis of different studies

Considering that the CH system in Malaysia was equivalent with standard broiler production in most temperate regions, a comparison was made with four particularly well known LCA studies on broiler production, namely Williams *et al.* (2006), Pelletier (2008), Katajajuuri (2008) and Leinonen *et al.* (2012). An important note is that these LCA equivalent studies have adopted different FU to the one used in the current study. Pelletier (2008) and the current study chose one tonne live weight as a FU, Katajajuuri (2008) chose one tonne of processed product while Williams *et al.* (2006) selected one tonne dead weight and Leinonen *et al.* (2012) took one tonne of expected edible carcass weight as a FU. Thus, the comparison values must be interpreted with caution since each impact value will be represented by a different number of broiler chickens. For example Pelletier (2008), Leinonen *et al.* (2012), Williams *et al.* (2006) and the present study needed 442, 778, 394 and 459 chickens respectively for their chosen FU. Therefore, sometimes the comparisons in the following sections will focus not only on the FU, but also on an individual chicken basis. Thus Table 3.11 shows the values of four impact categories associated with these five LCA studies on broiler production on both a FU and an individual chicken level.

Climatic factors such as temperature and humidity play a major role in ensuring optimum growth of broiler chickens. Most previous studies on LCA related to broiler production (as shown in Table 3.11) were conducted in places with a relatively cold temperate climate, with prolonged winter and moderate summer temperatures, which require additional heating and insulation systems. Besides this, to prevent excessive moisture build-up during warm weather, ventilation is needed to maintain optimum performance. These factors were undoubtedly a major contributor to the higher usage of energy for housing management in these previous studies. The current study utilised approximately 30 to 67% lower energy than the other studies.

Even though the present study deals with broiler production in a relatively hot climate (which experiences high temperature and humidity all year round and faces challenges to expel excess heat, thus requiring good ventilation with evaporative cooling systems to control the environment in the CH system), the findings showed that the energy use on an individual bird level was still 44% and 46% lower than for Leinonen *et al.* (2012) and Pelletier (2008) respectively.

Table 3.11: Values of four impact categories of energy use, global warming potential (GWP), acidification potential (AP) and eutrophication potential (EP) from five LCA studies on broiler production at a particular FU and at a single chicken level

Study	Study case	Country	FU*	Energy use MJ	GWP kg CO2 equiv.	AP kg SO2 equiv.	EP kg PO4 equiv.
Current Study	Type of production**	Malaysia	one tonne LW	8,413	1,321	17.4	10.3
Williams *et al.(*2006)	Type of production**	U.K	one tonne DW	12,000	4,570	173.0	49.0
Pelletier (2008)	Farm management**	U.S.A	one tonne LW	14,959	1,395	16.0	4.0
Katajajuuri (2008)	Production network	Finland	one tonne PP	16,000	2,079	35.0	2.0
Leinonen *et al.* (2012)	Type of production**	U.K	one tonne EC	25,390	4,400	47.0	20.0

	Per bird			
	Energy use MJ	GWP kg CO2 equiv.	AP kg SO2 equiv.	EP kg PO4 equiv.
Current Study	18.34	2.88	0.04	0.02
Pelletier (2008)	33.84	3.16	0.04	0.01
Leinonen *et al.* (2012)	32.63	5.66	0.06	0.03

**Abbreviations as follows: LW (live weight); DW (dead weight); PP (processed product); EC (edible carcass)*

***Type of production system: Current study (closed house); Williams et al. (2006) (non-organic); Pelletier (2008)(standard system); Leinonen et al. (2012) (standard indoor).*

Besides climatic factors, the choice of system boundary also influenced the impact level. For example, Katajajuuri (2008) chose production networks of processed products (i.e. honey marinated and sliced broiler fillet) as a FU which involved all stages of upstream and downstream activities (i.e. production and distribution systems); these consumed a large amount of energy, especially diesel and electricity for transportation and storage, along the production chain. Thus climate and system boundary explained the variation of impact value among studies.

Time to complete the production cycle (i.e. finished weight, determined by the integrator) was influenced by feed composition, FCR and total amount of feed consumed. The finished weight also determined the number of broiler chickens for one FU. Thus, these six inter-related production performance parameters, i.e. length of production, finished weight, feed composition, FCR, total amount of feed consumed and number of chicken were affected the values of the environmental burdens. The current study specified a length of production which was very similar to that used by Leinonen *et al.* (2012) but with a smaller number of birds, i.e. 459 compared to 778 birds per FU. Even though Pelletier (2008) needed only 442 birds to produce a FU of broiler chicken, his system required 48 days to complete a production cycle. Thus these scenarios give rise to substantial differences in amount of feed consumed per FU (1,782 kg, 1,898 kg and 2,913 kg respectively) and ultimately determined the differences in the amount of manure produced per FU at the end of the production cycle.

Based on the above conditions, the GW impact, which mainly resulted from CO_2 emissions of fossil fuel together with small amounts of N_2O and CH_4 from the chicken and its manure, showed a large variation between studies with the current study generated approximately 5% lower GWP per FU than Pelletier (2008) and 70% lower than Leinonen *et al.* (2012). When expressed on a single bird basis, the findings still showed a similar though less pronounced trend in impact.

Since poultry production in Malaysia is still highly dependent on importation of raw materials for feeds, the GW impact burdens mainly arise from transportation by oceanic freight (this category contributed 14% of total GW burdens in the CH system). Every one tkm of oceanic freight to transport imported raw materials from various countries to Malaysia released 8.58 g of CO_2, the highest emissions among gasses into the air. Therefore, to import sufficient raw materials for one tonne of feed for both broiler and breeder chickens required 15,145 tkm which released 129.89 kg of CO_2 to the atmosphere. In addition to this, feed crop cultivation is responsible for releasing the bulk of GW gases, especially cultivation of soybeans (which produced 46% of overall impact from broiler feed); as result of all upstream feed production processes including ploughing, harvesting, fertiliser and pesticides use. Thus, with the same FU chosen but differences in broiler production performance (i.e. less feed consumed, shorter cycle length and less manure in the current study) it might be expected that the current study would produce a lower impact value than that of Pelletier (2008). However, the estimated GW impact was approximately similar in both studies, perhaps since the broiler industry in the U.S.A uses mainly local feed as the inputs. Details about the relative impact of broiler feed provision to total environmental impact of broiler production will be elaborated in Section 3.8.4.

A higher amount of manure produced per bird per cycle was reported by Leinonen *et al.* (2012) compared to Pelletier (2008) and the current study was determined by six inter-related parameters (i.e. length of production, feed composition, FCR, total amount of feed consumed, number of chicken and finished weight) reflects the variation impact values of acidification and eutrophication. These arguments are consistent with those of Sharpley (1985) and de Boer *et al.* (2002), who found that several underlying factors affect the level of NH_3 and NO_3 released (i.e. the sources of acidification and eutrophication effects), such as feed ration and manure handling besides climatic and soil conditions.

The sources of acidification impact associated with broiler production derived from NH_3 emission, coupled with SO_2 from fossil fuel combustion, while the sources of eutrophication impact are NO_3, NH_3 emissions into the air and PO_4 leaching into water. Nitrogen is a key element leading to acidification and eutrophication occurrence and this element is obtained from the manure. In terms of proportional contribution to acidification and eutrophication incidents, at a FU level, Leinonen *et al.* (2012) stated that 52% and 38%

of burdens came from manure handling and feed production respectively. Conversely, Pelletier (2008) recorded that the majority of burdens were derived from feed production, approximately 97% while in the current study, feed-related inputs contributed on average 85% of burdens at the production stage, while manure emissions only contributed 9% respectively. However, considering the data on a single chicken level, both the Pelletier (2008) and the current study showed relatively similar values for acidification and eutrophication burdens (0.04 kg SO_2 and 0.02 kg PO_4 per bird respectively for acidification and eutrophication), reflecting the same choice of functional unit. Since Leinonen *et al.* (2012) chose a different FU, namely one tonne of edible carcass which requires an additional 336 and 319 birds compared to Pelletier (2008) and the current study respectively, additional burdens were accounted.

Besides differences in the main parameters which led to the variation of all burden values, the basis for the calculation also played a significant role. For example, the current study applied IPCC and generic formulae (a mixture of definition and equation) due to the incomplete nature of IPCC formulae in relation to certain gasses, as stated in Section 3.3.1.4; Pelletier (2008) used IPPC formulae whereas Leinonen *et al*. (2012) applied calculations based on generic formulae. Different formulae provided different emission factors and thus contributed to the differences in impact values.

3.8.3 Comparison of the total impact of burdens between different broiler housing systems

Differences in total impact across different housing systems can be explained by key input parameters; i.e. length of production cycle, finished weight, feed ingredients, FCR, total amount of feed consumed and number of broiler chickens per FU (see Table 3.2). Table 3.12 summarises the differences in impact values between the two housing systems. The OH system produced 6% to 7% higher impacts than the CH system for GW, AP and EP impact categories. Differences in GWP can be explained by greater feed consumption (4.05 kg versus 3.88 kg per bird in the CH system) and a longer production cycle (43 days instead of 40 days in the CH system). The longer production cycle resulting in more manure production (1.2 kg per bird) will have contributed to the greater impact in AP and EP categories. On the other hand the CH system recorded a 1% higher burden of energy use, largely due to the nature of the housing system which required more energy for heating and ventilation systems (this system requires 0.4 kWh for each chicken per cycle compared to 0.08 kWh for the OH system). Similar trends were recorded at single chicken level, but with a smaller magnitude.

Table 3.12: Values of four impact categories of energy use, global warming potential, acidification potential and eutrophication potential associated with production of broiler chickens in different housing systems at both the selected FU and single broiler chicken level

Impact Category		**Closed House** (Total impact per FU)	**Open House**	**Difference OH/CH**
Energy Use	MJ	8,412.70	8,304.41	-1.3%
Global Warming Potential	kg CO2 equiv.	1,320.74	1,404.08	6.3%
Acidification Potential	kg SO2 equiv.	17.39	18.63	7.1%
Eutrophication Potential	kg PO4 equiv.	10.25	10.94	6.7%
		Total impact per bird		
Energy Use	MJ	18.34	17.61	-4.0%
Global Warming Potential	kg CO2 equiv.	2.88	2.98	3.4%
Acidification Potential	kg SO2 equiv.	0.04	0.04	4.2%
Eutrophication Potential	kg PO4 equiv.	0.02	0.02	3.8%

3.8.4 Relative contribution of different inputs in the system boundary

Understanding the environmental impact in the current study involved careful consideration of each step, especially in feed since the production system is fundamentally dependent on feed-related activities, i.e. crop production (imported or local), processing and transportation links, which are far from actual activities at the farm level. The upstream activities related to basic field operations such as ploughing, sowing, application of fertilizer and plant protection and finally harvesting require additional energy and generated emissions along the broiler supply chain. This chain, including the transportation and processing stage to produce concentrated feed, and all these upstream activities are responsible for the bulk of impacts, especially if the nature of the production relies on imported feed.

As presented in Table 3.9, feed-related activities accounted for the largest part of environmental burdens estimated to be on average 89.8% of energy use, 94.1% of greenhouse gas emissions, 76.8% of acidifying emissions and 86.8% of eutrophying emissions for production of one tonne LW of broiler chickens. This insight is consistent with previous findings of broiler production (Williams *et al.*, 2006; Pelletier, 2008; Boggia *et al.*, 2010; Leinonen *et al.*, 2012). Multiple factors on farm contribute to the impacts from feed-related inputs such as finished weight and housing management; however the most recognisable source in the case of Malaysia was burdens arising from transportation of imported feed by oceanic freight as stated in Section 3.8.2.

For the crop-derived components, maize and soybeans, which accounted for 60% and 28% respectively of the total ingredients of broiler feed, released GW emissions of 455.01 kg and 782.82 kg CO_2 equiv. respectively for a FU. Even though maize was the major ingredient in broiler and breeder feed, the GW emissions from soybeans was 1.7 times greater than maize in the CH system. This finding was consistent with the results of Leinonen *et al.* (2012), which showed that soybeans had a 1.5% higher contribution to GW impact than burdens from maize in standard and free-range systems. This is mainly caused by GHGs released as a result of land-use changes in the exporting country, since to produce 1 kg of soybeans required the transformation of 7.9 m^2 of land-use.

Breeder feed-related burdens contributed the second largest amount to GW emissions, mainly for the same reasons as broiler feed mentioned previously. The similarity between the two housing systems, since they both needed a similar number of breeder hens, contributing 7.8% to GW emissions as a result of approximately 156 kg of feed.

Hence, when dealing with the environmental assessment of livestock products, consideration should be given not only at the animal rearing techniques, but great attention has to be focused to reduce the impact arising from the production and utilisation of feed.

In the current study, the greatest impacts from manure were in acidification and eutrophication impact categories (typically 22% and 12% respectively of AP and EP), arising from the burdens of ammonia release and nitrate leaching to the soil. Burdens for manure were slightly higher for the OH system, (4.51 versus 4.13 kg SO_2, and 1.39 versus 1.27 kg PO_4) arising from the extended production cycle in this system. Leinonen *et al.* (2012) also recorded a similar trend for an organic system, which produced a large amount of manure due to a longer production cycle as well as higher feed N content compared to other systems under investigation.

Based on the assumption that poultry manure could substitute for synthetic fertiliser nutrients in oil palm plantations, burdens associated with synthetic fertiliser production could be reduced. A conservative estimate of the consequence of NPK substitution of synthetic fertiliser with an equivalent ratio of poultry manure were offsets of between 3 to 52% of the selected impact categories. Due to the constraints in getting a close estimation of the actual amount of manure application, the ratio of 12:12:17 of NPK in synthetic fertiliser was used as a foundation model to investigate the projected outputs. This study always realised the assumptions of substitution used might be challenged by plantation producers, especially from large companies who are very concerned about productivity. The substitution approach is no doubt beneficial for green efforts, but at the same time might affect the crop productivity. It was explained in this study that the content of NPK in organic fertiliser (i.e. poultry manure) is much lower than synthetic fertiliser, i.e. 3 to 6 times, meaning that a large amount of organic fertiliser is required to fulfil the nutrient demand unless additional treatments are applied to the manure to increase its nutrient content. Thus, this study provides support for the development of future strategies to improve environmental quality by greater utilisation of existing by-products. However, given the over-riding influence of broiler and breeder feed, feed-related activities should remain the focus for any such strategies.

3.9 Conclusions

Although every effort was made to achieve a comprehensive analysis of environmental impacts of broiler production systems in Malaysia, the generic nature of broiler production systems with limitations of available data, particularly on manure-related burdens, means that the results presented here should be interpreted with some caution. Furthermore, in the present study broiler production was modelled based on the main production sites in the Peninsular Malaysia, whereas recent developments to cater for growing demand from the population in Borneo Island have led to an expansion in broiler production in that area. Thus there could be differences in transportation distances for raw materials which could affect the environmental impact. Despite a number of limitations, however, the uniformity of the broiler industry (i.e. CH and OH systems represent 99% of national commercial production from 10 major integrators) the general results presented in this study can be considered as representative of broiler production in Malaysia.

One of the most important findings from this study is that the CH system produces lower environmental burdens than the OH system, by 6% to 7% for GWP, AP and EP impact categories. Energy use was marginally greater in the CH system however, associated with ventilation, lighting and feeding systems within the building. This study has also demonstrated the potential to reduce environmental burdens of any system through improved production performance, especially when targeting feed-related activities which accounted for the majority of burdens. For example, a marginal (5%) improvement in FCR would lead to equivalent reductions in impact values. Therefore, there is considerable scope to improve feed efficiency by creating optimal conditions inside the house (i.e. accurate temperature and ventilation rate), minimising feed wastage and high standards of disease control to optimise growth. Indeed, some producers might argue that the CH system has an advantage over the OH system, since it offers to scope for a fully controlled environment unlike the OH system which has more rudimentary climatic control. Clearly human factors play a key role through diligent management on farm to achieve optimum production with minimum environmental impact.

To achieve the projected annual domestic production in Malaysia of 1.49 million tonnes by 2020, the main focus is to expand the potential market, especially for export purposes through diversified downstream activities. Thus efforts should be made to select the production system which is best able to provide higher production without compromising environmental impacts for the long term. Currently 60% of national chicken production comes from the OH system, but the evidence from this study suggests that the burdens of GWP, AP and EP could be reduced at a national level if CH systems were adopted instead. Indeed, in the future building designers and engineers may be able to provide even better forms of housing to reduce environmental impacts even further.

Chapter 4. Economic Valuation of Environmental Goods: Consumers' Willingness to Pay for Chicken Meat Produced with a Higher Regard for the Environment

4.1 Introduction

In parallel to a detailed environmental audit of the impacts of different broiler production systems, one of the objectives of this thesis (outlined in Section 1.4) was to gain a greater understanding of the attitudes of consumers to more sustainable forms of meat production, in essence to estimate the potential economic value that consumers in Malaysia might place on the environmental benefits of more sustainable broiler production. This approach has been widely used in environmental economics to estimate what the public might be willing to pay for certain environmental aspects such as reduced pollution and improved quality of the countryside, aspects which are intangible. In keeping with that broad approach, the concept of broiler chickens produced with additional environmental benefits (e.g. reduced pollution) through a higher regard for the environment (chicken-HRE) was proposed. Rather than focusing on one particular housing system for broiler chickens (which may have been confusing for many Malaysian consumers who have very little knowledge about broiler production), the concept was simply that chicken-HRE is 'broiler meat which has been produced in such a way that it has a lower environmental impact than conventional meat'. No specific details were given about how exactly chicken-HRE might be produced or the likely rearing conditions of the birds, this was simply a concept that we wished to propose to consumers.

Equally for the integrators and broiler producers, any move to more environmentally friendly production may require investment and, unless there are savings (e.g. through improved feed efficiency), this may lead to a higher cost of production which ultimately will need to be absorbed at consumer level. Therefore, the estimation of the readiness of consumers to pay a higher price for chicken meat in the market is vital, since chicken meat is the most important raw material in the Malaysian diet. Ultimately, the value of willingness to pay (WTP) will be an indicator of the readiness among the Malaysian population to pay for favourable environmental quality.

For the context of this study, it is also useful to gain some additional background information about consumers, including their attitudes to purchasing chicken meat as well as their level of understanding of general environmental issues and specifically the impact of broiler production on the environment. This information can then be used to examine the relationships between selected parameters which might influence the consumers' choices and their WTP, and ultimately to develop a regression model (such as Simple Regression and Binary Logistic Regression to represent the WTP of society to buy chicken meat produced with due consideration for the environment.

Thus the objective of the current chapter was to estimate the consumers' WTP for chicken-HRE by using the contingent valuation method (CVM) assessment. This objective was then divided into a number of questions as follows:

1) What are the socio-demographic and economic characteristics of the respondents which relate to their opinions of environmental issues, preferences and consumption status of chicken?

2) What are the parameters which are individually associated with consumers' behaviour when they purchase chicken?

3) What combination of parameters best explains consumers' WTP more for chicken-HRE?

4.2 Materials and Methods

4.2.1 Sampling strategy

4.2.1.1 Method of data collection

The survey was carried out using a structured questionnaire which was completed during a face to face interview. Specially trained assistants visited selected households to collect a range of information from respondents about their socio-demographic status, knowledge about the environment and other WTP-related questions. The following sections describe the sampling strategy, the form of the questionnaire as well as details about how the questionnaire was completed.

4.2.1.2 Scope and coverage

The survey covered households in 12 states in Peninsular Malaysia which is categorised into four regions, namely the northern, central, southern and eastern regions. Different regions in Peninsular Malaysia have a different economic status, as identified by the Gross Domestic Product (GDP) performance for each region, which might affect the WTP. Besides GDP status, Monthly Gross Household Income is also a good indicator of economic strength of the population due to the level of employment and economic opportunities. These factors will indicate the position of purchasing power of the population and thus may influence the WTP for certain products.

Besides the economic status of the region, the occupation and level of education attained by respondents were also recorded. Level of education attained was considered to be an important factor that may affect the level of awareness and knowledge about environmental issues, which in turn might affect the WTP for chicken-HRE. This is especially relevant for those who live or work near the main broiler production areas of Malaysia.

4.2.1.3 Sampling Framework

The sampling framework for the current study was based on the National Household Sampling Frame 2010 (DOS, 2011b) which is made up of Enumeration Blocks (EnBs) created for the 2000 Population and House Census. EnBs are geographically contiguous areas of land with identified boundaries. For sampling purposes, regional classification is found to be adequate for all states in Peninsular Malaysia.

States of Sabah and Sarawak were excluded from the survey due to time and financial constraints. However consumption trends in Peninsular Malaysia can represent the situation in Sabah and Sarawak since the importance of chicken meat is similar (see Section 4.4.1.1 (i)).

4.2.1.4 Sample design

Respondents were drawn independently within each region. The first stage units of sample selection were the EBs while the second stage units were living quarters (LQs) within the EBs. A LQ is defined as any structurally separate and independent building used for living purposes, with the assumption that every LQ was considered as one household. Thus, for each household, one respondent was interviewed to collect information based on everyone living in that household (e.g. to determine average chicken expenditure and consumption etc.).

The respondents were those who consumed chicken meat in their diet. The age limit for respondents was from 18 to 65 years, since the labour force age in Malaysia is 15 and the maximum retirement age for special occupations is 65. However the majority of Malaysians enter a job at the age of 18, i.e. after completing secondary level education. In the event that a respondent did not meet the criteria for participation in the survey (e.g. they did not eat chicken), then they were replaced and another LQ identified. The survey was carried out during June and July 2011.

4.2.1.5 Sample size

From each of the four regions of Peninsular Malaysia, the aim was to have at least 25 respondents, with a grand total of at least 100 completed questionnaires. Factors including cost and availability of assistants and constraints of time influenced the decision about sample size.

4.2.2 Structure of the Questionnaire

Using a structured questionnaire (see Appendix 3), consumers were asked about their understanding and general knowledge of environmental aspects, the concept of sustainability, demographic and household status as well as their chicken meat consumption and purchasing patterns. It was also necessary to determine respondents' understanding of livestock production impacts on the environment and ultimately their WTP value for chicken-HRE. Questions were also designed to discover consumers' attitude towards the market for meat with special characteristics.

To determine the WTP, an open ended elicitation (see Question 28) was asked. The advantages of using open ended questions are that they are straightforward and have no anchoring bias (Pearce *et al.*, 2002). A verbal reminder of current and historical chicken market prices was also given to assist any respondents who were unsure about giving their maximum WTP as they had never thought about valuing it before. However, open ended questions have a tendency for unrealistic answers (Pearce *et al.*, 2002). To overcome this risk, respondents were asked this question several times in order to ensure they were confident and aware of the amount or percentage WTP given. The questionnaire was written in English and translated into Malay language in order to facilitate the respondents who came from various educational backgrounds. As far as possible, the translation avoided the use of technical words and used simple expressions.

Due to constraints of time and the distance of the locations, it was necessary to employ assistants to carry out the survey. For this purpose, three assistants were employed, all of whom had received tertiary education and were familiar with the relationship between the livestock industry and environmental issues. To ensure the assistants clearly understood the objectives of the study and were able to explain each statement in the questionnaire to the respondents, one day of training was conducted before the survey began. .

4.2.3 Exploring Respondents Opinions and Behaviour

The questions in this section were divided into four main categories; i) opinion on sustainability-related issues; ii) opinion about level of environmental quality of water and air; iii) household chicken meat consumption and purchasing patterns; and iv) opinion on the effect of poultry production on environmental quality.

4.2.3.1 Opinion on sustainability-related issues

The management and conservation of the environment in Malaysia is implemented within the context of sustainable development. This means all economic activities which play a major role in determining national economic progress may directly and indirectly change the landscape of the environmental status. Respondents were asked to evaluate the relative environmental impacts resulting from different economic activities in Malaysia. The respondents were also asked to reveal their opinions on the efforts to prevent environmental degradation by the Government and the private sector and the level of importance of the national goal in protecting the environment. All these questions were presented in a Likert-type scale form.

4.2.3.2 Opinion about status on environmental quality level of water and air

After the respondents had been asked questions on the broad context of sustainability issues, the following questions referred to the specific environmental quality, especially their opinions about the status of two basic human needs namely air and water. Furthermore, these substances are the most common resources used, easily understood and detected in the event of contamination. These results should reflect their views on the efficiency of efforts to prevent environmental degradation.

4.2.3.3 Household chicken meat consumption and purchasing patterns

The relationships between product consumption and purchasing patterns were essential to complement the findings about estimation of consumers' WTP for chicken-HRE. Multiple parameters of socio-demographic and economic characteristics were acquired (including gender, age, occupation, education, amount of chicken meat consumption) and described by frequency and percentage.

4.2.3.4 Opinion on the effect of poultry production on environmental quality

The opinion of the respondents on the environmental impacts resulting from poultry production was ascertained, including elements on manure handling and prevention of disease outbreak. The results were designated as percentages of respondents with a given opinion.

4.2.4 Formation of Questions for WTP Estimation

The WTP of respondents for chicken-HRE was sought, with respondents given the opportunity to state either the absolute price (RM per kg of meat), or the percentage increment which they would be prepared to pay compared to current market price.

Prior to the actual survey, a pre-test on a draft questionnaire was conducted with the objective to test whether the issues were understood, the wording was suitable, the questions were sensible and flow of the questions was easy to follow. Explanation and reminder on several historical facts related to production systems and trend of sale price were provided to the respondents. A total of 32 respondents participated in the pre-test study, which was conducted among Malaysians living in Newcastle upon Tyne by face to face interviews. In light of the pre-test, the questionnaire was revised and the final version of the questionnaire used in the actual survey undertaken in Malaysia.

Estimations of WTP for chicken-HRE can be considered at two levels, i) national and ii) regional. WTP value at the national level is useful, especially for macro planning purposes, where WTP values can be used to strengthen the existing economic indicators, particularly for the agriculture sector, in determining the strategic directions of development activities and subsequently to ensure the effective distribution of projects and financial allocation. WTP value at the regional level is useful to reinforce benchmarking of development progress in the regions as well as an input for macro planning. Obviously, there are challenges in monitoring the effectiveness of implementation of development programmes at a micro level since there can be a strong influence of political issues. Therefore, like other regional economic indicators, WTP value at regional level can be used as a key performance indicator to reconfirm the social status from an agri-environment and food point of view.

4.2.5 Statistical analyses

The hypothesis testing questions were developed in order to permit generalizations from a selected sample to the population. The goal of the testing is to disapprove the null hypothesis (H_o) based on the data obtained from the sample. Since the data from a sample always bring uncertainty elements, the level of error (α), also known as level of significance is very important as it states the risk of rejecting the true null hypothesis. For this study, which involved social aspects, the normal practise is to set α equals 0.05.

In this study, the alternative hypotheses (H_a) of all questions were related to consumers' WTP, and these values were always higher than the average chicken meat price in 2010 for national and regional levels. Following this, the probability of rejecting a true null hypothesis was based on the test statistic result (p-value) which is less than the significance level α, and ultimately conclusions were drawn.

H_o: μ_R = Average chicken price at each region

Ha: μ_R > Average chicken price at each region

where μ = mean for population; $_R$ = region

4.2.5.1 *Estimation of consumers' WTP values*

To estimate the value of consumers' WTP for chicken-HRE, two conditions were imposed in the methods; i) categories of WTP; and ii) level of WTP. Categories of WTP were further divided into a) an absolute value; and b) the difference in WTP as a percentage of the current price of chicken meat. The justification to select both characteristics is because each region has a different average price; i.e. a certain region has already a lower price compared to other regions, and this can introduce a bias in the WTP of the population sample. Thus, percentage differences were compared as these take account of the difference in current price.

The second condition for the analysis on estimation of consumers' WTP was the level of WTP values which were divided into two levels; i) national level; and ii) variation of regional level, according to the four regions of northern, central, southern and eastern regions.

i) WTP values from all samples (uncensored data)

Of the study population, 192 respondents (91.4%) stated a value for the WTP question, while 18 respondents responded as 'Do Not Know' which was then considered as a missing value. Only the results from those respondents who gave a value for the WTP question were selected for further analysis. The results obtained from the preliminary analysis of the data distribution of the sample showed it was not normally distributed, due to a number of extreme value answers; i.e. more than 40% increase in WTP.

To estimate the WTP for both levels and categories (see Section 4.2.5.1), a Kolmogorov-Smirnov Test (z-test) was performed to compare the median WTP values with average chicken meat price. To compare the variation of WTP values at regional level, the Kruskal Wallis (H-test) was carried out to evaluate the differences, with expected mean rank value of the regions derived.

ii) WTP values from statistically censored data

From a total of 210 responses, 28 were discarded; i) 18 who responded as 'Do Not Know' in the WTP question; and ii) 10 respondents who gave extreme values of WTP which were considered as outliers in the data distribution. Both data conditions were considered as missing values. By using transformation methods and removal of outliers (see Section 4.2.6); a normal distribution was obtained that allowed for further analyses of 182 responses by correlation and regression. The approaches of the analysis were still based on both categories and levels (see Section 4.2.5.1).

A one sample t-test was used to analyse the difference in price from average current price for each region as mentioned earlier. To determine whether there were any significant differences between regions, a one-way analysis of variance (ANOVA), F-test was employed. Specifically, ANOVA tests the null hypothesis:

$$H_o: \mu_N = \mu_C = \mu_S = \mu_E$$

$$Ha: \mu_N \neq \mu_C \neq \mu_S \neq \mu_E$$

where μ = mean population; $_{N, C, S, E}$ = respective regions

With the condition, if the one-way ANOVA returns a significant result then the alternative hypothesis (H_a) is accepted, which is that there are at least two means of regions that are significantly different from each other. To determine the specific regions that differed from each other, Post-Hoc Multiple Comparison tests were performed, i.e. Turkey HSD and Duncan tests. Turkey HSD test was used to compare every region mean with every other region. The output was confirmed using a Duncan test which classified relevant regions through homogeneous subsets.

Results from both uncensored and censored data are presented to see whether the censored sample gave a different interpretation.

4.2.5.2 Relationship between Parameters

Selection of an appropriate relationship test depended on the type of the parameter. Since the nature of the questionnaire was more towards categorical-type of questions (including Likert-type scale form), additional steps were performed through transformation procedures to generate new suitable parameters. There were 14 new parameters that were established for further analyses as shown in Appendix 4. Of the 14 new parameters, four parameters were used directly in relationship tests, namely i) score in understanding pollution; ii) average class in understanding pollution; iii) score in environmental impact elements of production; and iv) recode occupation.

All relevant parameters were recoded in order to make sure that the coding systems were synchronised and therefore easier to compute into new parameters. The most essential recoded parameter was WTP option (Yes or No answer) which was used at the initial step of all analyses in the Select Cases stage together with the censored data set. By omitting Do Not Know responses, WTP could be categorised into WTP an additional value and WTP no additional value.

i) A score in understanding of pollution (later known as score understanding) was obtained by adding together recoded values for the six original parameters relating to the level of respondents' understanding about pollution issues (i.e. did they understand the type, concept, lifecycle, source and impact of the pollution: Question 1).

ii) The average class in understanding of pollution parameter was derived by calculating the average value of all recoded parameters mentioned earlier and subsequently new parameter was obtained which was categorical in scale.

iii) Score in environmental impact elements of production (later known as environmental impact elements) was formulated by adding together all recoded environmental impact elements (namely manure treatment (EM), preventing disease outbreak (disease) and manure handling (wellbeing): Questions 25 to 27) into an orderly coding system.

iv) Recoded occupation consisted of just two groups, namely Group A (who work at least with first degree qualification) and Others, where Others consisted of Group B, Group C and other (including full housewife).

These four parameters were renamed into simple and consistent terms as shown in Table 4.1

Table 4.1: Short names for derived parameters

Derived Parameter (after transformation steps)	Rename of Derived Parameter	Range of Scale
Score in understanding pollution	Score Understanding	1 to 5
Average class in understanding pollution	Class Understanding	<0.5 or >0.5
		(>0.5 = Strong Understanding)
		(<0.5 = Less Understanding)
Score in environmental impact elements of production	Environmental impact elements	0 to 9
Recode occupation	Recode Occupation	0 or 1
		(1 = Group A; 0 = Others)

i) Correlation and association analyses

The relationships between selected parameters were analysed using various correlation, association and comparative tests to determine the suitable parameters which might be used for a regression model. Although the cause and effect relationship cannot be determined, relationship tests can verify the strength of the relationship using coefficient correlation (r) or rho (ρ) or the strength of association, i.e. Phi or Cramer's V values. The Chi-Square test (also called the Pearson's Chi-square test or the Chi-square test of association) is used to discover if there is a relationship between two categorical parameters with the assumptions that two parameters are categorical data and there are two or more groups in each parameter. The Pearson test, through a correlation coefficient, is a measure of the strength and direction of association with the assumption that parameters are on a continuous scale and approximately normally distributed. The Independent t-test compares the means between two unrelated groups with the assumptions the dependent variable is on a continuous scale and approximately normally distributed. The last test of correlation and association used in this study was the one-way analysis of variance (ANOVA) which determines whether there are any significant differences between the means of three or more independent groups. Four important assumptions are required for this test, i.e. the independent variable consists of two or more categorical independent groups, while the dependent parameter has a continuous scale, is approximately normally distributed and the variances are similar for each category, demonstrated by the test of homogeneity of variances.

The relationship tests were mainly divided into three categories; i) understanding pollution elements; ii) level of socio-demographic and economic scenarios; and iii) factors influencing WTP. A further method applied for relationship tests was Tests within Layers, a test which allows examination of the relationship between two categorical parameters within a controlling parameter. The advantage of this test is that it is able to make a relationship which is formerly not significant to become significant by adding a suitable additional parameter into the relationship.

ii) Regression analyses

As described previously, there were two ways of expressing the WTP for chicken-HRE, namely WTP value (continuous scale) and WTP option (categorical scale of yes or no), and hence there were two possibilities of conducting regression analyses. Regression analysis for WTP value was performed by Linear Regression Analysis, while for WTP option was conducted using Binary Logistic Regression. These analyses can be used to predict the value of a parameter based on the value of another appropriate parameter (independent parameter) which was previously identified by relationship analyses.

For Linear Regression Analysis, Enter Method was applied, in which all independent parameters entered into the analysis at the same time. Parameters remained or were removed depending on the probability value (removed if the contribution of the parameter was not significant, and the method was terminated when no more parameters were eligible for inclusion or removal). The parameter used to predict the other parameter value is called the independent parameter or sometimes the predictor parameter. The parameter which one wishes to predict (i.e. WTP absolute value) is called the dependent parameter or sometimes the outcome parameter.

To estimate the Binary Logistic Regression model for WTP option, block entry of variables by using Forward Conditional Stepwise Methods was undertaken with entry testing based on significance of the score statistics of the selected parameters. This means, only the significant parameter after all potential parameters enter the testing 'block' was chosen. WTP option was the dependent parameter (DP) with other three independent parameters (IP, also known as covariates) chosen.

4.2.6 Conduct of statistical analyses

Data management and all analyses were performed using the IBM Statistical Package for the Social Science (SPSS) Software (19). There were 67 parameters gathered in the questionnaire. Data from some parameters were transformed (e.g. computed or recoded) to fulfil the test requirements such as those questions with categorical scale answers which were transformed into scores on a continuous scale (see Section 4.2.5.2) thereby allowing use of parametric statistical tests. All parameters were utilised, either for estimation of consumers' WTP or exploring respondent's opinions and behaviour or to determine the relationship between parameters.

Based on the type of distribution of the data, either parametric or non-parametric tests were performed on each parameter. A normal data distribution allows for further analyses by correlation and regression. Normality was assessed using one of two methods, either i) numerical (either skewness, kurtosis, Shapiro-Wilk or Kolmogorov-Smirnov tests) or ii) graphically (scrutinizing either the Q-Q plot range, stem-and-leaf plot or histogram) (Chan, 2003; Park, 2008). Where the original data distribution indicated a non-normal distribution, attempts were made to improve normality such as by omitting extreme values, a method advocated by some authors (Stoodley, 1984; Kinnear and Gray, 1994) followed by transformation procedures. Logarithm and square root transformations are commonly used for positive data and the multiplicative inverse (reciprocal) transformation can be used for non-zero data. After achieving normality of the data, parametric tests could be performed with more choices available.

4.3 Results

This section presents the values of consumers' WTP for chicken-HRE at both national and regional levels besides the findings of socio-demographic and economic characteristics of the respondents, their opinions about sustainability-related issues, level of understanding of environmental elements and consumer preferences when purchasing chicken meat. This section also reports findings from the multiple relationship tests between selected parameters which reflect the consumers' choices towards their WTP. Finally, a regression model is established which is expected be able to predict consumers' WTP for a new data sample.

4.3.1 Result of pre-test sample

As the objective of the pre-test sample was to test the final draft of the questionnaire, the pre-test did not aim to answer in detail the Objectives 2 of this study. However, some exploration of the data has been made as well as a conclusion on the value of maximum WTP. In general, the respondents stated that the structure and order of the questionnaire was sensible and easy to follow even though the content was quite technical and needed to be improved in order to facilitate public understanding.

The three most important findings on the respondents' opinions and behaviour, especially on sustainability-related issues, recorded that fifteen respondents (47%) believed that manufacturing was a major economic activity which contributed the most significant negative effects to the environment. Seven respondents (22%) said transportation, while four chose agricultural activities and chemical industries and two selected contruction as the major contributor. None of the respondents chose the mining industry since they believed this was a sunset industry and did not cause significant impact to the environmental quality. The majority of the respondents, i.e. 27 respondents (84%), agreed that the economic development was not in line with efforts to prevent environmental degradation. Meanwhile, in terms of consumption pattern and preferences towards chicken meat, 56% of respondents consumed chicken three to six times per week with a total weight of 3.5 kg per household per week. Twelve respondents (37%) said chicken was an important material in their diet, with a score of 3 out of 6 given on the response scale. Thirteen and ten respondents respectively (41% and 31 %) preferred to select chicken based on the safety and quality characteristics. Only four respondents (12%) chose price as their priority when they purchased chicken.

Based on their most recent experience of purchasing chicken meat at home in Malaysia, which was a maximum of four years ago, only 16 respondents (50%) agreed to pay more than the chicken sale price at that period as their contribution to the society to improve environmental quality through more environmentally friendly production systems. On the average, the WTP among respondents was RM8.64 per kg of chicken based on current sale price in 2010, equivalent to 22.5% above market price.

4.3.2 Results of actual survey: Sampling and socio-demographic and economic characteristics

A total of 210 respondents from four regions in Peninsular Malaysia were involved in the study, comprising 27, 93, 60 and 30 respondents from the northern, central, southern and eastern regions respectively. This fulfils the sampling criterion mentioned in Section 4.2.1.5, which aimed to have 25 respondents per region and a total of at least 100 completed questionnaires.

As can be seen in Table 4.2, the majority of respondents were between 26 - 45 years old (71.9%) and had received a tertiary level of education (78.6%). However, even though most respondents had obtained higher education, only 56.2% of respondents had an occupation in Group A category due to the fact that over half of those surveyed (61.4%) were female and, amongst these people, 20% who had gained tertiary education had decided to be a full time house-wife.

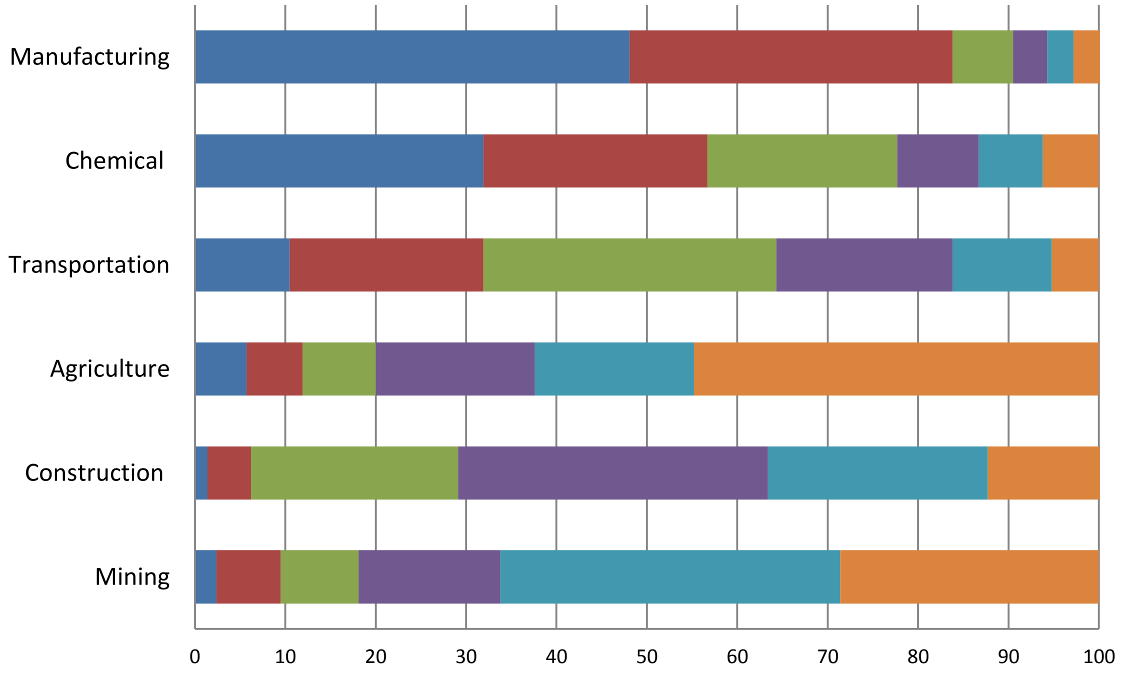
4.3.2.1 Opinion of sustainability-related issues

Respondents were asked to evaluate the environmental impacts resulting from the six major economic activities of Peninsular Malaysia. The results in Figure 4.1 show that 48.1% of those surveyed considered that the manufacturing sector was a major contributor to the negative impacts on environmental quality. Manufacturing was most frequently categorised as being extremely important, followed by the chemical industry (31.9%), transportation (10.5%), agriculture (5.7%), mining (2.9%) and construction (1.4%).

On economic activities, almost two-thirds of respondents (63.3%) stated that the efforts taken in these six economic activities to prevent environmental degradation were not in line with their rate of development. Only 77 respondents (36.7%) felt that the efforts from both industry and the Government were sufficient to prevent environmental degradation.

Table 4.2: Status of respondents by socio-demographic categories (gender, education level, occupation class and age category) in each of four regions in Peninsular Malaysia

Region	**Northern**		**Central**		**Southern**		**Eastern**		**Total**	
Socio-demographic	(n = 27)	(%)	(n = 93)	(%)	(n = 60)	(%)	(n = 30)	(%)	(n = 210)	(%)
Gender										
Female	**16**	*(59.3)*	**67**	*(72.0)*	**35**	*(58.3)*	**11**	*(36.7)*	**129**	*(61.4)*
Male	**11**	*(40.7)*	**26**	*(28.0)*	**25**	*(41.7)*	**19**	*(63.3)*	**81**	*(38.6)*
Education										
Secondary	**2**	*(7.4)*	**28**	*(30.1)*	**10**	*(16.7)*	**5**	*(16.7)*	**45**	*(21.4)*
Tertiary and above	**25**	*(92.6)*	**65**	*(69.9)*	**50**	*(83.3)*	**25**	*(83.3)*	**165**	*(78.6)*
Occupation Class										
Group A	**13**	*(48.1)*	**36**	*(38.7)*	**48**	*(80.0)*	**21**	*(70.0)*	**118**	*(56.2)*
Group B	**0**	*(0.0)*	**21**	*(22.6)*	**1**	*(1.7)*	**4**	*(13.3)*	**26**	*(12.4)*
Group C	**2**	*(7.4)*	**26**	*(28.0)*	**2**	*(3.3)*	**5**	*(16.7)*	**35**	*(16.7)*
Other	**12**	*(44.4)*	**10**	*(10.8)*	**9**	*(15.0)*	**0**	*(0.0)*	**31**	*(14.8)*
Age Category										
18-25	**1**	*(3.7)*	**14**	*(15.1)*	**1**	*(1.7)*	**7**	*(23.3)*	**23**	*(11.0)*
26-35	**12**	*(44.4)*	**49**	*(52.7)*	**18**	*(30.0)*	**12**	*(40.0)*	**91**	*(43.3)*
36-45	**11**	*(40.7)*	**10**	*(10.8)*	**28**	*(46.7)*	**11**	*(36.7)*	**60**	*(28.6)*
46-55	**3**	*(11.1)*	**19**	*(20.4)*	**13**	*(21.7)*	**0**	*(0.0)*	**35**	*(16.7)*
56-65	**0**	*(0.0)*	**1**	*(1.1)*	**0**	*(0.0)*	**0**	*(0.0)*	**1**	*(0.5)*



	Mining	Construction	Agriculture	Transportation	Chemical	Manufacturing
Extremely important (%)	2.4	1.4	5.7	10.5	31.9	48.1
Most important (%)	7.1	4.8	6.2	21.4	24.8	35.7
Important (%)	8.6	22.9	8.1	32.4	21.0	6.7
Less important (%)	15.7	34.3	17.6	19.5	9.0	3.8
Quite less important (%)	37.6	24.3	17.6	11.0	7.1	2.9
Extremely less important (%)	28.6	12.4	44.8	5.2	6.2	2.9

Figure 4.1: Opinions of the relative contribution of difference economic activities in Peninsular Malaysia to environmental pollution.

Table 4.3 provides a clear indication that the majority of respondents (88.6%) felt that the national goal of protecting the environment was very important, with 72% of respondents considering this to be the very top priority. Only 0.5% of respondents stated that protecting the environment was not very important.

Table 4.3: Opinion of the relative importance of the national goal to protect the environment

Importance	Level	Frequency	Percentage
Very important		**186**	**88.6%**
	very top priority	134	72.0%
	top priority	41	22.0%
	medium priority	10	5.4%
	less priority	1	0.5%
Somewhat important		**22**	**10.5%**
Not very important		**1**	**0.5%**
Do not know		**1**	**0.5%**

4.3.2.2 Opinions about status of environmental quality of water and air

The majority of respondents (70%) believed that water in Malaysia still requires some formal treatment before it could be drunk. Some 21% of respondents claimed that water seemed clean but has a low quality, while 5% of respondents did not know the status of water quality in their area.

Opinion on the status of air quality recorded that 40% of respondents considered that the air in Malaysia is clear, 30% of respondents recorded air as less thick and only three respondents (1%) considered that the horizontal visibility was very low (between 500 – 2,000 meters). 15 respondents (7%) revealed that they did not know the status of air quality in their area.

4.3.2.3 Household chicken meat consumption and purchasing patterns

As Table 4.4 shows, over half of those surveyed (50.9%) reported that chicken meat was an important raw material in their diet, with 2.3 kg per household per week. Meanwhile, another 23.8% of respondents revealed that chicken meat is very important in their diet, with 3.0 kg per household per week. Only 3.8% of respondents mentioned that chicken meat was not important in their diet.

Table 4.4: Opinion of the relative importance of chicken meat in the diet and weight of chicken (of carcass equivalent) consumed per household per week

Level of Consumption (n)	Consumption/household/week (kg)
Extremely Important 16	**5.2**
Very Important 50	**3.0**
Important 107	**2.3**
Less Important 29	**2.0**
Not important 8	**1.3**

Table 4.5 shows that almost half of respondents stated that quality, including appearance, texture and freshness of the meat, was the main factor influencing their decision to purchase chicken meat. Meanwhile, 40% of respondents believed that safety and price (26% and 14% respectively) were essential in their decision. Other elements such as convenience, ethics and nutritive value shared a percentage of less than 10.

Table 4.5: Characteristics of chicken meat which influence consumer decisions to purchase chicken meat

Major characteristic	Frequency	Percentage (%)
Quality	85	40.5
Safety	55	26.2
Price	30	14.3
Convenience	18	8.6
Ethics	15	7.1
Nutritive value	7	3.3

4.3.2.4 Opinions about the effect of poultry production on environmental quality

More than half the respondents (n= 107) believed that environmental problems arising from poultry production were generated from the production stage (including the housing system) and of these 81% of responses came from those who had received tertiary education. Some 44% stated that manure handling had negative environmental impacts, with respondents who had gained secondary and tertiary education represented

25% and 75% respectively. Only 5% of respondents considered that production of feed (including transportation from importing countries and local farms) contributed to environmental problems with 82% of answers obtained from those with tertiary and above education levels.

Investigating the results by age category, half of the sample (114) was derived from respondents aged between 18-35 years of age and of these 54% of respondents believed that the production stage activities were a source of environmental issues in broiler production, while 41% and 5% thought environmental issues arose from manure handling and production of feed respectively.

In response to the question on three environmental-related aspects arising from poultry production (diseases which can be transmitted to chickens and humans; improvement in feeding rate and manure treatment by using effective microorganisms; impact of housing design on manure handling processes), most of those surveyed indicated their agreement on the importance of those aspects and categorised them as extremely important. The findings are illustrated in Table 4.6.

Table 4.6: Opinion about the relative importance of three specific environmental-related aspects of poultry production

	Extremely Important *(%)*	**Very Important** *(%)*	**Important** *(%)*
Disease Outbreaks	**162** *(77.1%)*	**40** *(19%)*	**8** *(3.8%)*
Manure Handling Process	**146** *(69.5%)*	**52** *(24.8%)*	**12** *(5.7%)*
	Yes *(%)*	**No** *(%)*	
Feeding Rate and Manure Treatment	**210** *(100%)*	**0** *(0.0%)*	

4.3.3 Willingness to pay for chicken-HRE

4.3.3.1 WTP values from all samples (uncensored)

Of the study population, 192 respondents (91.4%) stated a value for WTP for chicken-HRE, while 18 respondents responded as ‘Do Not Know’ which was then considered as a missing value. In this section, only the results from those respondents who gave a value for the WTP question are presented, i.e. 192 respondents. The results obtained from the preliminary analysis of the data distribution of the sample showed that it was not normally distributed, due to a number of extreme value answers (i.e. more than 40% increase in WTP). Thus a Kolmogorov-Smirnov Test (z-Test) was used.

Table 4.7 shows the same trend for both absolute value and the percentage increment at national and regional levels. There was a significant difference from current price in absolute WTP ($p < 0.05$) at a national level. The mean WTP among respondents was RM 8.05, equivalent to a 14.2% premium. At a regional level, the central and southern regions showed a significant WTP value ($p < 0.05$), while the northern and eastern regions showed no significant difference in WTP from current price and percentage increment as illustrated in Tables 4.7 and 4.8 respectively.

Table 4.7: Mean WTP for chicken-HRE based on an absolute value (RM/kg) and percentage increment (%)

	Average Market Price [a]	**Mean WTP**	
	RM/KG	RM	% increment
National Level	7.05	8.05	14.2
Regional Level			
Northern	7.22	7.93	9.9
Central	6.86	7.85	14.5
Southern	6.53	7.51	15.1
Eastern	7.07	8.08	14.3

[a]: Federal Agriculture Marketing Authority, Malaysia (FAMA, 2011).

Table 4.8 shows that 50% of the population sample in all regions and categories (an absolute value and percentage increment) were willing to pay an increment of 10% above the existing market price for chicken, i.e. the range price from RM 7.18 to RM 7.94 per kg chicken meat.

A Kruskal-Wallis test (H-test) showed that absolute WTP was significantly lower ($H(3) = 18.445$, $p < 0.001$) for respondents from the southern region compared to those in the other three regions. However, an H-test showed that there was no significant difference in the percentage increment of respondents' WTP between different regions; ($H(3) = 2.616$, $p = 0.455$)

Table 4.8: Median, percentile and statistical test values of WTP for chicken-HRE based on an absolute value (RM/kg) and percentage increment (%)

	Median		**Percentile**				**z-test Value**		**Sig. Value**	
			25th		**75th**					
	RM	%	RM	%	RM	%	Value	%	Value	%
National Level	7.76	10	7.40	5	8.46	20	2.951	2.976	0.000	0.000
Regional Level										
Northern	7.94	10	7.29	1	8.66	20	0.878	0.878	0.211	0.211
Central	7.55	10	7.20	5	8.23	20	2.392	2.405	0.000	0.000
Southern	7.18	10	6.86	5	7.84	20	1.408	1.397	0.019	0.020
Eastern	7.78	10	7.42	5	8.84	25	1.099	1.107	0.089	0.086

4.3.3.2 WTP values from statistically censored data

In this section, the results show analysis of data which were statistically censored, i.e. from 192 responses which gave a WTP value, a further 10 respondents were discarded by removal of outliers procedures (as mentioned in Section 4.2.6) giving a normal distribution that allowed for further analyses by correlation and regression. The approach of the analysis was still based on i) absolute WTP; and ii) percentage increment of WTP at national and regional levels. A one sample t-test was used to analyse the difference in price, at a national level and for each region, from average current price as mentioned earlier.

i) Absolute value of WTP

Analysis of censored data showed that the mean WTP for chicken-HRE meat was significantly more than average current price at both national and regional levels (see Table 4.9). Respondents in the northern, central, southern and eastern region were willing to pay an additional 0.71 cents, 0.85 cents, 0.81 cents and 0.91 cents respectively above the average market price for one kilogram of chicken meat.

Table 4.9: Willingness to pay for chicken meat produced with a higher regard for the environment based on an absolute value (RM/KG) and percentage increment (censored data)

	Average Market Price	Mean		Std. Error		t-test value		Sig. Value	
	(RM/KG)	RM	%	Value	%	Value	%	Value	%
National	7.05	7.91	12.21	0.045	0.633	177.138	19.295	0.000	0.000
Region									
Northern	7.22	7.93	9.89	0.139	1.925	57.186	5.139	0.000	0.000
Central	6.86	7.71	12.39	0.065	0.940	119.435	13.173	0.000	0.000
Southern	6.53	7.34	12.47	0.071	1.093	102.878	11.413	0.000	0.000
Eastern	7.07	7.98	12.84	0.136	1.919	58.754	6.691	0.000	0.000

Again, half of the sample population at national level and in all regions confirmed that they were willing to pay more than they currently paid per kilogram of chicken meat during the survey period, i.e. 10% premium as shown in Table 4.10.

Table 4.10: Percentile of WTP for chicken meat produced with a higher regard for the environment on an absolute value (RM/KG) and percentage (censored data)

Items	Levels	Percentile				
		10	**25**	**50**	**75**	**90**
WTP for chicken sale price	**National**	7.12	7.4	7.76	8.46	8.81
(Percentage of WTP)		*(1.0)*	*(5.0)*	*(10.0)*	*(20.0)*	*(25.0)*
	Regional					
	Northern	7.22	7.29	7.94	8.66	8.66
		(0.0)	*(1.0)*	*(10.0)*	*(20.0)*	*(20.0)*
	Central	7.06	7.2	7.55	8.23	8.92
		(3.0)	*(5.0)*	*(10.0)*	*(20.0)*	*(30.0)*
	Southern	6.66	6.86	7.18	7.84	8.16
		(2.0)	*(5.0)*	*(10.0)*	*(20.0)*	*(25.0)*
	Eastern	7.07	7.42	7.78	8.66	9.15
		(0.0)	*(5.0)*	*(10.0)*	*(22.5)*	*(28.0)*

The test of equality of variance showed that the variance of the WTP variable for all four regions was equal ($p = 0.306$). The ANOVA test showed that there was a statistically significant difference between groups, indicating that at least one region is different from others, ($F(3,178) = 9.082$, $p < 0.001$). A Duncan pair wise comparison of means in Table 4.11 indicates that mean of respondents' WTP was similar for central, northern and eastern regions, but this was significantly lower in the southern region.

Table 4.11: Multiple comparisons between regions based on an absolute value

Duncan Test	Subset for alpha = 0.05		S.D
	1	2	
Southern	7.3		0.5
Central		7.7	0.6
Northern		7.9	0.6
Eastern		7.9	0.7

ii) Percentage Increment of WTP

The results shown in Table 4.9 indicate that for WTP on a percentage basis, the same results were seen as with absolute value. There was a significant difference ($p < 0.05$) in WTP at the national and regional levels from the current average sale price, i.e. a recorded increase of 9.9 to 12.8%. Similarly, 50% of the population sample was willing to pay an additional 10% above the existing sale price at both national and regional levels.

Based on the above findings, a one-way analysis of variance (ANOVA) was used to determine whether differences in WTP % increment between regions were significant. Although each region recorded a mean percentage increment in WTP which was always above the average sale price, the ANOVA test showed no statistically significant difference in the percentage increment of respondents' WTP between different regions, ($F(3,178) = 0.536$, $p = 0.658$). This result is supported by Duncan pair wise comparison of means in Table 4.12 which indicated that there was no significant difference in percentage increments in WTP of respondents from different regions. The range in the WTP was from 9.9% to 12.8%.

Table 4.12: Multiple comparisons between regions based on percentage increment

Duncan Test	Subset for alpha = 0.05	S.D
	1	
Southern	12.5	8.0
Central	12.4	8.7
Northern	9.9	8.4
Eastern	12.8	9.6

4.3.4 Relationship between variables

4.3.4.1 Factors associated with score understanding about pollution elements

Gender, education, occupation and income classes were chosen to be tested for their relationship with the level of score understanding about pollution.

Table 4.13 shows that education played a major role in determining the degree of understanding respondents had about pollution issues. Respondents who had a tertiary and above level of education had a higher mean value of score for understanding about pollution issues than those with secondary school qualification (score 3.5 compared to 2.9, p <0.001). The type of occupation and level of income of respondents also influenced their score for understanding about pollution. For occupation class parameter, a Duncan pair wise comparison of means indicated that there was a significant difference in the level of score for understanding about pollution elements for Groups A and B from Others and Group C (i.e. score 3.6 and 3.6 versus 3.1 and 2.9 respectively, p=0.001).

Table 4.13: Relationship of various factors to score understanding about pollution

Score Understanding About Pollution	**Type of Test**	**Value**
i. Gender	Independent t-Test	t(180) = 1.093, p = 0.277
ii. Education	Independent t-Test	t(180) = -3.700, p = 0.000
iii. Income class	ANOVA	F(5, 176) = 3.438, p = 0.005
iv. Occupation class	ANOVA	F(3, 178) = 5.444, p = 0.001

For the income class parameter, a Duncan pair wise comparison of means indicated that there were three significant subsets of income classes. Respondents who did not know their annual house hold income and who gained household income more than RM 5,001 per annum were classified in one group, while those who received an income below RM 5,000 per annum was classified in a other group. Respondents who refused to declare their annual household income were placed in a different group from the rest.

4.3.4.2 Factors associated with level of respondents' education

Level of education attained by the respondents was tested with multiple variables such as occupation class, importance of chicken meat in the diet, nutritive value in chicken meat (i.e. the nutritive value which they believe that chicken meat provides in their diet) and WTP. It is apparent from Table 4.14 that there was a strong positive association between the education respondents received and their occupation class (Cramer's V test = 0.786), a weak positive association with nutritive parameters (Cramer's V test = 0.292) and little association with WTP option (Phi test = 0.179).

Table 4.14: Relationship of various factors to education level

Effect of Education	**Type of Test**	**Value**
i. Score understanding	Independent t-Test	t(180) = -3.700, p = 0.000
ii. Occupation class	Chi-square Association	χ^2 (3) = 112.311, p = 0.000
iii. Importance of chicken	Chi-square Association	χ^2 (4) = 1.890, p = 0.767
iv. Meat nutritive	Chi-square Association	χ^2 (5) = 15.543, p = 0.008
v. WTP option *(Fisher's Exact Test)*	Chi-square Association	p = 0.014

4.3.4.3 Factors associated with the importance of chicken meat in the diet

The importance of chicken meat in the diet (divided into five categories: not important, less important, important, very important and extremely important) was tested with four parameters which included age, number of persons in the household, amount of chicken consumed and average class in understanding pollution among respondents.

As can be seen from Table 4.15, factors such as number of persons in the household and weight of chicken meat consumed had an association with perceived dietary importance of chicken and recorded significant values, albeit with a low strength of association (Cramer's V test = 0.202 and 0.255 respectively). Age and average understanding of pollution of respondents did not influence respondents' opinion of the importance of chicken meat in their diet.

Table 4.15: Relationship of various factors to opinion of the importance of chicken meat in the diet

Important Chicken in Diet	Type of Test	Value
i. Age	Chi-square Association	χ^2 (16) = 15.332, p = 0.444
ii. Numbers of persons in household	Chi-square Association	χ^2 (12) = 22.379, p = 0.035
iii. Weight of chicken/week	Chi-square Association	χ^2 (20) = 47.196, p = 0.000
iv. Average understanding	Chi-square Association	χ^2 (4) = 1.177, p = 0.903

4.3.4.4 Factors associated with consumers' WTP option for chicken-HRE

Table 4.16 indicates that only occupation and education showed significant associations with WTP option (Yes or No), although the strength of associations was relatively low (Phi test = 0.221 and 0.179 respectively). Gender and average class in understanding of pollution were not significant in influencing respondents' WTP option.

Table 4.16: Relationship of various factors to WTP option (Yes or No)

WTP Option	Type of Test	Value
i. Education *(Fisher's Exact Test)*	Chi-square Association	p = 0.014
ii. Average understanding *(Fisher's Exact Test)*	Chi-square Association	p = 0.531
iii. Gender	Chi-square Association	χ^2 (1) = 1.945, p=0.163
iv. Occupation class	Chi-square Association	χ^2 (1) = 8.923, p = 0.003

4.3.4.5 Factors associated with absolute value of WTP for chicken-HRE

The absolute value of WTP was tested with the same parameters as investigated in the WTP option above, with an additional three continuous parameters, namely score understanding, weight of chicken consumed per week and number of persons in the household (HH). Table 4.17 shows that there were no statistically significant correlations, apart from number of persons in the household which showed a significant, weak positive correlation with absolute value of WTP.

Table 4.17: Relationship of various factors to absolute value of WTP

Absolute Value of WTP	Type of Test	Value
i. Education	Independent t-Test	t(180) = -0,629 p = 0.531
ii. Average understanding	Independent t-Test	t(180) = -0.687, p = 0.493
iii. Gender	Independent t-Test	t(180) = -1.657, p = 0.099
iv. Occupation class	ANOVA	F(3,178) = 1.591, p = 0.193
v. Score understanding	Pearson's Correlation	r = -0.004, n = 182, p = 0.953
vi. Weight of chicken/week	Pearson's Correlation	r = 0.035, n = 182, p = 0.637
vii. Number of persons in household	Pearson's Correlation	r = 0.179, n = 182, p = 0.016

4.3.4.6 Tests within layers with WTP

Using tests within layers, some additional relationships were observed for WTP. As can be seen in Table 4.18, a significant relationship was recorded between respondents' WTP option and their average understanding about pollution parameters. Thus, besides education as a parameter which has an association with respondents' WTP option, respondents who stated they understood aspects of pollution were willing to pay more for chicken-HRE.

Table 4.18: Relationship of WTP option with education and average understanding as a control parameter

WTP Option	Control Parameter	Value
	Education *(Fisher's Exact Test)*	p = 0.014
Average understanding		
Do not understand *(Fisher's Exact Test)*		p = 0.511
Understand *(Fisher's Exact Test)*		p = 0.042

When using occupation class as a controlling parameter, as can be seen in Table 4.19 there was a significant relationship between WTP options and female, who were willing to pay more. This contradicts the result shown previously in Table 4.16 where gender was shown to have no overall relationship with WTP option.

Table 4.19: Relationship of WTP option with occupation class and gender as a control parameter

WTP Option	Control Parameter	Value
	Recode occupation *(Fisher's Exact Test)*	p = 0.004
Gender Male *(Fisher's Exact Test)*		p = 0.673
Female *(Fisher's Exact Test)*		p = 0.005

To examine whether the relationship between WTP option with education level was the same for male and female, tests within layer considering education as a controlling parameter showed there was no effect of gender. Only education had a significant relationship with WTP option as shown in Table 4.20.

Table 4.20: Relationship of WTP option with education and gender as a control parameter

WTP Option	Control Parameter	Value
	Education *(Fisher's Exact Test)*	p = 0.014
Gender Male *(Fisher's Exact Test)*		p = 0.585
Female *(Fisher's Exact Test)*		p = 0.104

4.3.5 Regression model of factors influencing WTP for chicken-HRE

4.3.5.1 Binary logistic regression

WTP option was determined as the dependent variable with other three independent parameters, namely occupation and education, which were significant in relationship tests, and gender which was significant in the test within layers (see Section 4.3.4.6). Table 4.21 provides the summary of the binary logistic regression model in which occupation was only the variable to enter the model with p= 0.009. From Nagelkerke R^2, approximately 12% of the variation in the WTP option was explained by the regression model using occupation class (Group A and Group of Others) as a predictor.

Since 88% of the variance remained unexplained, there were other factors which were not included in the model which were also determinants of the WTP option.

Table 4.21: Summary of binary logistic regression of WTP option with three selected independent variables of occupation class, education and gender

			B	S.E.	df	Sig.	Nagelkerke R^2
Variable in the equation	Step 1[a]	Occupation class	-2.003	0.769	1	0.009	0.118
		Constant	3.714	0.716	1	0.000	
Variables not in the equation	Step 1	Education			1	0.143	
		Gender			1	0.828	

a. Variable(s) entered on step 1: Occupation.

Probability (WTP options) = 1 / 1 + e^{-z}, where the estimated regression equation:-

$$\mathbf{z = -3.714 + 2.003 * Occupation\ class}$$

From this logistic regression model, the probability of willingness to pay more for chicken-HRE was 0.847 for Group A and 0.976 for the Group of Other. These values indicated that there was no significant different in probability of WTP between the occupation classes. This is supported by the classification table of observed and predicted output in Table 4.22 which shows that all respondents were willing to pay some additional value after observation.

Table 4.22: Classification table of observed and predicted number of respondents after the significant independent parameter was entered into the model

			Predicted WTP Option	
	Observed		**Zero/Nothing**	**With Value**
Step 1	WTP Option	Zero/Nothing	0	17
		With Value	0	165

4.3.5.2 Simple regression analysis

Selections of independent parameters (IP) for simple regression analysis were based on correlation results from Section 4.3.4.5. Hence the number of persons in a household (numbers of HH) was chosen as the IP for the test. Even though number of persons in the household showed a significant correlation with the importance classes of chicken meat (see Table 4.15), the scale of this parameter was categorical with non-ranking order, therefore did not fulfil the prerequisite for this analysis since one of the assumptions for the linear regression is that the parameters chosen are measured at the interval or ratio level (continuous scale). Table 4.23 shows that the number of persons in the household had a significant relationship with the absolute WTP, though the R^2 value is low. From coefficient table, the estimate regression equation $Y= b_0 + b_1X$ can be written as: **WTP absolute value = 7.67 + 0.054*(Numbers of HH)**

bo = 7.67 is the value of absolute of WTP, when numbers of HH = 0. Since this is not possible (all respondents had at least two persons in their household), it simply represents the y-intercept of the estimated regression line, a value of 7.67.

b_1= 0.054 means that absolute value of WTP is estimated to increase by 0.54 cents for every additional 10 persons in the household. Based on this estimated regression equation, the absolute value of WTP can be predicted from the increased number of persons in the household.

Table 4.23: Summary of simple linear regression of absolute WTP with number of persons in the household as an independent parameter

ANOVA					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	2.103	1	2.103	5.95	0.016
Residual	63.619	180	0.35		
Coefficients					
Model	**B**	**Std Error**	**t**	**Sig.**	
Constant	7.669	0.109	70.371	0	
Numbers of persons in the HH	0.054	0.022	2.439	0.016	
Coefficient of Determination (R^2)					
Model	R	R Square			
1	0.179	0.032			

4.4 Discussion

In this study, four regions were selected to establish the opinions of the Malaysian population on their WTP for chicken-HRE based on socio-demographic and economic characteristics such as population distribution, the status of chicken meat for Malaysian diet, age, gender, level of urbanisation, location of production and regional economic status. This section also discusses some issues and challenges encountered during the implementation of the survey which influenced the respondents' opinions. The findings in the previous section will be elaborated and justified in this section, namely i) the respondents' opinions and behaviour towards environmental issues; ii) the value of WTP more for chicken-HRE; and iii) the elements affecting the consumers' WTP.

4.4.1 Socio-demographic and economic characteristics of respondents

4.4.1.1 Population distribution

Based on the Population and Housing Census 2010, the Department of Statistics (DOS) reported the total population in Malaysia was 28.3 million, distributed across Peninsular Malaysia (22.6 million, 79.6% of the population) and another two states of Sabah and Sarawak and one Federal Territory of Labuan which are located on Borneo Island (5.8 million, 20.4% of the population). The Census 2010 also revealed that the total number of households in Malaysia was 6.53 million, with states in Peninsular Malaysia accounting for 83% of the total number of households (i.e. 5.27 million).

Only states in Peninsular Malaysia were considered in this study, due to time and financial constraints, and were divided into four regions of the northern, central, southern and eastern with population distribution of 6.09, 8.22, 4.17 and 4.08 million respectively. Figure 4.2 shows the Malaysia map, consisting of 12 states in Peninsular Malaysia with two states and one Federal Territory in Borneo Island. Nevertheless, based on justifications below, the coverage and sample size were adequate to represent the Malaysian population as a whole. Table 4.24 shows the population distribution by states in 2010.

i) The importance of chicken meat for the Malaysian diet

Chicken meat is one of the most important raw materials for all Malaysian diets, as indicated by the per-capita consumption which in 2010 was 35.0 kg per annum, the highest amongst meat products. Thus chicken meat consumption can be considered as a benchmark for livestock-based consumption patterns in Malaysia (DVS, 2010).

Chicken consumption in Peninsular Malaysia was 38.0 kg per person per annum, considerably higher than consumption in either Sarawak (26.6 kg per person per annum) or Sabah (21.4 kg per person per annum). Based on this status, chicken meat can be used as an indicator to analyse the consumer purchasing trend for meat products under Food at Home of the Consumer Price Index (CPI) which recorded meat as having the third highest of the Expenditure Weights Used Share of 2.9 after Rice, Bread and Other Cereals (4.6) and Fish and Seafood (4.5) in 2010. The weights are meant to reflect the relative importance of the goods and services as measured by their share in the total consumption of household. The consumer price index for meat products in 2010 was 120.4, an increase of 2.9% compared to the same period in 2009 (DOS, 2011a). Based on both indicator values, which reflect the importance of chicken meat in daily consumption besides the similar trend in Peninsular and the states of Sabah and Sarawak, it appears that the data gathered in this study are valid and able to represent the overall status of the Malaysia population towards chicken meat consumption patterns.

4.4.1.2 Age factor

From 2000 to 2010 the proportion of working age population (15 to 64 years) increased from 62.8 to 67.3%, while the proportion of population aged 65 years and over has also increased from 3.9 to 5.1% (DOS, 2011b). These trends are in line with the transition of age structure towards an aging population and have implications for the ability of consumers to purchase chicken and their dependence on chicken meat in their diet.

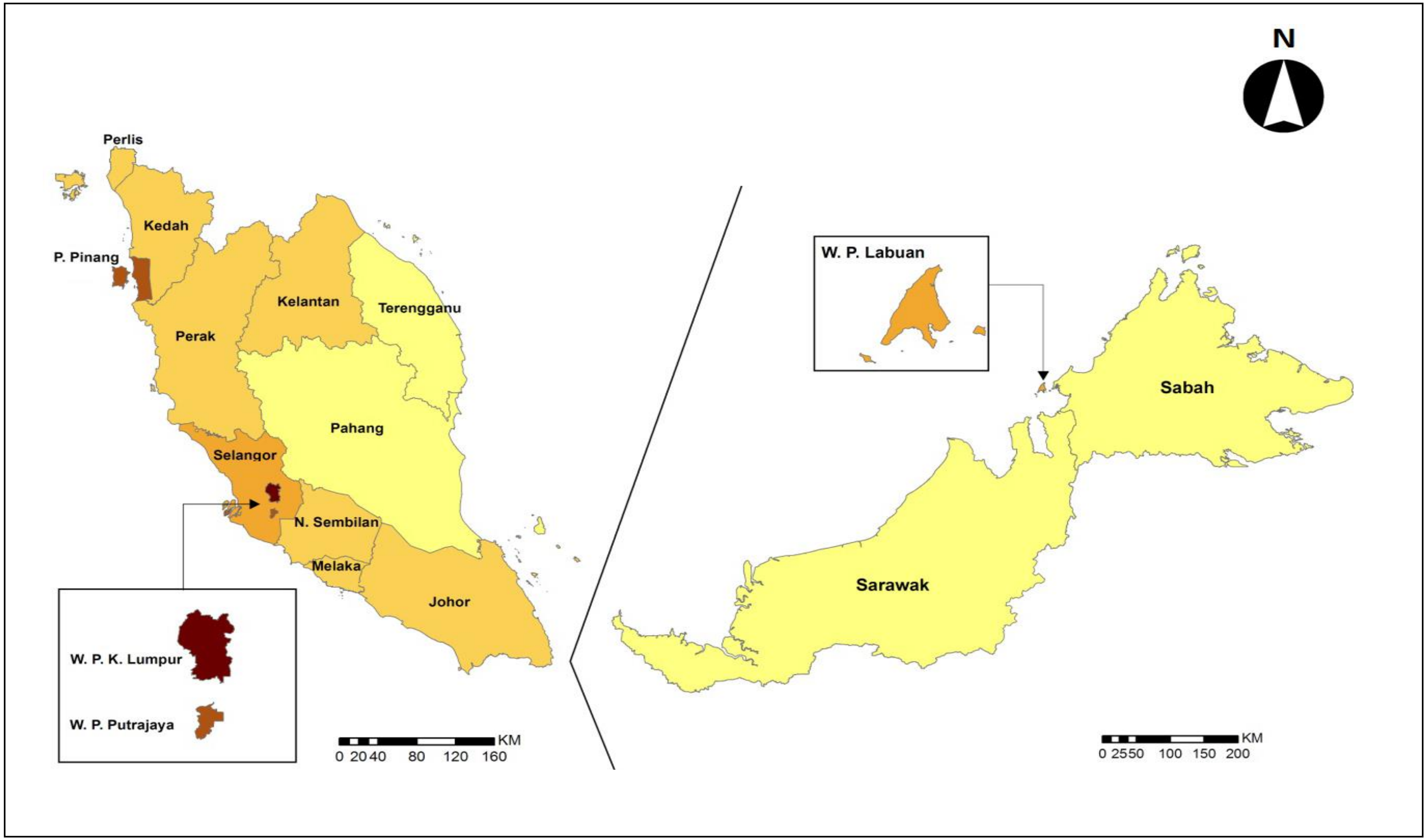


Figure 4.2: Map of Malaysia, comprising 12 states in Peninsular Malaysia and two states with a federal territory in Borneo Island. The geographical location and time constraints limited coverage of this survey to focus only on states in Peninsular Malaysia

Table 4.24: The status of population distribution and household by states and gender based on Population and Housing Census 2010 from 2008 - 2010 for Malaysia

REGIONS AND STATES	POPULATION DISTRIBUTION (million)	HOUSEHOLD (million)	GENDER	
			Male	**Female**
Perlis	0.23	0.05	0.11	0.12
Kedah	1.95	0.44	0.98	0.96
Pulau Pinang	1.56	0.39	0.78	0.78
Perak	2.35	0.57	1.19	1.17
Northern region	**6.09**	**1.45**	**3.07**	**3.02**
Selangor	5.46	1.34	2.82	2.64
W.P Putrajaya + WP Kuala Lumpur	1.74	0.44	0.89	0.86
Negeri Sembilan	1.02	0.24	0.53	0.49
Central region	**8.22**	**2.02**	**4.24**	**3.99**
Melaka	0.82	0.19	0.41	0.41
Johor	3.35	0.78	1.77	1.58
Southern Region	**4.17**	**0.97**	**2.18**	**1.99**
Pahang	1.5	0.31	0.8	0.7
Terengganu	1.04	0.21	0.53	0.51
Kelantan	1.54	0.30	0.77	0.77
Eastern region	**4.08**	**0.83**	**2.1**	**1.98**
Sabah	3.21	0.53	1.66	1.55
Sarawak	2.47	0.54	1.27	1.2
W.P Labuan	0.09	0.02	0.04	0.04
Sabah, Sarawak + W.P. Labuan	**5.77**	**1.09**	**2.98**	**2.79**
TOTAL	**28.33**	**6.35**	**14.56**	**13.77**

Source: Department of Statistic Malaysia (2011b)

4.4.1.3 Gender ratio

The latest Malaysia statistics show that the gender proportion of males to females in 2010 was 51.4 to 48.6, with men outnumbering women (DOS, 2011b). However, in the current study, 61.4% of respondents were female due to the nature of purchasing culture in Malaysia. Females are the ones who normally purchase the groceries on a daily basis. In the design of the survey, the decision was made to ascertain the WTP from the person who was purchasing the meat, irrespective of gender and employment status. Besides the culture factor, the survey findings also supported this scenario. As indicated in Table 4.19, there is a significant relationship between female gender within occupation class with the agreement to pay more for chicken-HRE, but not for male. Table 4.24 shows the gender proportion by state in 2010.

4.4.1.4 Level of urbanisation

Based on the fact that urbanisation is one of the factors fuelling the massive global increase in demand for livestock-based products, as stated in Chapter 2, the proportion of urban population in Malaysia has also increased from 62% in 2000 to 71% in 2010. Apart from Kuala Lumpur and Putrajaya, which have 100% urbanisation, the other states with a high level of urbanisation are Selangor and Pulau Pinang with 91.4 % and 90.8% respectively (DOS, 2011b). The increasing urban proportion explained the findings in the current study on the importance of chicken meat in the daily diet while, at the national level, it was reflected by an increase of 2.9% in CPI for meat products. Thus, the efforts to expand the poultry production are crucial to meet the domestic demand and chicken-based processing industry.

4.4.1.5 Regional socio-economic status

The northern parts of Peninsular Malaysia (except Pulau Pinang) are mainly suitable for paddy cultivation and rice-based industries, which gives a different type of purchasing power among the population. In contrast, the central region is the focus for other economic activities, such as services, manufacturing and construction, therefore it offers huge employment opportunities. This region has had a rapid economic growth and is also where the Federal Administrative Centre is located, so that people living in the central area might be expected to have access to current information including awareness about environmental issues. However, due to the high cost of living, most of the population in the central region are struggling to meet their good standard of living, giving a unique pattern of living capability and purchasing power level.

Before exploring in detail the explanations and rationalisations of results, some issues on the challenges and problems encountered during the implementation of the survey need to be highlighted in order to gain a complete understanding of the outcomes.

4.4.2 Challenges encountered during implementation of the survey

Some respondents queried the design of the questionnaire which made them feel awkward and less patient, especially to see the long statements at the beginning which described the hypothetical scenario of the study. However, the orderly explanation by the trained interviewers allowed the questionnaire to be easily understood. The photographs attached, showing aspects of pollution, also facilitated understanding of the respondents. The comprehensive statements in the questionnaire were important because the purpose of the questionnaire was to test the level of respondents' understanding which would lead to the selection of the WTP response.

According to initial assumptions, the level of household income was considered to be a key parameter for determining the purchasing power of respondents. However, the proportion of respondents willing to provide such information was low. Although, the author could have made some estimates of household income (e.g. by using the reference list of salary employment in Malaysia for both public and private sector) this was not considered to be appropriate since respondents had not declared it. It becomes harder to obtain household income data for self-employed respondents; however the number of respondents falling in this category was low, i.e. 31 respondents which represented 14.8% of the sample. Thus due to the difficulties in gathering information on household income (both for employed and self-employed), the decision was made to choose employment and education status as the main parameters to explore factors affecting respondents' WTP for chicken-HRE.

4.4.3 Exploring opinions and behaviour of respondents

As expected, and with the same result from the pre-test, respondents felt that manufacturing was categorised as a major negative contributor to the environment. The Economic Planning Unit (EPU, 2012a) recorded that the Gross Domestic Product (GDP) of Malaysia grew at a rate of 6.0% in 2010, and the manufacturing sector remained the second most important contributor to the economy, accounting for 6.2% of GDP after services. The manufacturing sector is commonly associated with industrial production and involves the use of large quantities of inputs as raw materials to be transformed into finished goods on a large scale, releasing a significant amount of environmental burdens during this process. Gray (1997) through his study 'Manufacturing plant location: Does state pollution regulation matter?' proved that there was a connection between state concerns on growing numbers of manufacturing plants with negative impacts to the environment. The study indicated that those states with stricter regulations, stronger political support for pollution regulation and providing greater abatement costs, tended to have lower rates of new plants and less impact on the environment. This situation implies that the public is often concerned about the environmental impacts resulting from manufacturing activities, which is consistent with the finding in the current study.

Meanwhile, it was not surprising that respondents stated that the mining sector made a small contribution to pollution, since this sector is becoming a sunset sector and the number of mining areas in Malaysia has significantly reduced in recent years. For 2011, the mining industry contributed just 3.2% to the GDP (EPU, 2012a). For the remaining period of the 10th Malaysia Plan (2011-2015), the mining sector is expected to grow at an annual growth rate of 1.1% (EPU, 2011).

However, an interesting finding was on opinions about the agriculture sector; respondents did not consider that agriculture had a major negative impact on the environment (it scored the highest percentage in the "extremely less important" category, at 44.8%). This finding could be due either to a lack of knowledge or deficiency in awareness about the real sources of pollution. However, considering education status of respondents, most (78.6%) had received tertiary education (this result in itself a potential for bias, which will be discussed later in Section 4.4.6) which one might expect should provide sufficient basic knowledge about the status and description of each of the economic activities and their environmental impact. Thus lack of knowledge may not be the reason, but perhaps a deficiency in awareness, especially about the interconnections between activities such as agriculture as the main raw materials provider for the agriculture and food-based manufacturing sector, where the respondents thought the impact burdens were solely from manufacturing and did not take the burdens from agricultural activities into consideration. However for more complex interaction, a study by Sharpley (1999) on the relationship between poultry production, phosphorus and water quality proved that deep knowledge plays a major role in understanding the complexity. That study stated that with the encouraging development in poultry production more manure is applied to agricultural land beyond the actual requirement and, as a result of excessive Phosphorus (P) being added into the land, there is increased potential for P loss in the surface runoff which ultimately accelerates eutrophication incidence. In such a situation, an in-depth understanding of agriculture is crucial and yet in general the public have difficulty relating inevitable potential pollution to agricultural activities. Therefore in the current study respondents' understanding of environmental impacts from economic activities needs careful interpretation and really depends on the features of the activities.

Despite the fact that the growth in national GDP of Malaysia increased from -1.7% in 2009 to 6.0% in 2010 (EPU, 2012a), 63.3% of the respondents were still not satisfied with efforts made by the Government and the private sector to prevent environmental degradation, even though the respondents might not really know or have access to the actual figures on environmental status. In general, according to the Malaysian Quality of Life Index, the quality of life in Malaysia has increased by 15.6% in 2009 with individual housing, education and health increasing by 32.3%, 30.9% and 30.8% respectively, while income and distribution increased by 21.2%. However, over the same period, the index for the environment decreased by 1.2% from 94.1 in 2008 (EPU, 2012b), suggesting that the public has concerns about pollution and environmental degradation.

As far as water and air quality status are concerned, the results need to be interpreted with caution since 5% and 7% of respondents revealed that they did not know the status of air and water quality in their area. This lack of awareness occurs despite the education status mentioned previously and efforts that the Malaysian Government makes to inform the public through the media. However, 70% of respondents stated that the water still required formal treatment before it could be consumed, which is broadly in line with the report on water quality monitoring by the Water Environment Partnership in Asia (WEPA, 2012) that in 2010, 51% of water in Malaysia was considered to be clean, 36% was slightly polluted and 13% was polluted. The Department of Environment (DOE), which is responsible for managing water quality in Malaysia, has an objective to rehabilitate and improve the water quality to achieve a clean condition, i.e. to maintain at least Class II, water which requires normal treatment. For air quality, the general finding that 40% of respondents considered that the air is clear was consistent with the Air Pollution Index (API) reading which is hugely influenced by weather and monsoon, as released by the DOE.

Perhaps the most interesting finding about consumer opinions was that the effect of poultry production on environmental quality challenged consumers' knowledge about how the poultry industry functions. The finding that respondents believed the major contributor to environmental pollution came from production of birds, and only 5% of respondents considered that feed production contributed to environmental problems, does not support the results of the LCA in Chapter 3 of this thesis. The actual values from the complete life cycle assessment of broiler production showed that on average between 76.8 to 94.1% of environmental burdens for broiler production were associated with feed production for the broilers and breeder hens (including production of raw materials, transportation and processing) whereas only about 1.4 to 22% of burdens arose from manure handling. This contrast between consumers' opinions and reality can be explained by the difficulties of the general public in understanding the environmental impacts of broiler production in detail, as explained earlier, coupled with non-visualisation of the negative impacts in the short term. Thus, the general public view might be that the environmental impact arising from poultry systems is still relatively small compared to other economic activities which produce visual effects, such as smoke from factories which has a considerable influence on public opinion. Stamm *et al.* (2000) argued that although people are aware and understand in a general sense about environmental pollution and its impacts, they face difficulties in proposing solutions due to a lack of understanding about the detail of the process. In their study, Stamm *et al.* (2000) proved that mass media and interpersonal communication can make a positive contribution to improving public understanding.

A similar trend of opinions was seen if the analysis was explored using a selected demographic factor such as age category. Some 54% and 41% of respondents in the age category of 18-35 years believed the source of environmental burdens came from activities at production stage and manure handling respectively, while only 5% cited feed production. Even though this age category has been referred to as the Net Generation (i.e. incredibly sophisticated in terms of being technologically advanced, Gardner and Eng, 2005), it may be that they still have difficulties in understanding the complicated (and non-visual) process of broiler production where so many of the negative impact activities are apparently hidden.

4.4.4 Willingness to pay more for chicken-HRE

To date this is the first study to use a stated preference method such as CVM to determine the WTP more for chicken-HRE. Before exploring in detail the actual WTP value obtained from the respondents, this section will highlight several facts about the improvement elements introduced in the elicitation format.

Two important elements in CVM are the way in which the hypothetical scenario facilitates understanding of respondents on the objectives of the study and how the WTP question is asked in the survey. Carson *et al.* (1993) stated that a high quality CVM survey, which is typically conducted using trained interviewers and involves extensive use of visual aids such as maps, photographs and charts, will be able to acquire the closest estimation of WTP for intrinsic values. Many environmental economists agree that CVM is a highly developed survey approach for non-market valuation which should be able to mirror real behaviour of consumers in the actual market. CVM was famously used as a tool in to evaluate the claims for compensation arising from environmental losses, such as the well-known case of the Exxon Valdez oil spill at Alaska in 1989, as described previously in Chapter 2 (Carson *et al.* 1993; Pearce *et al*, 2002; Asafu, 2005; Mitchell and Carson, 2005; Stevens, 2005).

Both Carson *et al.* (2001) and Pearce *et al.* (2002) argue that different types of elicitation format typically produce different estimates of WTP, with double bounded dichotomous choices giving a lower value than a single bounded dichotomous choice. An open ended format often produces a lower mean WTP estimate than other formats. This is consistent with one of the principle recommendations by the National Oceanic and Atmospheric Administration (NOAA) which handled the Exxon Valdez oil spill case, namely that a dichotomous choice should be preferred. However, in the current study, it was considered that an open ended question on WTP was more appropriate, based on the nature of the subject and the difficulty to determine the linkage with environmental impacts. In addition, without any mention of recommended values that respondents could select from, open ended questions have less embedded bias, i.e. do not bring any starting point bias or yea-saying bias, even though this type of question has a tendency for lower bids. Thus, with the extra effort taken during the survey as described in Section 4.2.2, it can be argued that the value of WTP stated by respondents in the current study is a reasonable close estimate of their true WTP more for chicken-HRE. Nevertheless there were a number of deficiencies that remained and which will be discussed in Section 4.4.6.

The findings from two initial tests on different types of sample distribution showed that at a national level people were willing to pay between 12 to 14% more for chicken-HRE (depending on whether it was the WTP for all samples, or censored samples). Respondents in the southern region recorded the lowest mean absolute value for WTP, followed by people in the central, northern and eastern regions; values provided by all samples gave higher mean values compared to censored data at both national and regional levels due to the presence of outliers. These findings were supported by the statistical analysis tests which confirmed that the mean rank and mean value for respondents' WTP from the southern region was different from the other three regions. However, when WTP was expressed as a censored percentage increment of market price (resulting in a normal distribution allowing further analyses by correlation and regression, and ensuring that WTP values were not too high due to the presence of extreme values) differences between regions were not significantly different.

The average price for chicken meat paid by respondents was lower in the southern (RM 6.53/kg) and central (RM 6.86/kg) regions mainly due to logistic reasons, since the majority of chicken production farms are located in Johor and Perak. The principle of income elasticity of demand, which is closely related to the population income distribution as mentioned in Chapter 2, means that as household income raises there is increased demand for chicken meat which offers good value for money to the public. This finding is relevant to respondents living in the central region who have the greatest job opportunities compared to other regions even though they are struggling with the high cost of living. People in the northern and eastern regions have to pay 0.3% to 2.4% higher than the national average price for chicken, mainly as a result of the transportation and storage costs. As mentioned previously (Section 4.4.1.5), the main economic activities in the northern and eastern regions are based on agriculture (mainly paddy)/fisheries generating an average Monthly Gross Household Income of RM1,076.78 per month and RM 981.33 per month respectively, while people in the central and southern regions generated an average Monthly Gross Household Income of RM1,312.88 per month and RM 1,284.33 respectively. These figures reflect the ability of consumers to purchase goods, including chicken meat.

This scenario has similarities with a study conducted by Richardson and Loomis (2008) in evaluating the passive value of endangered species in different locations within the U.S.A and other developing countries. The study showed the factors which influenced respondents' willingness to contribute, such as the standard of living. Standard of living was the factor which determined the mode of payment preferred, i.e. respondents in the U.S.A preferred to contribute for conservation efforts through a lump sum payment, while respondents from developing countries chose a recurring scheme which was less binding. This study highlights that different communities across the world may offer different WTP values dependent on socio-demographic and economic status.

Since the current survey was conducted during a period of economic downturn in Malaysia, during which an increase in fuel price lead to higher prices of daily goods including chicken meat, this created a challenge to obtain a fair feedback from respondents. In difficult economic times, respondents are very careful to prioritise the household income, so their priority was for the most important daily goods such as staple foods, utility bills and other compulsory commitments such as mortgage and insurance. This finding may help to explain why respondents in the northern region had a WTP value that was only 9.9% greater than the average sale price. On the other hand, respondents from the eastern region who experienced the lowest average Monthly Gross Household Income still stated a substantial WTP of 12.8%. A willingness to pay more could be due to the abundance of alternative cheaper protein sources, such as fish products, which are available in eastern Malaysia (fish shows one of the highest CPI expenditure weights of 4.5) as well as the lower cost of living (EPU, 2012a; DOS, 2011a), thereby reducing their reliance on chicken meat.

Even though the mean WTP values showed that at least one region is different from the others (i.e. the mean WTP of respondents in the southern region was lower than for other regions), the median values at national and regional levels confirmed that most respondents were willing to pay 10% more than they currently paid per kilogram of chicken meat. At a macro level of developmental planning, whether the mean or median values are used could lead to quite different interpretations. As mentioned in Section 4.2.4, the WTP value can have a use at a macro level to strengthen existing economic indicators as well as to reinforce benchmarking of development programmes at the regional level. The WTP value in the context of the current study could also be used to determine the value of the benefit, reflecting consumer behaviour and demand characteristics. Thus it is very relevant for the purpose for cost-benefit analysis, i.e. if the mean benefit value outweighs the mean costs, the project should proceed. Thus it might be considered that investment in poultry production systems which reduce environmental impact could be achieved because respondents in the current study appeared to be willing to pay more for a type of production which was less environmentally impacting.

In contrast, the median WTP value can be taken as indicative of public motivation and choices since it represents the endorsement by at least half of the respondents in the survey. Thus, the same scenario might mean that the majority of people were willing to pay more for their chicken after realising the potential long term benefits. This is an additional indicator that hints at the confidence of the population as a whole towards efforts related to environmental improvements. Clearly there is a need to replicate this survey with a larger and more diverse group of respondents before this finding can be confirmed for the population of Malaysia as a whole.

4.4.5 Factors affecting consumers' WTP for chicken-HRE

As mentioned earlier, the purpose of the survey was to test the level of respondents' understanding about broiler production and how this might affect their WTP for chicken-HRE. The correlation and association tests showed that level of education and income class (which in turn is highly influenced by occupation class) played a major role in determining the level of understanding respondents had about broiler production and the potential impacts to the environment. These three parameters are interrelated, i.e. having a minimum academic qualification will normally allow an individual to gain employment thus ensuring a steady income. In 2010, the unemployment rate in Malaysia was 3.4% and, according to Keynes' Theory of Employment, any country which achieves unemployment rate of 4% or below is considered as achieving full employment (Hicks, 1936). This situation implies, with such a low rate of unemployment, that the level of understanding about environmental concerns will increase.

In addition, selection of meat characteristics was also highly dependent on education level, especially for advanced characteristics such as nutritive value (including nutrient content and calorific value) which was only identified by those respondents who received higher education. Ordinary characteristics such as price, convenience and quality (appearance, texture and the freshness) of the meat were not differentiated by education level. In the current study, quality of the meat was the main factor influencing the decision to purchase chicken meat. This is consistent with a study by Fox *et al.* (2002) on food safety, which reported that 30% of respondents were willing to pay a 10% premium for chicken meat with a reduced risk of contracting salmonella.

Before continuing with the relationship tests between selected parameters, some comments about the format of the WTP question used in the current study may be useful. The open ended elicitation format was divided into two questions, namely i) WTP option (Yes or No answer) and if the answer was Yes then ii) the WTP absolute value. There were 192 respondents who gave an answer on their WTP option, of which only 175 respondents were willing to pay more than they currently paid. As with the mean and median values, these WTP values also conveyed different interpretations. The WTP option answer drew a general agreement on the hypothetical scenario provided (namely broiler meat produced with a reduced environmental burden). However, the WTP absolute value can give some extra information about respondents, taking into consideration other important aspects of their lives, before stating any amount of additional sale price which then revealed their true willingness to pay. This improvement format, i.e. by introducing ‘Double Confirmation of Open Ended Questions’ allows us to obtain two WTP values, and could reduce some criticisms of the CVM approach as elaborated in Chapter 2, especially on embedding factors which can occur where respondents seek a “warm glow” effect associated with contribution to a good effort. The respondent still has a chance to get a satisfactory feeling by choosing agreement on the WTP option question, thus the respondents who determined a specific amount of contribution for the WTP absolute value question actually revealed their true willingness to pay.

The correlation and association tests highlighted numerous parameters which had a significant relationship with WTP option; i.e. education, occupation class, gender (for female) and status of understanding (understand response), while WTP absolute value revealed the significant relationship with the number of persons in the household. Since correlation and association tests only determine whether there is a positive or negative relationship between parameters, at this stage we cannot determine independent parameter(s) which contribute the most to the dependent parameter, in other words we are not able to explain the cause and effect of the relationship.

Binary regression analysis for WTP option with independent parameters of education, occupation class, gender (for female) and status of understanding (understand response) showed that only occupation class entered into the regression model with a coefficient of determination of Nigelkerke R^2 of 12%. The explanation on the cause and effect of this relationship is mainly due to evidence on the interrelation between parameters (education, income and occupation class) with WTP option, as stated previously.

Simple regression analysis for WTP value was conducted with the number of persons in a household as an independent parameter for the test. However, the relationship showed a relatively low value of coefficient of determination (R^2) of only 3.2%, indicating little relationship between WTP and number of persons in a household. One might have imagined that as the number of persons in a household increased then the WTP would have been lower because of greater household food expenditure. Outputs from Table 4.15 showed that the number of persons in the household and weight of chicken consumed had a significant association with importance of chicken in the daily diet.

Even though each dependent parameter has an explanation for the relationship with the independent parameters, the low coefficients of determination for both models indicate that there are other significant parameters which were not addressed by the questionnaire. Moreover, it is a challenge to recognise the potential parameters which could bring a high coefficient of determination of cause and effect relationship when dealing with a subject in which the public has common interest and abundance of substitution for the good. However, even though independent parameters have a weak relationship, they can still provide some indication of the likely willingness of the Malaysian population to pay for chicken-HRE.

4.4.6 Limitations of the survey

Despite efforts made to gather information about the attitudes of the general public in Malaysia to broiler production and environmental quality, and their WTP more for chicken-HRE, the results nevertheless highlight a number of deficiencies in the survey.

i) Sample size

In the current study 210 respondents took part, representing a substantial increase in the number of completed questionnaires initially planned (n=100). Such a sample size is in line with other WTP/environmental quality surveys. For example, Fox *et al.* (2002) recruited 87 primary shoppers to participate while Glass *et al.* (2005) achieved a 50% response rate from a random sample of 300 Northern Irish residents.

In addition, according to the Household Expenditure Survey 2009/2010 (DOS, 2011c), meat products (of which chicken meat is known to be the main category, see Section 4.4.1.1(i)), showed an average household expenditure per month of RM62.86, with a standard error of 1.7% (i.e. within 95% of confident level) (DOS, 2011c). With such a low standard error, this gives an indication that expenditure on meat has a fairly homogeneous characteristic and low variability among consumers.

However, given that the number of households in Malaysia was 6.35 million in 2010 (DOS, 2011b), this survey represents only a fraction of the total number of households and therefore any stated WTP should be interpreted with caution and taken simply as an indication.

ii) Extrapolation of the survey to the Malaysian population

In addition to the sample size, other points may limit the extent to which the results of this survey are directly applicable to the population of Malaysia as a whole. Distribution of the respondents in this survey showed some regrettable bias. Not only was the proportion of females higher than the national population (61% in survey versus

49% in population census, DOS, 2011b), the typical level of education was tertiary (79% of respondents) whereas sources suggest that only 33% of the working population in Malaysia in 2011 had received tertiary or higher level of education (DOS, 2013). Although the proportion of the labour force that has attained tertiary education is growing (annual growth rate of 3.3%) for the 10-year period up to 2011, there is clearly a degree of bias in the respondents who participated.

Besides that, as highlighted already in Section 4.4.1.3 and Table 4.19, female respondents in the survey were generally willing to pay more for chicken-HRE than males, perhaps because the females of the household are the ones who normally purchase the groceries and are faced with decisions about what meat to select.

Finally the decision to exclude some 18 respondents who indicated they did not know what level of price increment they were prepared to pay for chicken-HRE, along with the reluctance of some respondents to state their annual household income (n=14, 7%), may have inadvertently biased the data.

iii) Structure of the questionnaire

With hindsight, the layout of the questionnaire (Appendix 3) may have had an impact on the way in which participants responded to the question posed about their willingness to pay for chicken-HRE. Preceding the WTP for chicken-HRE with information about avian influenza may have confounded the response given, since respondents may have felt that they were in some way showing a willingness to spend more to be certain of minimising their risk of contracting the human strain of avian influenza.

There may be other issues that could have affected respondents' stated WTP, both culturally (e.g. the need to appear willing to comply with official government departments, despite the researchers clearly stating that the survey was being undertaken by a Newcastle University PhD student) and socially (the questionnaire was completed with the help of a research assistant, so that the respondents may have felt obliged to provide an answer that they thought would sound more impressive to the researcher). In assessing farm animal welfare, it is well known that the answer someone may give about their readiness to pay more for animal products that originated from animals given higher level of welfare may not always match with their actual spending pattern, the consumer versus citizen debate (Cicia and Colantuoni, 2010).

vi) Concept of chicken-HRE

As mentioned in the introduction, the objective of this survey was not to undertake an economic analysis of a specific broiler chicken housing system, but more to gain an estimate of the disposition of consumers to support efforts to reduce environmental impacts through the market. One disadvantage of this approach however is that the respondents may not have had a clear grasp of exactly what they were being asked to pay more for. For example, they may have thought that by simply indicating their willingness to financially support chicken-HRE they would solve all environmental issues around poultry production. Growth in the urban population (see Section 4.4.1.4) for whom chicken meat is very important in their diet, may mean an increasing gap in the knowledge of poultry production. Indeed, the majority of respondents (despite a tertiary education) thought that manure would have the largest impacts on environmental burdens and were largely unaware of the significant impact arising from broiler feed. Clearly a more specific way of assessing consumer WTP for environmental benefits in broiler production would have been to quantify the exact benefits that chicken-HRE may deliver, for example to enquire 'for a 10% reduction in environmental impact, how much extra would you be willing to pay'. However, even this approach has its limitations, since the consumer is expected to judge whether the 10% reduction in environmental impact is actually 'worth' paying for.

4.5 Conclusions

Socio-demographic and economic factors play a major role in influencing consumers' understanding of the relationship between broiler production and the potential environmental impacts generated from the industry. The current study only focused on environmental economic analysis in order to place values of environmental goods through application of CVM. As such this approach does not sufficiently represent the economic point of view in terms of the concept of sustainability.

Although a number of deficiencies in the design and implementation of the survey mean that the results should be interpreted with caution, a key finding is that there is a proportion of the population that appear willing to pay more for agricultural production which supports the environment. The finding that half of the respondents in the survey were willing to pay an increment of 10% above market price for chicken-HRE, as a contribution to the marginal change in environmental quality associated with more environmentally-friendly animal husbandry practices in broiler production in Malaysia, is one which warrants further investigation.

Chapter 5. Integration of Quantitative and Qualitative Research: Mixed Method Research

5.1 Introduction

The third objective in the current study was to investigate potential policy changes which could be brought in to broiler production in Malaysia to achieve production target and to assess the impact of these policy changes on the industry from the opinions and perspective of broiler producers, integrators and the Government. In order to fulfil the objective, quantitative findings from both previous chapters need to be integrated with qualitative results derived from selected broiler producers, integrator companies and relevant Government agencies using a mixed method approach. These three stakeholders, together with consumers, will determine the future of broiler industry in Malaysia.

This objective was divided into a number of questions as follows:

1. What are broiler producers' opinions regarding their readiness to adopt broiler production that is environmentally-friendly and economically sound, and what is their perception towards the inevitable environmental impacts arising from broiler production?
2. What challenges do integrators face in running their business, i.e. what are the limitations which might prevent them from participating and co-operating with producers to achieve more sustainable broiler production? How can the Government assist integrators to develop a broiler industry in the future that is both profitable and has a low environmental impact?
3. What criteria govern those producers and integrators who remain in this industry despite consistent challenges faced along the supply chain of production?
4. What are the Government roles that will ensure the environmental endowments last until the next generation without compromising economic growth? These roles include the effective implementation strategy related to legislation and regulations to ensure that economic development is in harmony with efforts to preserve the environment.

5.2 Mixed Method Study

Based on the background given in Chapter 2, mixed method can be defined as a class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study (Johnson and Onwuegbuzie, 2004). Previous studies have also shown that this method can provide more comprehensive views than a single methodology (Hughes *et al.,* 1997; Spash, 1998; Poortinga *et al.,* 2004).

The current study made an attempt to apply a mixed method using a combination of enhancement and completeness schemes (as described in Chapter 2). The rationale of choosing these two approaches was mainly due to the coverage of the study, which involved multiple stakeholders with different functions who provided both quantitative and qualitative information. Some of the functions are correlated, while others are totally stand-alone. Therefore, the enhancement approach allows gathering of information for augmenting justification, while the completeness approach will handle the isolated data by filling gaps between functions. These approaches will be explained in detail in Sections 5.4.2 and 5.4.3.

The current study aimed to determine attitudes of all stakeholders' involved in the Malaysian broiler industry (i.e. consumers, producers, integrators and the Government) on the potential negative impacts arising from broiler production to the environment and the ability to achieve economic expectations if the broiler industry maintains the current production trend. This requires the study to seek producers' opinions on their readiness to accept more environmentally-friendly production systems, and the consumers' willingness to pay the potentially higher price for products produced by this system. In addition, this study also solicited the opinions of integrators about the challenges of dealing with producers, in addressing environmental issues and also the potential implications of producing chicken meat with a lower environmental impact. Finally, Government perspectives on the future of the broiler industry were recorded.

Before going into detail about how the mixed method analysis will be conducted, a qualitative method is required for the mixed method analysis and this will be presented in the next section.

5.3 Materials and Methods for the Qualitative Study

The outcomes from Chapter 3 and Chapter 4 of this thesis were to identify broiler production systems which produced low environmental burdens and estimate the value of consumers' WTP for chicken-HRE in relation to the possibility of changes in broiler production. To ensure the findings from both assessments could be realised in practice requires the involvement of four important players of the broiler production chain, i.e. firstly, responsible producers to raise chicken which is healthy and safe for human consumption. Secondly, integrator companies who provide producers with day old chicks (DOCs), feed, veterinary services, transportation, processing and marketing. Thirdly, alert and sensitive policy makers who are aware of changes in terms of demand, availability of the latest technologies and robust legislation that will determine the pattern of national chicken meat production. And finally, regulators who are accountable to check that progression of the broiler industry is in accordance with the national target towards sustainable development.

5.3.1 Main elements in qualitative surveys

A qualitative survey was conducted among the four stakeholder groups to obtain their opinions and perceptions regarding the development of broiler production and to ensure the effectiveness of efforts towards a sustainable broiler industry. The first group was producers, who were questioned on their readiness to change their production system to one which is more environmentally-friendly and cost-effective in the long term. The second group was integrator companies, who act as a backbone of broiler production and are engaged in all activities along the production chain. The questionnaires for both stakeholders were also designed to explore the motives that govern them in engaging in broiler production, since this sector is highly capital intensive and reliant on imports for many of the inputs, especially poultry feed, which are highly vulnerable to price fluctuation in the international market.

The third group was policy makers, to explore interventions from the Government for medium and long term planning strategies, including finance-related aspects which is the most frequent issue raised by the producers. Comprehensive planning strategies, with precise selection of priorities for economic activities in medium and long term periods will shape the interest of the public, as well as the business communities. The interventions must not only be policy statements but, even more importantly, must address issues at the implementation stage besides increase the effectiveness of regulation and enforcement measures.

Finally, competent regulators with sufficient enforcement manpower and comprehensive environmental regulations were assessed to ensure better environmental quality and preserve it for future generations. Since the environmental issues cut across almost all economic activities, they should be supported with adequate facilities and effective enforcement actions to encourage industry players and the public to take part sustainably. The third and fourth groups of activities fall under the Government jurisdiction and responsibilities.

5.3.2 Implementation of survey

5.3.2.1 Poultry producers

In order to obtain producers' opinions about their involvement in broiler production and manure management, a survey was conducted involving six farms, i.e. three farms for each housing system. The selection of six farms was based on the characteristics of broiler production in Malaysia which is highly concentrated and homogenous, with only 10 integrator companies accounting for 75% of total chicken meat output in Malaysia. Besides the study by Mohamed *et al.* (2013), discussion took place with representatives from the government agencies DVS (personal discussion in June 2011) and MARDI (telephone conversations and electronic mails on December 2012 – January 2013) to ensure that the selected farms were representative for each housing system. The interview was informal, in order to obtain unbiased responses. The questionnaire used for the producers is shown in Appendix 5. All interviews relating to this qualitative survey (including those of integrators and government agencies) were recorded on hard copy of questionnaires and are available for inspection.

The qualitative questions consisted of two categories as follows:-

i. Opinions related to broiler production and housing system practices.
   a. Satisfaction with the performance of their current housing system.
   b. Challenges of using their current housing system to generate a profit.
   c. Level of guidance given from the integrator, especially regarding assistance to minimise environmental impacts.
   d. Awareness of the availability of financial support from financial institutions and government incentives, especially to cover the initial construction costs for the house and barn equipment.
   e. Role of the Government in attracting more entrepreneurs to participate in broiler production in order to ensure continued growth in output.

ii. Opinions related to manure management

The producers were also asked subjective questions related to manure as a by-product from broiler production:-

   a. General knowledge about environmental impacts from manure and efforts to improve effectiveness of disposal techniques.
   b. Potential to undertake additional efforts, such as treatment of the manure, to eliminate hazardous gasses and odour from the house
   c. Level of satisfaction about the current manure disposal techniques used.

5.3.2.2 Broiler integrators

To gain a comprehensive understanding about the broiler industry, informal interviews were conducted with representatives from a number of broiler integrators. From informal discussions at a broiler industry-government forum, six major integrator companies were identified who were willing to participate in the study, namely Leong Hup Poultry Farm Sdn. Bhd., Ayamas/KFC Breeder Farm Sdn. Bhd., CAB Breeding Farm Sdn. Bhd., Dindings Breeder Farm Sdn. Bhd., Charoen Pokhphand Farm Sdn.

Bhd. and Goldkist Sdn. Bhd. Collectively these six companies account for 45% of the chicken meat produced in Malaysia in 2010 (Serin *et al.*, 2011b). The position of representatives from the six major companies is given in Appendix 6. The full questionnaire is given in Appendix 7, and comprised a series of questions designed to cover three main areas as follows:-

i. Opinions on general aspects of broiler production including existing challenges in the industry.
   a. Current issues facing the broiler industry in Malaysia.
   b. Prominent challenges in dealing with the producers and steps taken to ensure a beneficial outcome for both parties.

ii. Opinions and preferences (if any) for a particular housing system, with consideration for long term marketing strategies including maintaining and expanding international market share.
   a. Factors influencing preference for a particular housing system.
   b. Efforts taken to minimize environmental impacts from broiler production.
   c. Financial implications of implementing strategies to lower the environmental impact of broiler production.

iii. Opinions and expectations on the future of the industry.
   a. Impact of environmental and animal welfare issues (which may be followed by implementation of legislation) on the competitiveness of the industry.
   b. Level of satisfaction about Government assistance to promote sustainable development of the broiler industry, particularly through improvement of housing system practices and effective manure handling strategies to reduce environmental impact.
   c. Level of consumers' acceptance of chicken meat with a particular additional marketing feature, such as chicken-HRE.
   d. Important areas of the industry that should be upgraded with effective intervention from the Government.

5.3.2.3 Policy makers and other Government implementation agencies

In order to gain Government perspectives, as outlined in Section 5.3.1 above, guided interviews of one-to-one conversation using a pre-determined structure according to the functions of the organisations, were conducted with officers from various government institutions related to broiler production in Malaysia such as MOA, DVS, MARDI, EPU, DOS and the Federal Agriculture Marketing Authority (FAMA). The selection of these ministry/central agency/departments was based on their functions in livestock development in Malaysia, i.e. involved in formulating policy and strategies for livestock production and any activities at post-production stage. These government agencies also have important roles in legislation, and in implementing, co-ordinating and evaluating R&D and innovation to enhance the productivity and competitiveness of the livestock sector. All eleven officers represented middle or top levels of management, i.e. were involved in policy making. Their positions in the organisation are shown in Appendix 8. Appendix 9 shows the questionnaires designed for these six agencies to derive perceptions on medium and long term policy directions for the broiler industry in Malaysia. The information covered four main elements as follows:-

i. Perspectives related to strategy direction according to national policy priorities
   a. The National Development Plan of 10th Malaysia Plan (2011-2015) outlines the green effort which is Valuing Environmental Endowment as one of the policy thrusts; thus what are the action plans which accompany the policy statement?
   b. The status of development allocation related to environmental preservation projects compared to other economic and social development programmes.
   c. Strategic directions at micro level (ministry and related departments) to stimulate development of the broiler industry.

ii. Perspectives on efforts through Research and Development (R&D) strategies
   a. Factors that hamper R&D in animal feed, particularly for poultry development.

b. Recommendations from a research perspective to reduce reliance on imported feed.

iii. Perspectives on strategies to encourage industry development, particularly through improvement of housing systems (upgraded existing housing or new housing) and effectiveness of implementation along the production chain such as market intelligence information, regulations and legislation.

iv. Perspectives on strategies to improve manure handling practices in order to reduce the negative impacts derived from ineffective manure handling, without limiting economic performance of broiler production.

The findings from qualitative surveys are elaborated in Section 5.5.

5.4 Materials and Methods: Mixed Method

Before exploring in detail on how both quantitative and qualitative findings were integrated, this section will elaborate the approach to combine the results into a single study by carrying out four procedures, namely i) setting out the integrated research question; ii) selecting the unit of analysis; iii) sample for study, and iv) instrumentation and data collection.

5.4.1 Integrated research question

The quantitative methods of LCA and CVM, besides the qualitative survey, have identified several questions towards sustainable broiler production. Given that each research method has been restricted to several specific questions, to employ the mixed method these questions need to be integrated into a single set of research questions (Yin, 2006). The nature of the current study illustrated that the quantitative assessments were designed to address the tangible output issues, while the qualitative method was intended to solve process questions.

Therefore the integrated research question in the current study is as follows:-

> "*What are the potential efforts, including policy strategies that could be brought in to broiler production in Malaysia to achieve sustainable production, taking into consideration the status of tangible values on environmental impacts and socio-economic abilities with the opinions and perspectives of various stakeholders on their readiness to accept and capacity to implement the programme within the industry?"*

5.4.2 Unit of analysis

To enhance the integrity of a single study of mixed method, the unit of analysis should also be integrated. The rationale of this step is to ensure multiple methods employed during individual assessments consistently maintain the same point of reference (Yin, 2006). Even though individual assessments focussed on isolated characteristics (i.e. LCA focuses on producer inputs, CVM emphasises the consumer's preferences and the qualitative method concentrated on three main players, namely the producers, the integrators and the Government), at a macro level of analysis all stakeholders actually have connection to each other as illustrated in Figure 5.1. Thus, these connections represent a unit of analysis known as "*functions of stakeholders' entity".* Functions of stakeholders' entity refer to the integration process which represents and focuses on the role of each stakeholder, i.e. consumers, producers, integrators and Government agencies. The purpose of the unit is to avoid the risk of "decomposing", which refers to steps in the integration process which lead to an isolated study. This was seen in the study by Ginsburg (1996) on community healthcare which was inadvertently decomposed into two isolated studies with two independent units of analysis (namely geographical area and a service delivery system). As a result, there was no ability to connect the units and hence the mixed method study could not be integrated. For the current study, Figure 5.1 shows how an integrated unit of analysis from diverse functions of multiple stakeholders was developed to ensure it remains as a single study.

5.4.3 Samples for study

According to Yin (2006), sampling procedures need to be considered carefully in maintaining a single study. Even though most desirable samples in mixed method prefer to employ nested data, in the current study the data were non-nested. Nesting data refers to multiple types of data which are collected from the same respondent (Small, 2011). Non-nested data were collected since the study was concerned with three aspects; firstly the status of environmental impacts which involved significant participation from producers; secondly, demographic-compositional and perceptual factors which shape consumer behaviour and preferences; and thirdly, challenges at the implementation stage faced by producers, integrators and the government, who are responsible to ensure the industry's objectives are achievable.

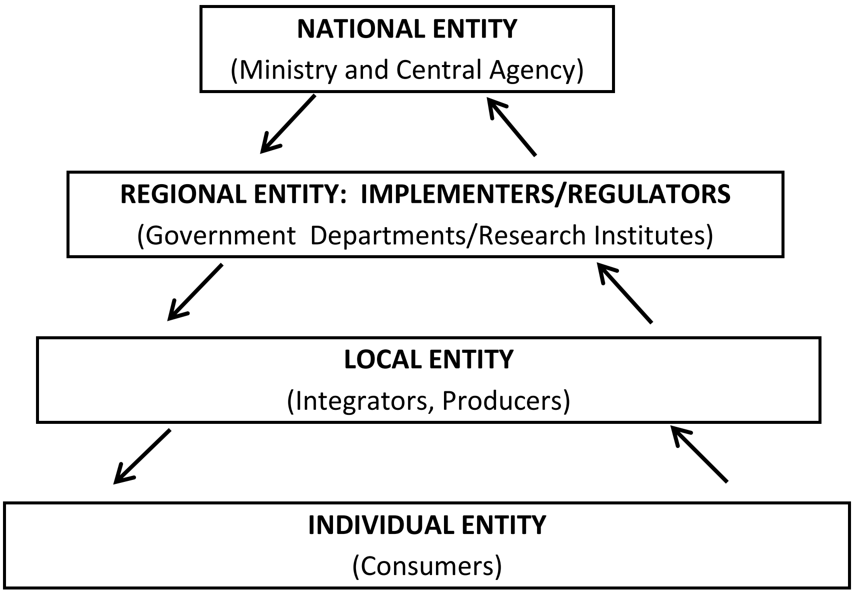


Figure 5.1: Integrated unit of analysis for mixed method analysis derived from multiple environmental, economic and behavioural assessment methods using qualitative and quantitative approaches from the individual entity up to the national level (modified after Lipset *et al.*, 1956).

In this situation, the conditions to fulfil nested design were almost impossible since it involved four different stakeholders with different positions and functions. However, there are strong linkages between nests from the macro level perspective, i.e. the supply chain of chicken meat products, from the national policy directions in the broiler industry down to the implementers (producers, integrators and the Government) until the level of consumers. This connection ensures that the study remains a single study, even with a non-nested design. Small (2011) argued that non-nested data collection is useful to understand complementary research, i.e. utilising diverse sources of information. The suitability of this approach was shown by Cook *et al.* (2007) who studied underground gun markets in the USA which involved multiple groups, such as gun club members, gun dealers, professional thieves, prostitutes and police, which complemented administrative data for the number of cases of suicide, homicide, robbery and other crimes. By using a non-nested design, Cook *et al.* (2007) were able to show that the actual transaction cost in an illegal gun market was in fact higher than people expected.

In the current study, the components of the first and second nests comprise the sources and type of data as explained in Chapter 3 (LCA) and Chapter 4 (CVM), which involved 189 producers and 210 respondents respectively. The third nest originated from the qualitative data obtained from six producers of selected production systems, six integrators companies and eleven officers from six governmental agencies related to the broiler industry, as elaborated previously in Section 5.2 and 5.3.

5.4.4 Instrumentation and data collection

Since the current study employed a non-nested design, it thus comprises multiple types of measurement methodology. The first nest employed specialist software for environmental impacts assessment, the second nest applied face-to-face interviews using a structured questionnaire, and the third nest involved in-depth guided interviews using questionnaires with selected producers, integrators and regulators. The most important point to highlight here is that the various methods remain as a single study since a greater divergence in instrumentation can lead to multiple studies (Yin, 2006).

Although the measurements applied were not the same for each nest, efforts were taken to ensure the complementary variables between nests focussed on a single set of research questions by using enhancement and completeness scheme options. Findings from the three nests in the previous chapters and in Section 5.5 of this chapter were able to be combined despite the different methods used for measurement. Nest 2 and Nest 3 showed some similarity of methods and in the nature of results, while impact values in Nest 1 showed connections to the both latter nest’s findings. These strategies support

Yin (2006), who stated that the more the findings overlap or complement each other, the more mixed method can be part of a single study.

5.5 Results of Qualitative Surveys

The findings of the qualitative survey from broiler producers, integrators and Government's agencies, shown in Table 5.1, 5.2 and 5.3 respectively, covered all aspects of the broiler production chain. Opinions from the producers for each housing system were compressed into a single answer for each element. Their opinions were presented in percentage form, as indicators of their opinion about a particular question. Most producers using the same housing system gave relatively similar answers, strengthening the idea of a homogenous broiler industry in Malaysia as suggested by Mohamed *et al.* (2013), although nevertheless there were some contradictions as seen in Table 5.1.

Opinions from six major integrators were classified into two main categories. Firstly, general challenges, such as urbanisation or raw materials supply, and specific challenges, such as the selection of a particular housing system and its impact on the competitiveness of production. Secondly, views regarding the future of the broiler industry and the possibility of stringent legislation on environmental protection and animal welfare. All individual responses were documented, however a summary is provided in Table 5.2.

In addition, perspectives from Government's agencies were divided into two categories, namely macro planning and micro implementation. Macro planning drives medium and long term national development strategies according to priorities which will ultimately determine the amount of budget allocation for development programmes implemented through ministry and agencies. The detail of programme implementation, including interaction with all stakeholders and target groups, is known as micro planning. The qualitative findings are presented in the form of policy statements encompassing environment and broiler industry-related programmes, budget allocation as an indicator of government commitment, existing strategies at the implementation stage and challenges faced by the industry.

Table 5.1: Opinions from broiler producers using two different housing systems (closed house and open house systems) towards different aspects of broiler production, housing system and manure handling practices

Area of question	Closed House	Open House
	1. Production System	
a. Satisfaction with level of performance of the current housing system.	All producers were satisfied with production performance and plan to build new CH housing or upgrade the existing OH housing.	2/3 of producers were interested to change to CH but faced financial constraints.
b. Challenges of using the current production system to generate a profit.	Diseases (mainly Newcastle disease (ND) and avian flu- H5N1).	Diseases (mainly ND and H5N1) and nuisance odour emissions.
c. Guidance from the integrator, especially regarding assistance to minimise environmental impact.	All producers were satisfied about the level of guidance from the integrators.	2/3 of producers were satisfied while 1/3 was not satisfied.
d. Awareness about the availability of financial support from financial institutions and government incentives, especially to cover initial construction costs for the house and barn equipment.	All producers obtained a loan from commercial banks and the Govt. financial institution. Besides this, they also enjoyed an incentive of reinvestment allowance which minimise their exposure to income tax	2/3 producers used their own finance and did not receive/apply for any Govt. incentives.
	2. Manure Management	
a. General knowledge about the environmental impacts from the manure, their efforts to increase their awareness and improve the disposal process.	All producers were aware and attended relevant workshops to increase their knowledge.	2/3 of producers stated that they attended the workshops organised by the Govt. agencies, whi not attend.
b. Implementation of additional steps (such as treatment of the manure) to eliminate hazardous gasses and odours in the house.	All producers applied effective micro-organisms (EM)[1] onto manure and found benefits, especially for workers' health.	1/3 of producers were aware about the benefits of manure treatment but still were not convinced to use it.
c. Level of satisfaction and opinion about the current manure disposal method.	All producers were satisfied with the current disposal method i.e. sell to plantation farms	All producers sell the manure to plantation farms.

[1] *EM typically consists of five families of effective and disease-suppressing microorganisms which inhibit the growth of those pathogenic bacteria which cause odours. According to the DVS (2011a), EM also can improve gut activities and lead to more efficient digestion.*

Table 5.2: Opinions and perspectives of six broiler integrators about general aspects of broiler production including current challenges, preferences for a particular housing system and expectations about the future of the Malaysian broiler industry

i. General aspects of broiler chicken production[2]

1. Major challenges currently faced by the broiler industry in Malaysia.	Disease outbreaks and implementation of related biosecurity were the most prominent challenges, followed by farm management issues (e.g. insufficient number of workers) besides a volatile sale price. Backyard slaughtering was another issue, where birds are killed and processed in the open air, and there can be improper disposal of waste leading to water pollution and a low quality product due to the absence of cold chain facilities. Accuracy of marketing information, increasing population and income which leads to an expansion of residential areas are another emerging issue. Fluctuation of sale price (n=2); Disease (n=3); Shortage of manpower (n=2); Backyard slaughtering (n=2); Surplus chicken meat supply (n=1); Urbanisation (n=1).
2. Main costs involved in production of broiler chickens.	Feed is the main cost; feed represents the most serious issue for the broiler industry and rising feed prices will impact all integrators. Feed (n=6).
3. Basis of agreement between integrator and their producers, and criteria upon which new broiler producers are selected.	Type of agreement: Agreement on a per-batch basis (completion of one production cycle) (n=4); Agreement on an annual basis (n=2). Method: Integrator uses their own search teams to identify potential new producers (n=3); Integrator waits to be approached by new potential producers (n=3). Criteria: Producers selected on the basis of their knowledge of practical broiler production for new producers (n=6); historical performance for existing producers (n=6); and trust (n=6).

4. Most prominent challenges involved in dealing with the producers.	Integrators identified three challenges, namely attitude, efficiency of farm management and knowledge. Half the integrators highlighted that attitude of producers will determine the productivity and influence farm performance. Two integrators stated that level of knowledge of poultry rearing, especially on technical issues such as early detecting of disease symptoms, were among the important issues to address. Attitude (n=3); Inefficient farm management (n=3); Knowledge (n=2).

ii. Specific housing system[2]

5. Preference for a particular housing system and reasons.	Those integrators who use the CH system belief that this system offers higher productivity coupled with better environment for chicken as well as their workers and the public. These companies intend to expand the proportion of CH in their production chain in the future. For integrators using the OH system, they argued that quality of chicken is the most important element, regardless of the type of housing system; efficiency of operation of the CH system relies heavily on operator's capability. These integrators were also in favour of the CH system and requested Government intervention to address issues related to administration matters such as land matters. Of the 6 integrators interviewed, three used the CH system for up to 90% of ther production output, and three used the OH system for up to 80% of their production output.
6. As a company do you take any steps to minimize the environmental impacts from broiler chicken production?	Two types of environmental pollutants arise from broiler production in Malaysia, namely manure and slaughterhouse waste. Manure generates flies and odour problems. Methods to reduce the occurrence of flies include conventional methods of manure handling (i.e. shovel soiled manure twice, at Day 26th and at the end of the production cycle, n=1) and utilisation of prohibitors such as effective microorganism, EM (n=2). To overcome problems of slaughterhouse waste, establishment of integrated rendering plants allow material to be processed into value-added materials such as poultry by-product meal and feather meal which is an excellent source of protein (n=1). Some companies have invested in the establishment a biogas plant as a contribution to minimise environmental impacts through reducing the amount of fossil fuel used and CO_2 produced i.e. using CH_4 to replace natural gas consumption. However to achieve real impact using economies of scale is still a major challenge (n=1).

	Another approach towards improving the environment would be through providing financial aid for producers to build a CH system which would minimize the environmental impacts (n=1).
7. Additional advice for producers to minimise their environmental impact and the nature of that advice.	Most integrators provide advice during scheduled weekly visits and technical visits. Nevertheless, some integrators only provide additional advice upon request. Weekly visitation (n=1); Technical visitation (n=4); Upon request (n=1).
8. Opinion on any additional cost to produce broiler chickens with a lower environmental impact and reason(s).	Integrators could be grouped according to one of three responses. Firstly those integrators who had made investment in converting the majority of their current housing system to one of a lower environmental impact system, i.e. the CH system, and are accredited by SALT (Livestock Farm Accreditation Scheme) which needs to be renewed annually. For these integrators, assuming that the implementing of the CH system would be considered 'acceptable' to legislators, they considered that there would be no effect on the cost of production, since this factor has been considered during planning stage. The second group was those integrators who stated that production cost will increase and become a burden to them, and it may not necessarily contribute to a better environment (from manure handling aspect). (Important note that the issue of feed miles issue and detail about the contribution of feed contributor to environmental pollution are considered new to most integrators). Besides that, it is critical to retain trained workers (either moved to other companies or restriction in renewal of working permits) especially for the CH system. The final group of integrators was those who admitted the benefits from lower environmental impact system which could increase the productivity through better feed efficiency and low mortality rate, but struggled to adopt this new system because of financial limitations (i.e. did not have money to invest). First group (n=3); Second group (n=2); Third group (n=1).

iii. Future of broiler production[2]

9. Opinion on the future for the broiler chicken industry in Malaysia.	All integrators agreed the broiler chicken industry in Malaysia will remain as an important sector with positive growth rate. Chicken meat is still an affordable source of protein for Malaysian consumers, besides being a consistent raw material for meat-based downstream activities. In addition, with celebrations by the four major ethnic groups of Malaysia throughout the year, chicken meat will remain popular. One integrator proposed that there could be consolidation within the industry through the merger of a number of big players to achieve economies of scale and higher productivity. Through the establishment of a larger business, the new integrator would be better able to withstand pressures and challenges arising especially from the inconsistency of retail chicken price and the fluctuation of the cost of raw materials on the international market. Positive growth and remain an important industry (n=6); Merging companies (n=1).
10. Opinion on how environmental regulations and animal welfare issues might impact the broiler industry in Malaysia.	All integrators view these movements as positive for the industry and consumers, as well as facilitating export penetration. Nevertheless, these movements will influence the development of the broiler industry unless the Government is able to provide effective procedures for enforcement. The Government should also consider some positive incentives or re-implement previous incentive in the form of reinvestment allowance, especially for small-medium scale farmers (n=6).
11. Opinion on preferences of Malaysian consumers in purchasing chicken meat with a particular additional marketing feature, such as higher welfare characteristics. 12. Opinion on preferences of Malaysia consumers in purchasing chicken meat from lower environmental impacts of broiler chicken production?	All integrators stated that in general the awareness among consumers regarding environmental and welfare issues in broiler industry are increasing and might shape the preferences towards chicken-HRE. Consumers' preferences depend on purchasing power which is highly associated with socio-demographic and economic status. With encouraging status of education and environmental awareness, besides positive growth of household income trend, integrators expect that consumers are willing to pay extra to have high quality meat. Likely to purchase and interested in environmentally-friendly broiler chicken meat (n=6).

13. If your company was to take steps to reduce environmental impact which lead to an increased cost of production, do you think this might impact on your ability to penetrate export markets? Please provide details.	There were three situations based on existing production practices. Those integrators (using predominantly CH systems) who had already made investment in lower environmental impacting systems and meet SALT accreditation, they argue that help is needed to maintain export share and to enable them to penetrate new market destinations without incurring additional cost of production. For other integrators who currently prefer the OH system, their competitiveness will be affected if environmentally-friendly systems become compulsory. However, integrators still questioned the need to change the housing system since most farms had already achieved export requirements, particularly to Singapore which currently does not require chicken to be produced from lower environmental impact systems such as the CH system. In this case, there would be no increase in production cost. No effect on competitiveness (n=3); No effect on competitiveness even though with non-environmentally-friendly system, i.e. the OH system (n=1); Negative effect on competitiveness (n=2).
14. Opinion on sufficiency of Government assistance to promote development of the broiler industry, particularly through the improvement of housing system practices and effectiveness of implementation along the production chain. Please specify.	None of the integrators interviewed were satisfied with current efforts taken by the Government. Six areas were suggested to promote development of the industry: i) Human resources: lack of practical poultry husbandry knowledge to handle problems in the production stage besides understaff issue to focus on core job (n=3). ii) Attempts to synchronise efforts of relevant authorities to address the urbanisation issue is still slow (n=1). iii) Slaughtering issue: There is a need to address the issue of backyard slaughtering. Meat from this system enjoys a similar sale price to that produced from integrated slaughtering plants which require more investment (n=1). iv) Effective Government-to-Government communication: More effective strategic planning especially to assist the industry penetrates international markets through reciprocal approaches with any partner countries. (n=2). v) Technology transfer: Find more efficient ways to develop the industry through effective technology transfer to educate producers about the potential benefits of R&D findings, especially on feed (n=1). vi) Input costs: More effective plans are needed to cap fluctuating cost of raw materials and to implement a ceiling price on raw materials during festival seasons (n=1).

15. Opinion on Government efforts to promote effective manure handling strategies to reduce environmental impact. Please specify. .	In general, the integrators were not satisfied about levels of enforcement, even though decreasing numbers of complaints have been seen regarding smell and flies issues (n=4). Government should promote the use of biogas plants (n=1). Serious action is needed (with political will) to address the backyard slaughtering issue which leads to improper disposal of waste and low quality product due to the absent of cold chain facilities (n=1).
16. The most important issues related to Malaysian broiler production that should be changed.	Each integrator proposed a different issue that required change: i) Intensify management efficiency at production level through knowledgeable managers and farm workers. ii) Improve effectiveness of enforcement and regulation processes. iii) Increase efficiency of logistics to reduce post-harvest losses (e.g. contamination of Salmonella prior to entry into the processing facility) and facilities at market such as regional cold storage. iv) To protect the industry, do not allow imports of broilers or poultry meat. In addition, do not re-introduce a ceiling price (of broiler chicken in the market) during festival seasons. Speed-up any outstanding issues between Federal and State Governments, especially related to land, i.e. to gazette new production area. v) Introduce stimulating incentives, such as export incentives, soft loan (i.e. a loan below market interest rate) for newcomers to the industry, as well as introducing a minimum price for chicken meat which can help to protect the industry. vi) Clamp down on backyard slaughtering facilities which are often unhygienic.
17. The most important issues related to Malaysian broiler production that you want the Government to change.	Four aspects were identified which require diligent implementation through better strategic planning: i) Effective enforcement of poultry farming and poultry-related activities (the processing of poultry and poultry waste) which are stated in Poultry Farming Enactment 2005 (n= 6). ii) Efficiency of management and human resources especially to handle immediate issues such as disease occurrence and other technical matters (n=2). iii) Accelerating technology transfer of potential research findings particularly in feed-related aspects (n=1). iv) More effective and accurate provision of market intelligence information (n=1).

[2] *Number of integrators who reported that finding; total n=6. However, certain integrators gave more than one answer.*

Table 5.3: Perspectives of people representing different Government agencies about aspects of poultry production in Malaysia, including formulation of policy strategies, monitoring of implementation programmes and enforcement of regulations

Policy Direction	Perspectives	Additional Remarks
a. Macro Planning: Policy direction strategies and action plans		
As the green action which is Valuing Environmental Endowment is one of the policy thrusts in the National Development Plan of 10th Malaysia Plan (MP) (2011-2015), what are the actions plan which accompany the policy statement?	The Government has introduced three progressive policies to support the national agenda on environmental protection and conservation, i.e. National Policy on the Environment, National Green Technology Policy and National Climate Change Policy. These policies accompany with action plans which specify actions to take by implementing agencies according to specific functions and time frame.	
	Since environmental aspects cut cross all economic and social sectors, an AFFIRM Framework has been introduced as a complete ecosystem framework for environmental sustainability. The AFFIRM Framework is represented by Awareness, Faculty, Finance, Infrastructure, Research and Marketing elements. Of these, three of the elements are related to environmental aspects of broiler production as elaborated in the next column:-	Awareness shows that environmental sustainability is a shared responsibility for all in society. Faculty is dealing with efforts to increase local capacity and capabilities through the introduction of green topics as a compulsory part of the school curriculum. Government has introduced financial incentives to attract business to participate, such as providing soft loans, tax incentives for building and designs that work harmoniously with nature.

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b. Macro Planning: Development budget allocation

Status of development allocation related to environmental preservation programmes compared to other economic and social sectors.	The number of environmental-related programmes has increased from 6.1% in 9th MP to 11.9% in 10th MP of all economic activities, even though the amount of allocation did not change much, i.e. 4.8% to 5.4% respectively of overall economic development programmes allocation due to several environmental projects being combined with existing development projects as tools to examine the social and environmental impacts of their target group.

c. Micro Planning: Implementation by ministry and agencies

Strategic direction at micro level to stimulate the broiler industry. This includes the strategy to increase the number of integrators and take advantage of the positive acceptance from the industry towards vertically and horizontally integrated production. Besides this, improvement in the effectiveness of market intelligence information and updating of information on domestic and international legislation and regulations are also important.	DVS is monitoring integrator performance through assessment during e-permit (traceability) applications. All producers need to fulfil all prerequisites according to the Poultry Farming Enactment 2005, Animal Feed Act and Animal Act in order to be entitled to a licence for production and other permits. A good record of the integrator's performance is crucial to maintain satisfaction among producers and thus will create an environment conducive to attracting more entrepreneurs to this industry. Enhance the effectiveness of dissemination of information on livestock-related issues, including the latest legislation, regulations and marketing strategies.

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Animal Feed	Perspectives	Additional Remarks
a. Micro Planning: R&D opportunities and challenges		
Status about imported poultry feed in Malaysia and factors that may have hampered R&D in animal feed, particularly the use of local raw materials for poultry feed.	90% of poultry feed is imported, especially soya bean and maize. To substitute a major percentage of existing raw materials with local raw materials will result in diets of insufficient nutrient content which will not meet the basic requirements for chicken growth. Despite studies showing there is potential to use by-products from oil palm as a substitute for certain nutrients, the integrators/producers have yet to be fully convinced as the industry is a very capital-intensive industry and profit is always a major determinant for them.	
c. Micro Planning: R&D potential		
Recommendations to reduce imported feed from research perspectives.	Research on substitute poultry feeds based on Palm Kernel Cake (PKC) and Palm Kernel Expeller (PKE) should be intensified since Malaysia has a large oil palm industry which provides a substantial resource of these materials. Encouraging findings showed that PKC has a suitability to substitute maize for poultry feed after enzyme-treatments of PKC. The inclusion of enzyme-treated PKC at 20% in both starter and grower broiler feed without negative impact to performance shows promise for development towards reducing dependence on imported feed. The details of these findings are elaborated in Section 5.6.4.2.	Effective collaboration between Commercial Providers of PKC with Oil Palm Operators such as contract farming needs to be established to ensure a consistent supply of quality PKC raw material; ultimately this could increase confidence among industry players to choose feed from local raw materials. Raising producers' awareness about the negative impacts of imported food, such as feed miles, needs to be emphasised in any industry development strategies.

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Housing System	Perspectives	Additional Remarks
Perspectives on strategies to encourage industry development, particularly through the improvement of housing system practices, and effectiveness of implementation along the production chain.	To promote environmentally-friendly production systems, which in general need high initial investment, requires support from various parties, especially in finance. Besides financial sources from the commercial banks, which normally require collateral and thus can be a burden for medium-scale producers, intervention from the Government through implementation of certain positive incentives could attract more players to the industry. Update information on international regulations and legislation on current import requirements besides market intelligence information, particularly on existing export countries, which are crucial to maintain the market share as well as to penetrate new potential export destinations.	As mentioned in Chapter 2, previously, a Reinvestment Allowance under the Income Tax Act 1967 was implemented for chicken producers to shift from the OH to the CH system as an incentive to encourage participation towards more environmentally-friendly production and stimulate the industry. In 2010, the incentive was terminated.

Manure Handling	Perspectives	Additional Remarks
Perspectives on strategies to improve manure handling practices in order to slow down the negative impacts derived from ineffective manure handling, but at the same time not limit the economic potential.	Producers' awareness is reported to be increased and their willingness to apply simple and quick treatments, such as utilisation of effective micro-organisms (EM[1], some producers even make EM[1] by themselves), shows a positive direction towards more environmentally-friendly production. Other recommendations on this aspect are explained in the Policy Recommendations in Chapter 6.	

5.6 Results of Mixed Method and Discussion

The results for mixed method are presented according to stakeholders' involvement in broiler production, namely consumers, producers, integrators and the Government. Quantitative findings from consumers' perceptions/preferences and producers' performance (which is translated through environmental impact values) were combined with qualitative findings of opinions from producers, integrators and together with Government's commitments to implement the broiler production towards sustainable development programmes.

In contrast to other chapters, this chapter presents each result accompanied with explanatory remarks in order to facilitate understanding and its relation to social phenomena, i.e. the relationship between environment, economic and social elements of sustainable broiler production. Furthermore, to the best of the author's knowledge, no previous studies using mixed method have been conducted in this area, hence the discussion section, which typically considers the strengths/opportunities and weaknesses/threats of issues arising by comparing the current study results with those from previous studies, could not be formulated in this way. All explanations to support the findings were solely based on the Malaysian social and political scenario.

5.6.1 Consumers' acceptance of WTP value, perceptions on environmental issues and preferences for environmentally-friendly products

The quantitative approach of CVM was employed to estimate consumers' WTP value for chicken-HRE, their preferences for different quality characteristics of chicken meat and perceptions on environmental issues in general, as well as broiler production specifically.

5.6.1.1 Potential impacts of consumer's WTP value on society

The WTP value in the current study was estimated by the CVM representing an estimation of the consumers' WTP for chicken-HRE. Despite the limitations of the sampling strategy that may have inadvertently created a degree of bias, the suggestion that half of the population may be willing to pay an increment of 10% above market price as a contribution to the marginal change in environmental quality, showed there might be some potential to change to more environmentally-friendly production methods. However, it remains to be seen whether the offer of a 10% increase in market price would be sufficient to cover the higher initial capital investment in systems such as the CH one with sophisticated ventilation and control systems (although as will be discussed later in Section 5.6.2.4, average running costs for the CH system are lower than the OH system). Realising the benefits for the long term, even though they face the risk of a higher sale price for chicken, consumers showed encouraging behaviour by giving an endorsement to integrators and producers to implement this production system; they agreed to pay more per kilogram of chicken meat during the survey period, i.e. 9.9% to 12.8% and 12% premium, at regional and national levels respectively. These two WTP values confirmed consumer demand for better environmental quality.

5.6.1.2 Level of consumers' understanding about environmental pollution

During the implementation of the surveys, most respondents lacked knowledge about how broiler production impacted environmental quality and even their general knowledge about broiler production was relatively low. Therefore most respondents had difficulty in understanding the negative impacts resulting from broiler production. At the same time, most respondents were aware of the important contribution of the broiler industry to the national economy and food supply, and had concerns about the fluctuation of sale price.

To obtain knowledge of the level of respondents' understanding about environmental pollution, responses to five elements were sought, namely type, concept, lifecycle, source and impact of environmental pollution. Type, source and impact were well understood by most respondents, with 99%, 91% and 84% respectively understanding these elements. However, the more complex the element, i.e. concept and lifecycle, the greater was the score for not understanding, i.e. 58% and 74% respectively. This situation supports the finding that only 5.7% of respondents categorised agricultural activities as being extremely important to environmental pollution compared to other economic activities. The complexity of agricultural activities, which involve interactions with soil, underground water and air, added to the difficulties in understanding.

5.6.1.3 Level of understanding about broiler-related production activities

More than 70% of respondents considered that three environment-related aspects of broiler production, namely diseases which can be transmitted to chicken and humans, the importance of additional treatments to the manure and the influence of housing design in handling the manure, were important. Even though almost 50% of consumers did not understand in detail the major inputs involved in broiler production, nor the complex interaction of manure with the soil and underground water, when it came to health issues they could easily relate to general issues such as the outbreak of avian flu with the occurrence of deaths amongst chickens and humans due to the failure in implementing good agricultural practices.

5.6.1.4 Product preference characteristics

Although the level of consumers' understanding about the relationship between sources of potential environmental burdens and impacts on humans and chickens was mixed, in general consumers showed greater awareness about product attributes, shown by the clear choices of characteristics when purchasing the product, i.e. 40% of them chose quality as a main characteristic. Producing a "quality" meat product requires at least a minimum of good husbandry practices as this must reflect the assumptions of consumers about the production process, including environmental related aspects.

5.6.2 Integrated findings from producers' performance and opinions towards environmentally-friendly production system

In contrast to the single approach applied for consumers, analysis of producers' opinions used both quantitative and qualitative methods. The quantitative analysis of environmental burdens was useful to estimate the impact values of various broiler housing systems, while a qualitative approach was used to obtain producers' opinions about benefits and potential obstacles in responding to the consumers' endorsement through their WTP statement.

5.6.2.1 Producers' awareness about environmental-related issues in broiler production

The results of the survey of producers regarding their knowledge about negative elements arising from broiler manure reinforce those of consumers. All producers who practised the CH system at a medium to large scale had knowledge about aspects of manure management and regularly attended relevant workshops organised by the implementing agencies. On the other hand, producers using the OH system admitted that they have the knowledge, however their interest to implement good practice in handling manure (such as applying effective micro-organisms (EM) to the manure in order to reduce odour which cause nuisance and flies around housing) was still low. An EM product typically consists of five families of effective and disease-suppressing microorganisms which inhibit the growth of those pathogenic bacteria which cause odours. According to the DVS (2011a), EM also can improve gut activities and lead to more efficient digestion. This situation is perhaps due to the nature of the production system, i.e. the CH system requires more capital investment and thus close monitoring between the integrator and the government agencies to ensure profitability. In consequence, perhaps these producers are more likely to obey and implement good agricultural practice compared to those with less capital intensive systems.

5.6.2.2 Financial challenges for investment in a new housing system or upgrading current housing system

The producers' concern about obtaining financial aid from commercial banks or the Government financial institutions needs to be addressed carefully. There is a rationale to reintroduce the attractive incentive, i.e. Reinvestment Allowance, which received encouraging responses from producers. Although the country needs to allocate special budget to reimburse the investment made, the effects in the long-term would hopefully improve profits through expansion of the CH production. This scenario was reflected in a statement made by one of the major integrated poultry companies, Leong Hup Poultry Farm Sdn. Bhd., that environmental-friendly production can be increased by between 30% - 40% by converting existing housing systems (i.e. the OH system) to the CH system. This increase in output could help national chicken meat production meet the demand for the local and the export market (Musa, Z., 2004; Leong Hup Sdn. Berhad, 2011).

5.6.2.3 *Production advantages arising from the consumers' endorsement*

To assess the producers' perceptions about the estimated WTP values of consumers, two aspects were considered, namely the potential for the business and the challenges they would face. The consumers' WTP indicated the potential for both stakeholders to make more profit than they currently obtained, i.e. RM0.60 to R0.79 per bird using the OH and the CH systems respectively, with a more attractive production cost in the CH system (approximately 2.4% lower - RM7.87 for each bird compared to RM8.06 for each bird in the OH system). The details of estimation of income and cost of production for both production systems are shown in Appendix 10 (Serin *et al.*, 2012). In addition to this, the low mortality rate of 3.5% in the CH system compared to an average of 6% in the OH system, besides better utilisation of space (each bird takes up only 0.09 m^2 compared to 0.12 m^2 in the OH system - see Section 2.5.1), certainly can stimulate their interest towards more environmentally-friendly production. Nevertheless, the main constraint facing them is capital availability.

5.6.2.4 *Comparison between average cost of production in different housing systems and expected value of chicken meat produced*

Clearly the production costs for broiler chickens and the price producers are likely to receive from the market will have a large bearing on the adoption of new housing systems. To provide a clear picture on the advantages of adoption of 'enhanced production techniques', such as the CH system, Table 5.4 shows the estimated cost to produce one kilogram of expected edible carcass from either the CH or OH systems, along with retail prices consumers in Malaysia currently pay for chicken or might be willing to pay in the future.

These data show that there is a substantial reduction in the cost of production per kg edible carcass of birds produced in a CH system compared to those from an OH one (a difference of RM0.30/kg, equivalent to 6% lower cost). The retail price represents consumers' demand for both commercial chicken meat (current price) and when factoring in their WTP more for chicken-HRE (stated future price). These data suggest that consumers are willing to pay an additional RM0.71/kg edible carcass for meat which is produced in an environmentally-friendly way. In this case then it seems that even though consumers were willing to pay slightly more for chicken-HRE, in the case of the CH system this might not be necessary since the additional cost of production is only RM 0.30/kg carcass. However, the data also suggest that further benefits to the environment are possible from additional improvements made to the CH system (refining the housing system itself, or making improvements further along the chain, in raw material acquisition or transport for example) which, although they may increase the cost of production slightly, could yield further benefits to the environment for which consumers appear willing to pay.

Table 5.4: Estimated cost of production for broilers (per bird and per kg expected edible carcass) in two different housing systems and retail prices (current and estimated for chicken-HRE)

Parameter	Closed House (CH)	Open House (OH)	Difference
1. Estimated cost of production			
Average finished weight (kg/bird)	2.18	2.12	
Expected edible carcass weight (kg/bird)*	1.53	1.48	
Average cost of production per bird (RM)[1]	7.87	8.06	
Average cost of production per kg edible carcass (RM)	5.14	5.45	**0.30**
	Average Market Price		
2. Consumer responses on current and future prices			
Current market price per kg edible carcass (RM)	7.05		
Estimated retail price including WTP of 10% more for chicken-HRE (RM per kg edible carcass)[2]	7.76		
Difference in price per kg (RM)	**0.71**		

*assuming a 70% killing out proportion (DVS, 2011b)
[1] Serin *et al.* (2012)
[2] Assuming WTP of 10% more than current market price, taken from Section 4.3.3.2

5.6.3 Opinions of integrators on current/future performance of the broiler industry

Besides financial issues, qualitative face to face interviews with integrators were carried out to understand the challenges they face, financial impacts and their expectations about the future of the industry.

5.6.3.1 Existing challenges of the industry

Existing challenges in the broiler industry can be divided into two sources, namely multiple surrounding factors and dealing with producers.

i. Challenges of multiple surrounding factors

The integrators faced several general challenges including poultry disease, rapid urbanisation, various marketing aspects (such as price, surplus of supply and slaughtering practices), variability of inputs (mainly raw materials) and manpower.

Poultry disease and urbanisation are two inter-related factors, since a disease outbreak could result not only from a weakness in farm management (e.g. a lapse in biosecurity) but also could be associated with the growing trend of urbanisation. Over the period of 2000 to 2009, the population in urban areas grew at a rate of 2.2% compared to only 1.6% in rural areas (EPU, 2012b). This situation has resulted in expansion of residential areas which encroach upon broiler production sites that were originally some distance from human settlements, i.e. at least 0.2 km. This makes it difficult to prevent disease outbreaks, especially those such as HPAI that can be transmitted to and from humans.

There are various factors along the supply chain which influence marketing aspects such as price and supply. In Malaysia, broiler chickens from integrators are sold to wholesalers and certified processors who have invested in appropriate slaughtering plants with the necessary waste treatment facilities and high standards of hygiene. On the other hand, wholesalers or retailers with small backyard slaughtering facilities require less overhead cost to operate but, in the absence of cold chain facilities, face difficulties to maintain freshness and hygiene of the products. These small plants have been associated with reports of indiscriminate disposal of waste into waterways leading to pollution. However products from both integrated processing plants and backyard facilities enjoy a similar sale price in the market, an outcome that the integrators are not satisfied with and therefore request serious intervention from the Government.

Another challenge highlighted by the integrators and one that they believe distorts marketing strategies is the importation of poultry meat which is permitted during festival seasons (as described in Section 2.5.2(2i)), to cater for the increased demand, but which creates surplus of supply. The integrators claimed that these imports are not required, since domestic production in Malaysia is already in excess of demand. This aspect needs to be dealt with caution, taking into consideration the accuracy in providing market intelligence on real time domestic demand.

ii. Challenges encountered in dealing with producers

Integrators listed a similar set of challenges regarding dealing with producers, namely knowledge of practical poultry husbandry, an engaging and creative attitude and competency of farm management. Collectively these factors will determine the productivity of the farm. Level of knowledge about poultry production was also the main criterion for selection of newcomers, whereas historical performance was used to inform decisions about retaining existing producers. Several integrators also went to the lengths of establishing the background and performance history of any new potential growers through their in-house recruitment teams, as well as conducting an interview prior to appointment. Some 67% of integrators deal with their producers on a batch agreement basis, i.e. an agreement that lasts for the completion of one production cycle, to ensure the ability of producers' performance and profitability.

5.6.3.2 Opinion on choice of housing system and the effect it may have on competitiveness of production

Two integrators thought that the CH system was more profitable in the long term and facilitates achievement of their marketing strategies, while three integrators preferred to maintain the OH system. One company currently has an equal percentage of the CH and OH housing systems but showed an increasing trend towards the CH system. Integrators in favour of the OH system claimed that quality of the meat produced is the most important element, even more important than type of housing system. They also argued that even with the CH system, productivity really depends on the efficiency of farm management (i.e. knowledge of workers to operate the housing equipment correctly etc.), and even small mistakes can give a large negative impact on production.

Integrator companies favouring the CH system had also made some investment to build integrated rendering plants to process slaughterhouse waste into value-added materials, such as poultry by-product meal and provided financial aid to producers to build more

CH systems. Meanwhile another integrator which expressed an interest in expanding the number of the CH systems in their production chain had built a biogas plant as a contribution to minimise environmental impacts through reducing environmental burdens. The other integrators had taken steps to improve environmental quality, especially to tackle problems of smell and flies arising from manure (use of both conventional methods of disposal and use of EMs).

Considering that environmental issues have become a vital issue in development programmes, at both national and international levels, the development of poultry farming in Malaysia is also heading in the same direction to ensure the objective of increasing exports can be achieved. Hence, the Poultry Farming Enactment 2005 outlines a method to improve environmental quality in poultry production by converting and upgrading the production system to one which is more environmentally-friendly, which is currently the CH system.

Apart from environmental aspects, animal welfare is also a concern, not only to the development implementers but also to animal rights activists. In Malaysia, currently the adoption of the concept of animal welfare is not accompanied by law, but is guided by good animal husbandry practices. Since animal welfare has become a central issue in animal production in many countries, and might therefore affect the export potential of Malaysian poultry meat, it is expected that legislation on animal welfare will be implemented in the future. All integrators were aware of these developments, and were positive to such movements that might facilitate export penetration, although there may be implications for the cost of production. Thus implementation of legislation on environmental impact of poultry related activities or animal welfare to be done in stages with effective enforcement.

For those integrators who had invested in more environmentally-friendly systems, which is widely accepted to be the CH system at present, these developments are expected to have little impact on their competitiveness or ability to maintain market share, especially for exports. The situation is different for other companies who would need to invest, particularly if an environmentally-friendly system becomes compulsory. One integrator claimed that any legislation to convert from conventional OH production systems should not be undertaken in a hurry, since the major country to which Malaysian poultry meat was exported had yet to request any specific housing system -

as long as the meat met standard food requirements such as the level of antibiotic used, they argued that any production system could be maintained. Furthermore, these integrators argued that existing good practice (using the SALT approach) was sufficient to fulfil quality requirements. Hence for this particular integrator, they argued that there would be no increase in cost of production to maintain competitiveness.

However this strategy was not shared with the other integrators who have wider objectives, i.e. have plans to expand their export market destinations with a variety of products. At a global level, there is an expanding market for halal food and poultry-based industrial raw materials. With a global Muslim population of 1.8 billion, the market for halal food is estimated at US$547 billion a year and this trend is expected to increase to USD2.1 trillion in tandem with the fivefold population growth in the Muslim population (MGCCI, 2011). Taking advantage as a moderate Muslim country, besides recognition by the United Nations that Malaysia produces the highest quality of halal food (in accordance with the Codex general guidelines for the use of the term halal in Geneva in 1997), this will assist in strengthening Malaysia as an International Halal Hub (MGCCI, 2011). The investment of those integrators will help to accelerate the objective through employment of the CH system which has been proven to increase the level of farm production, such as in studies by Serin and Sobri (2011a), Serin *et al.* (2012) and Leong Hup Poultry Farm Sdn. Bhd. (2011) press statement.

5.6.3.3 Impact on competitiveness of production

Even though the consumers’ preferences depend on purchasing power, which is highly associated with socio-demographic status (average monthly household income for all ethnic groups showed an upward trend from 2004 to 2009 with an average growth rate of 4.4 percent; EPU, 2012a), the ability to purchase chicken with additional environmental characteristics is plausible. Therefore, in line with positive development of living standards of Malaysians in general, the majority of integrators believe that awareness of environmental and welfare issues among Malaysian consumers is increasing and this might shape their purchasing of meat and meat products. Integrators believe that the majority of consumers are willing to pay extra to obtain high quality meat. For some integrators, producing chicken meat with a higher regard for the environment (if that is attached to a specific housing system other than OH systems) would increase their short term cost of production as described previously. However, the exact amount that consumers are WTP is still debatable (conservative estimates from the WTP survey in the current study may not necessarily be realised if the survey were repeated on a larger scale to gain a better estimate of the overall population) so that integrators cannot guarantee that the extra price consumers are prepared to pay will meet the required capital cost of new housing systems. Instead integrators may hope that any investment will be compensated for by reduced feed requirements, improved health or lower mortality associated with a new and more efficient system.

5.6.3.3 Most important issues that need to be addressed to promote broiler production and the Government's role in achieving that

The most important issues to encourage development of the broiler industry in Malaysia can be divided into those relating to broiler production level and Government interventions. At the production level, integrator companies and producers need to increase the level of proficiency of farm management including technical knowledge of broiler rearing among farm workers as well as the abilities of managers. This alone might have significant effects on lowering environmental pollution, since feed utilisation was shown in Section 3.6.1 to have one of the largest impacts on environmental burdens arising from broiler production. Meanwhile, for the Government's role, a most significant aspect stated by almost all integrators is the effectiveness of regulation of legislation. In addition, any proposals for implementation should take into account the ability of the producer to comply with any new regulation. Other important aspects along the supply chain include the establishment of regional cold storage to address the issue of small scale slaughtering plants, as mentioned previously, more accurate marketing information to match real demand and facilitation of exports. Finally, issues such as limitation in granting import permits, minimum and ceiling prices and land-related issues need to discuss at a macro level, taking into consideration other vital aspects such as social and economic impacts.

Integrators suggested that Government intervention should be in the form of strategic planning to overcome slaughtering-related matters between integrated and small scale producers which will influence the overall industry. The same market price for all kinds of chicken meat, i.e. regardless of the production method, is believed to be the main reason for the slow progress in improving the industry. There is also a need to be actively involved in any international marketing strategies such as requesting partner countries to provide for equal privileges enjoyed by their similar businesses in Malaysia. Integrators also contend there has been a lack of enforcement on issues of smell and flies as a result of improper manure management, even though these aspects are clearly stated in Poultry Farming Enactment 2005.

The integrators stated that, so far, there has been minimal intervention from the Government regarding assistance to promote the use of housing systems which produce a lower environmental impact as well as manure handling/treatment strategies and other processes along the production.

5.6.4 Government's perspectives on the potential of the broiler industry and commitment in implementing sustainable economic activities

5.6.4.1 Government's role in improving environmental quality

Even though 63% of respondents in the consumer survey stated that the efforts taken in six selected economic activities to prevent environmental degradation were not in line with their rate of development, this perception should be interpreted with caution and needs to be compared with the actual status of the Government efforts in implementing development programmes. As stated in Section 5.5 above, AFFIRM approaches were introduced in any development programmes, besides an increase in budget allocation for stand-alone environmental programmes as well as the collaboration with existing development programmes. This demonstrates the seriousness of the Government in appreciating the environmental endowments. If these efforts could be translated into an easy method which could be understood by the public, it would be able to reflect the consumers' indication that the majority of them (88.6%) felt the national goal of protecting the environment was very important and, of these, 77.2% indicated that it was the top priority.

This strongly suggests that the public concerns about environmental quality need to be supported with visible efforts, such as the implementation of practical green topics as a compulsory element of the school curriculum. Creating awareness and understanding of environmental issues at an early age will effectively achieve positive impacts towards environmental preservation.

5.6.4.2 *Government's tasks to facilitate the commitment from integrators, producers and consumers to promote the broiler industry*

All stakeholders were asked to indicate to what extent they were ready to participate or contribute to implementing more environmentally-friendly broiler production systems. The effectiveness of their contributions will depend on the efficiency of the Government implementation programmes. It is not only limited to the competence to provide a strategic plan at the production stage, but also encompasses the ability to equip this with three major peripheral activities, namely in research and development (R&D), basic requirements for facilities under Government control and strengthened enforcement of regulation aspects.

R&D, particularly in the area of poultry feed, has been identified as an effective approach for long term strategies, since Malaysia is hugely dependent on imported raw materials for the broiler industry. By-products from oil palm such as PKC (Palm Kernel Cake) and Palm Kernel Expeller (PKE) have huge potential and are still not optimally utilised to substitute imported feed. In Malaysia, these by-products are derived from nuts of palm trees after extraction of palm kernel oil through two extraction methods, namely screw press extraction and solvent extraction (Chong *et al.*, 2003; Noraini *et al.* 2009a). The former method produces PKC while the latter method produces PKE. PKC is a useful energy and protein source for ruminants but its high fibre content (13% - 20%) and dry structure has limited the potential for non-ruminant use (Alimon and Hair-Bejo, 1996; Chong *et al.*, 2003). Several studies have been conducted, and shown promise, to improve this potential by using three types of enzyme-treatment methods, namely direct enzyme supplementation in ready-prepared feed, enzyme treatment in the by-product and enzyme treatment through fermentation (Chong *et al.*, 2003; Sundu, 2006; Noraini *et al.* 2009b; MARDI, 2012). Chong *et al.* (2003) showed that following enzyme treatment (using a mixture of mannanase, α-galactosidase and protease on PKC), a "new-PKC" can be included at up to 20% in both starter and grower diets to substitute maize without changing the level of overall nutrients in the boiler diet. This inclusion has significant economic benefits since imported maize is almost 50%-60% of current feed composition.

To ensure the application and commercialization of this finding requires rapid transfer of knowledge to the broiler industry players who currently have some reservations about the use of by-products in poultry feed. The findings from by-product research can only be commercialised with the consistent availability of PKC/PKE of high quality, which is important to avoid detrimental effects on the performance of broiler chickens (Chong *et al.,* 2003; Noraini *et al.*, 2009a). Advances made in the quality of the oil palm and the oil palm extraction process, i.e. screw press extraction and solvent extraction, may affect the quality of PKC/PKE produced (Noraini *et al.*, 2009a). Efforts should be made at management planning level to ensure the extraction process meets certain standard requirements, so that a uniform quality of by-products can be produced for animal feed processing. Effective collaboration mechanisms need to be established between oil palm operators and commercial companies and research institutes, such as a contract farming agreement to guarantee a consistent supply of PKC/PKE. Rapid transfer of knowledge to the broiler industry players is crucial to develop confidence among integrators/producers about the merit of substituting imported raw material so that there is no drop in production performance. Pilot projects can be introduced to show the positive impacts from the research, and this should facilitate accelerated uptake of the findings. However, it must be remembered that the very production of oil palm is not without controversy, since the expansion of oil palm plantations associated with deforestation has been reported to have a high carbon debt. Steps should be taken to ensure that the utilisation of by-products from oil palm comes only from plantations managed on a sustainable basis. In addition, strict monitoring and regulating of planting and production activities should be based on existing oil palm cultivation policy, which only allow these on legally designated agricultural land and does not encroach protected virgin forest, in accordance to national commitment to the International Tropical Timber Organisation (ITTO) (MPIC, 2008; NRE, 2011).

Basic requirements in broiler production, especially related to land and water which are state matters pursuant to the Federal Constitution, need to be addressed carefully. A platform such as the State Agriculture Members Meeting should be used to seek agreement and collaboration between Federal and State Governments and to speed up any outstanding issues related to water and land. Land conversion and urbanisation issues are among the challenges faced by broiler producers wishing to expand production.

The effectiveness of the enforcement of regulations has always been an issue. Inadequate manpower is always a major concern, whilst illegal production in certain isolated areas has added to the difficulties of the monitoring process. Thus, the existing 11 locations of Permanent Poultry Production Park throughout the country need to be fully exploited with attractive packages for production, not only for enforcement purposes but also to facilitate production areas that have ND disease-free status and obtain an optimum level of biosecurity.

5.7 Conclusions

The findings can be summarised into four classes, namely environmental quality status, the credibility of WTP for chicken-HRE, the reliability of environmental impact values and the readiness of all stakeholders to implement more environmentally-sound development programmes.

5.7.1 Environmental quality status

The level of understanding and awareness about general environmental issues among the Malaysian population mostly matched national indicators, as revealed in Chapter 4. Nevertheless, specific knowledge about certain environment-related aspects, such as environmental impacts arising from broiler production, which involve concepts and lifecycle of certain technical elements, are still low.

There were mixed findings among producers on this aspect, depending on which housing system they operated*;* which is highly associated with commitment on agreement with the integrator, particularly for the CH producers. In general all producers have some knowledge about environment impacts from broiler production. The CH producers, who have the strongest association with the integrator, have been provided with a scheduled business plan and are profit oriented, practising good animal husbandry including manure handling, which all contributes to minimising environmental pollution. Conversely, these approaches were not fully practiced among the OH producers, perhaps due to lack of interest or the fact that it was not compulsory for them to do so. Furthermore, since the broiler industry is known as a capital-oriented business, additional efforts such as purchasing manure treatment substances and hiring labour will incur additional cost of production, without necessarily increasing profit.

5.7.2 Credibility of WTP for chicken-HRE and impact upon the industry

After considering benefits for the long term, the majority of consumers surveyed in this study appeared willing to pay at least 10% more for chicken-HRE than they currently paid for chicken. Despite possible sample biases, this endorsement is consistent with various indices such as the importance of chicken products as a result of the trends among the population towards urbanisation and increasing age. The credibility of the WTP value was also supported by the ability of the population to purchase the product through income indices for each region.

In line with the positive endorsement of chicken-HRE given by consumers on chicken-HRE, producers and integrators should be willing to implement more environmentally-friendly broiler production systems. However the industry is faced with several obstacles, particularly with regard to the financial issue of high initial investment cost. Almost two-thirds of producers felt that previous Government efforts to support economic and environmentally-friendly production, by introducing positive incentives for a certain period of time, was a good approach and encouraged more producers to implement environmentally-friendly production systems. Even though producers did not know the exact cost of this incentive to the national budget, they claimed that, in the current unstable economic situation, stimulating domestic economic activities was the best approach to stimulate growth in the economy.

Comparison of the cost of chicken meat production in different housing systems with the likely price that consumers would be willing to pay for environmentally-sound production methods suggests there is clear potential to expand adoption (and even further refinement) of the CH system across the Malaysian broiler industry. However producers may still need government support to be confident in making this substantial capital investment.

Integrators who had invested in the CH system for its higher productivity and lower environmental impact considered that moves by consumers to select only chicken-HRE would have little impact on their cost of chicken production. Other integrators, still reliant on the OH system in their production chain, argued that investment in new housing systems to produce chicken with a lower environmental impact would only increase their cost of production.

Clearly there is an assumption by some integrators that simply adoption of the CH system will be sufficient to satisfy consumer (and legislator) concerns about the environment. In reality, however, there may be further improvements to be made to the CH system before Malaysian chicken meat may be fully ‘acceptable’ on environmental grounds to every consumer/NGO, since it remains heavily reliant on imported raw materials to manufacture broiler feed, with the associated environmental burdens arising from transport from South America in particular. In a global marketplace, chicken-HRE may more likely be specified in terms of kg CO_2 per kg poultry meat for example, rather than being associated with one particular housing system.

Indeed, some integrators questioned whether a change in housing system was necessary, since the lucrative export destination of Singapore (the major export destination for Malaysian chicken meat) did not currently require chicken meat to be produced with any environmental credentials. Whilst it can be argued that there may be some inherent differences in production performance and environmental impact between housing systems, one integrator also pointed out that it is the quality of stockmanship or management that was the most important element in the successful operation of a broiler growing farm.

Skill of the farm workers and diligence of management can also have a part to play. For example, simple steps taken on farm to reduce feed wastage when factored across an integrated production chain can have a large impact on feed requirements, and this study has demonstrated the over-riding impact of broiler feed on the environmental impacts of broiler production. Equally, attention to detail on biosecurity and prompt treatment of any signs of disease can limit the debilitating effects on birds so that high growth rate and efficient utilisation of feed are maintained.

Besides financial aspects, the integrators called for clear action from the Government to overcome inefficiencies in enforcement. Strict enforcement of standards of public health, meat safety and environmental pollution in backyard slaughter plants along with participation in strategies to expand overseas export markets are needed. Integrators welcomed the implementation of any relevant legislation and/or adoption of any concepts that may facilitate expansion of export markets.

5.7.3 Reliability of environmental impact values

The findings for impact values of four selected impact categories, which used foreground data obtained from Serin *et al.* (2011b) using different broiler housing systems, were consistent in trend with previous studies as discussed in detail in Chapter 3. In addition, the socio demographic findings from the consumer survey showed that 40% of consumers chose quality as the most important element when they purchased chicken meat, implying a requirement to implement good animal husbandry practices in the production, which needs some elements related to good environmental management.

Besides this, from the Government's point of view, these findings support the ideas behind the policy thrust related to the national agenda on environmental protection and conservation through three policies and action plans as described previously.

5.7.4 Readiness of all stakeholders to accept moves towards more environmentally-friendly broiler production

Despite some limitations in the methodology (the number of consumers and broiler producers interviewed), the results suggest that at least a proportion of consumers, producers and integrators in Malaysia appear willing to contribute towards a form of broiler production which balances environmental concerns with national economic growth. However, this development can only be achieved with effective governance, namely recognising that environmental programmes are cut-cross all economic activities and therefore implementing a national development initiative with sufficient budget allocation, especially for an R&D agenda, which accelerates outstanding issues under the Government control and improves the level of regulation and enforcement. These are important and need effective actions.

Chapter 6: General Discussion and Policy Recommendations

6.1 Embracing Pluralism in Sustainable Development: Economic Growth, Environmental Management, Social Acceptance and Political Influence

6.1.1 The dilemma of sustainable development implementation

The concept of sustainable development was popularised in Our Common Future Report published in 1987 (Brundtland, 1987, Drexhage and Murphy, 2010; also known as the Brundtland Report) which contains guidelines towards sustainable efforts which have, since then, been widely applied in many development programmes. The classic definition of sustainable development is the conveyance of the benefits of development to the present generation without compromising the needs of future generations, and therefore calls for convergence between the three pillars of economic development, environmental protection and social equity. However, after more than 25 years of implementation, the actual achievement of sustainable development has been rather slow (Michel, 2008). The sustainable development concept was in accordance with Goodland and Ledec (1987), who argued that the application of neoclassical economics to measure actual development overlooked, or at least undervalued, major environmental issues including ecological consequences; it therefore did not represent the real situation and so could not be used to describe actual development. They also stated that the lack of consideration of the economic value of environmental goods was due to difficulties in measurement and valuation, thus the benefits from intangible environmental values, such as environmental quality and preservation of biological diversity, featured even less in neoclassical economic analysis.

The failure to incorporate environmental values in the accounting of development growth has for a long time affected the maintenance of natural resources. Thus overuse of resources as inputs eventually causes an external cost which gives rise to the situation where costs or benefits cannot be accounted and transmitted to the actual price (Davies, 2010). This scenario has led to difficulties in some countries of achieving equal weighting at policy level the economy and environment; in many instances the economic agenda has had favour in the decision making process.

Therefore, planning and implementation of sustainable development programmes should go beyond the classical concept and instead incorporate good governance which is able to value all elements along the development process besides active participation from society, i.e. co-determination and power sharing throughout the program cycle (Nelson and Wright, 1995). This method is also known as a participatory development approach which will benefit all stakeholders and make the programme more successful and sustainable (Mohan, 2001).

6.1.2 The livestock revolution and structure of the broiler production supply chain

Delgado *et al.* (1999) stated that the livestock revolution is the next food revolution after the green revolution, but that the livestock revolution has different driving forces. The green revolution was based on the supply side phenomenon, i.e. it depended on acceptance and adaptation of technologies such as seed-fertiliser innovation in developing countries. The livestock revolution however is demand-driven with notable demand for poultry meat and milk in developing countries which affects production patterns and trade. This scenario is the result of a combination of: population growth, which is expected to reach 9.15 billion by the year 2020 and which will increase demand for all types of food, population income growth, which determines purchasing power, and finally rapid urbanisation, which brings changes in lifestyle and food intake. Poultry meat, through broiler production, recorded the highest increase in global production growth by a factor of 7.0 (711%) from 1967 to 2007, whilst production per capita has also increased, albeit at a slower rate (a factor of 4.0, 369%) for the same period (FAO, 2011b). In addition, according to FAO (2012), world poultry meat production in 2010 was 98 million tonnes and is expected to reach 122.5 million tonnes by 2020 (Best, 2011).

The livestock industry, which is driven by demand, really depends on the efficiency of its supply chain, a supply chain which not only guarantees the availability of products for consumers but also facilitates the process of traceability (Opara, 2004; Levinson, 2009; Rickard, 2011). Thus supply chains which previously served simply to balance supply with and demand for the product in order to achieve the economies of scale in production and avoid surplus supply in the market, can now be optimised as a tool to improve the quality of products through traceability, especially for imported products (Rickard, 2011).

6.1.3 Development of broiler production in Malaysia

The growing demand for animal products for human consumption requires the broiler industry in Malaysia to be more resilient and sustainable. It requires not only a competitive market which is determined by supply and demand, but also effective intervention from governance that is responsible for creating and prioritising the national development programmes, including these of the livestock sector.

The livestock industry in Malaysia has been growing steadily over the past 15 years, particularly the poultry sub-sector where production has recorded an annual growth rate (AGR) of 5.3% between 2005 and 2009. As a result, supply has surpassed the domestic demand (122% self-sufficiency in 2009), whilst over the same period the export market has improved significantly (MOA, 2010a; DVS, 2010). However, at farm level there is scope to increase output even further. In farm business management study, Serin and Sobri (2011a) estimated that the technical efficiency index (derived from the estimated production frontiers method) of Malaysian broiler production was 0.89, i.e. that broiler farms produced only 89% of their potential. The efficiency of production between the different regions of the country (Peninsular, Sabah and Sarawak) was unequal, with farms located in Sabah being generally less efficient (-2%) compared to those operating in Peninsular and Sarawak.

In the longer term, the broiler industry in Malaysia requires strategic planning that focuses not only on production, but also addresses the aspects of sustainability. Chicken meat is an important raw material in the diet of Malaysians, and is a relatively cheap source of protein. With improved education and widely available media, knowledge about environmental issues amongst the public is increasing. Therefore this thesis presented an opportunity to i) estimate the environmental burdens of different broiler production systems in Malaysia, as explained in Chapter 3; ii) estimate consumers' WTP for chicken produced in a more environmentally-friendly way (termed 'chicken-HRE'), thereby gaining an indication of society's readiness to pay for environmental quality, as elaborated in Chapter 4; and finally iii) explore the impact of potential policy changes designed to reduce the environmental impact of broiler production in Malaysia, from the perspectives of poultry producers, integrators and the Government, using a mixed method analysis as described in Chapter 5.

6.2 Assessment of Environmental Impacts of Broiler Production in Malaysia

As shown in Chapter 3, LCA was employed to estimate the burdens produced from different broiler production systems in Malaysia. Currently 99% of national chicken meat in Malaysia is produced from intensive housing systems - 60% from the OH system and 40% from the CH system. The remainder is produced in a semi-intensive system which produces special meat from indigenous breeds.

Results of LCA showed that the CH system produced lower environmental burdens than the OH system, by 6 to 7% for GW, AP and EP impact categories, but marginally greater burdens for energy use, i.e. 1.3%. Broiler and breeder feed-related inputs accounted more than three quarters of the total impact values, i.e. 77 to 94%, followed by other on-farm inputs and emissions. Broiler producers argue that a CH system requires a high capital investment (see Section 5.6.2.2), and therefore finance remains a major obstacle for implementation of new CH systems. However, the CH system is associated with benefits in efficiency. Serin and Sobri (2011a) conducted a survey involving 256 farms (189 in Peninsular Malaysia, 32 in Sabah and 35 in Sarawak), 23% of which used the CH system. Amongst the important findings of this survey was the fact that, regardless of the scale of operation, the CH system farms were 4% more efficient than those using the OH system. Greater efficiency was associated with lower FCR values, less mortality and higher net margin per chicken, which ultimately determines the cost of production and potential farm income. These findings were consistent with another survey conducted by Serin *et al.* (2012) estimating the costs and farm income between the CH and OH systems and summarised in Table 6.1. According to Serin *et al.* (2012), average cost of broiler production for a single broiler chicken in the CH system was 2.4% lower than the OH system. Therefore it seems that if producers can overcome the high initial capital investment (often with an inherent reliance on imported machinery which attracts tax, elaborated in Section 6.5.2 (i.b)), the CH systems offers the possibility of greater efficiency leading to lower environmental impacts and costs of production.

Table 6.1: Comparison of estimated costs and farm income of broiler production for open house and closed house systems with an initial flock size of 100,000 day old chicks (Serin *et al.*, 2012; full details are shown in Appendix 10)

Parameter	**Closed House (CH)**	**Open House (OH)**
Feed Conversion Ratio	1.75	1.85
Mortality Rate (%)	3.50	6.00
Net Margin (RM/head)	0.79	0.60
Av. Production Cost (RM/kg)	3.94	4.03
Av. Production Cost (RM/head)	7.87	8.06
Approx. Farm Income (RM/month)	39,628.00	29,869.00

However, careful consideration of any differences between production systems is required when considering the implications for the Malaysian broiler industry as a whole. LCA and the other environmental assessment tools described in Section 2.7.1 have been developed to assess the environmental impact of a wide range of economic activities, but the process is far from simple. For example, ISO (2006) defines two objectives of LCA Interpretation as follows:

i. To analyse results, reach conclusions, explain the limitations and provide recommendations based on the findings of the preceding phases.

ii. To create understandable, complete and consistent findings, in accordance with the goal and scope of the study.

The interpretation process however is not as simple as simply stating that system A is better than system B, thus System A is the best choice. The interpretation should not just be based on the estimate of impact values calculated at the end of life cycle assessment phase, especially when considering that there is an inherent degree of uncertainty about the results. At various points in the LCA process, the researcher is required to make some assumptions or estimates and the results depend on the quality of the foreground data that is derived from multiple sources. Thus it is important to retain a degree of caution when interpreting the environmental impact values. This does not imply that efforts made in conducting environmental assessments are a waste of time and resource, since these estimated impact values are useful as indicators and provide decision makers with a better understanding of the environmental impact of different forms of production, especially when it could be associated with human health and safety issues (ISO, 2006). Furthermore the LCA study does not take into account other important aspects of sustainability such as economics (costs of meat production in different systems, profitability and domestic and international competitiveness), politics (willingness and/or ability of the government to provide and monitor incentives to more sustainable production) or social concerns (effects on employment, support for local services).

6.2.1 Welfare status between production systems

Another important aspect of sustainability which is relevant to modern broiler production is the issue of animal welfare. As outlined in Section 2.4.1, animal welfare refers to the state of physical and mental well-being in which an animal is in harmony with its environment (Brambell, 1965). Animal welfare can be considered under the five freedom principles, i.e. freedom from i) hunger and thirst, ii) discomfort; iii) pain, injury, infestation or disease; iv) fear and distress; and v) freedom to express normal behaviour (Brambell, 1965; FAWC, 1992; DEFRA, 2002).

Although as yet there are no reports in the literature investigating broiler welfare in Malaysia, the framework of the five freedoms was used to gain some impression of the welfare aspects of the three broiler production systems used, as shown in Table 6.2. The SI system was included in this preliminary analysis by way of comparison, since some consumers, especially in Europe, hold to the belief that semi-intensive by its nature means higher welfare. These five freedoms are addressed in three main areas, namely a) housing management elements, b) characteristics of modern broiler breeds and c) post- production activities.

i) Housing management elements

Stoking density and climatic factors inside the house are two welfare-related issues during the production stage which are relevant to the freedoms of (i), (ii), (iii) and (v) mentioned above. The OH and SI systems offer a greater space allowance (i.e. 0.12 m^2 per bird, equivalent to a stocking density of 17.7 and 17.5 kg per m^2 assuming 8 birds each of 2.12 kg and 2.10 kg finished weight per m^2 respectively) than the CH system which has a stocking density of 24.2 kg per m^2 (11 birds of 2.18 kg finished weight per m^2). Adequate spacing allows birds greater freedom to move around and perform their natural behaviour and is also a vital aspect of environmental control (thus thermal comfort) since this factor indirectly affects other important climatic factors in the house such as temperature, humidity and the quality of litter. In addition, the OH system allows birds access to fresh air and natural light, albeit within the confines of a covered roof. The European Union's Scientific Committee on Animal Health and Animal Welfare (SCAHAW, 2000) report on the welfare of intensively housed broilers recommended that stocking density at 25 kg per m^2 or less is important to avoid major welfare problems. However, many commercial broiler producers will argue that birds can be reared under high welfare at a higher stocking density than this providing that standards of management (e.g. to monitor litter quality) and ventilation systems are high. Thus, whilst the CH system restricts space allowance to a level approaching the 25 kg per m^2 target, it is not possible to conclude that welfare is inherently reduced without empirical evidence collected on commercial systems in Malaysia.

In the CH system, birds are raised on a litter base of wood-shavings (approximately 5 cm thick) while the OH system uses a wooden slatted floor. A deep litter of wood-shavings can, if it becomes wet due to the decomposition of uric acid in faeces and manure, cause 'ammonia burns' skin and foot sores such as breast blisters and foot-pad dermatitis (Turner *et al.,* 2003). On the other hand, the use of a slatted wooden floor in the OH system seems to be able to reduce foot defects and the amount of ammonia concentration as well as dust inside the house (since the faeces drop directly onto the soil below the house). With access to natural ventilation, it can be argued that the OH system provides adequate supplies of oxygen for birds which could reduce the disease occurrence associated with the ascites syndrome of heart failure (see Characteristics of modern broiler breeds below).

Therefore with the CH system there is even greater emphasis on the importance of high standards of stockmanship and design of the ventilation (and cooling) system, particularly in a humid environment, to maintain a friable litter. Indeed the CH system offers the potential for greater thermal comfort to the chickens, with greater protection from heat stress by providing a ventilation system of an appropriate design to accommodate the hot and humid climate that Malaysia experiences all year round. In contrast, the OH system relies on manual control of ambient air, requiring alert workers to adjust the moveable curtains to control the environment.

Table 6.2: Appraisal of adherence to the five freedoms regarding animal welfare applied to broiler production systems in Malaysia

Basic freedom (*and characteristic to achieve it*)	Relevant Parameter(s)	Closed House (CH)	Open House (OH)	Semi-Intensive (SI)
Freedom from hunger or thirst *Ready access to fresh water and a diet to maintain full health and vigour*	**Available of feed and water**	*ad libitum*	*ad libitum*	*ad libitum*
Freedom from discomfort *Providing an appropriate environment including shelter and a comfortable resting area*	**Production area**	Confined inside house	Confined inside house	Confined to certain area
	Type of house	Controlled environment	Open wall	Simple to modern house
	Type of floor	Deep litter	Slatted floor	Slatted floor
Freedom from pain, injury or disease *Prevention or rapid diagnosis and treatment*	**Type and frequency of treatment**	Regular inspection, scheduled treatments	Regular inspection, scheduled treatments	Regular inspection (but less veterinary input), advice given from technical personnel
	Housing management	Controlled lighting and ventilation system	Manual lighting & moveable curtain to control ambient air	Manual lighting & moveable curtain to control ambient air
Freedom from fear and distress *Ensuring conditions and treatment which avoid mental suffering*	**Catching and loading techniques**	Manual	Manual	Manual
Freedom to express normal behaviour *Providing sufficient space, proper facilities and company of the animal's own kind*	**Floor space area** *(m^2/bird)*	0.09	0.12	0.12
	Stocking density[1] *(kg/m^2)*	24.2	17.7	17.5
	Number of birds per m^2	11	8	8

[1] *Assuming 2.18, 2.12 and 2.10 kg finished weight per bird respectively for CH, OH and SI systems*

Even though all chickens are given *ad libitum* access to water and feed, the CH system uses automated drinkers and feeders, while the OH system uses manual techniques. Provision of sufficient drinking and feeding opportunities are important in any system, since overcrowded sheds can lead to blocked access for weaker birds. In addition to that, any malfunction of the feeders or drinkers may be exacerbated under large scale production systems (Rose, 1997).

To control disease outbreaks, it can be argued that since the CH and OH systems confine birds inside the house at all times, they provide a better management approach than the SI system. Scheduled veterinary treatments and minimal human contact associated with integrated production chains which favour the CH and OH systems, will further assist in reducing the risk of a disease outbreak. Avoid contact with humans is of particular importance in the spread of avian influenza.

ii. Characteristics of modern broiler breeds

According to the EU expert committee, the most deleterious welfare arise from R&D advancement on selective breeding for high production efficiency has changed the behaviour, biology and physical development of broiler chickens (SCAHAW, 2000). Morden broilers are pushed to grow rapidly to achieve a desired finished weight at an average of six weeks of age. Broilers bred for rapid body growth with large appetites tend to suffer from leg disorders and lameness due to abnormal bone development and infectious disease. Breeder hens which grow to adulthood might suffer from degenerative diseases such as osteoarthritis and ruptured tendons and ligaments.

Besides lameness, fast growing broilers are also prone to suffer from two forms of heart failure, namely ascites and Sudden Death Syndrome. These conditions are associated with a high requirement for oxygen to support the intensified metabolic demand, thus increasing cardio-pulmonary activities and leaving insufficient oxygen for other bodily needs (Turner *et al.*, 2003; Guy and Edwards, 2006).

These scenarios are applicable for chickens in both the CH and OH systems in Malaysia, since both housing systems typically use the same commercial genotype (as seen in Table 3.2 in the LCA analysis), but there might be a different level of incidence. Even though the birds are selected for rapid growth which requires the heart to increase its workload, the housing design in the OH system, which allows birds to breathe fresh ambient air and greater freedom to move around due to a lower stocking density, could reduce the occurrence of heart failure.

iii. Post-production activities

Post-production activities that are relevant to this study (i.e. a cradle to point of slaughter boundary) include catching and transporting chickens to the slaughterhouse. The technique of manually catching broilers in the shed is often undertaken at great speed with 4-5 birds carried at a time, inverted by one leg. Such operations often result in injury such as hip dislocation and internal haemorrhaging which can be fatal. Thus, in the UK, DEFRA (2002) recommend that ‘no catcher should carry by the legs more than three chickens (or two adult breeding birds) in each hand’ and ‘birds should be caught and carried by both legs’. Manual catching is used in both OH and CH production systems and an understanding of the importance of gentle handling of broilers during loading and unloading to maximise both welfare and meat quality should help minimise any physical or mental suffering. Integrated production systems have some advantages here because of the flow of information up and down the chain to minimise losses and promote freedom from fear and distress.

Crowding, thermal stress (which causes suffocation) and exposure to cold in winter are major welfare challenges during the transport of broilers (Turner *et al.*, 2003). All these can lead to fear and distress. According to SCAHAW (2000), there is inadequate legislation protecting broiler welfare during transport. In Malaysia broilers are very unlikely to be exposed to cold temperatures. It can be argued that in an integrated production system, using the CH system with a high quality ventilation system and a well-organised schedule of delivery of broilers into the processing plant, birds will experience minimum exposure to heat stress.

In summary, although this review of welfare considerations of different production systems has been by necessity brief, it has nevertheless shown that current production systems have both advantages and disadvantages. The CH system showed some advantage in creating a comfortable thermal environment and reducing the risk of disease, while the OH and SI systems offer natural surroundings for chickens to express their natural behaviour, however a greater risk of disease from greater exposure to pathogens in the SI system.

Welfare awareness programmes should be conducted with poultry workers, especially to ensure adequate access for birds to feed and drink. Clearly this brief section on animal welfare has not been able to address this important topic in detail and there is scope then for further research to quantify any system differences in animal welfare, to explore any potential trade off of environmental impact, and to ascertain consumers' WTP for welfare.

6.3 Consumers' Willingness to Pay for Chicken-HRE and Their Opinions About Environmental Issues

Chapter 4 of this thesis provided an introductory study of important issues relating to purchase of chicken meat with reduced environmental impact. The valuation method to assess issues related to society was conducted through a survey of socio-demographic and economic aspects of over 210 respondents. The results provided some suggestions as to how society view environmental aspects related to broiler production and its product (i.e. chicken meat) which later could be utilised to explore real consumer behaviour in the market (Hanley *et al.*, 2001). The majority of findings from the survey, such as opinions on sustainability-related issues (contribution of major economic activities to the environment and quality status of air and water) and household chicken meat consumption and purchasing patterns were consistent with many of the national economic indices released by the Malaysian government, such as the Population and Housing Census, GDP, CPI and Quality Life Index as elaborated in Chapter 4.

To gain some estimate of the value that consumers might place on environmental quality, the current study employed economic valuation of environmental goods through a contingent valuation approach to determine the marginal utility value. In this context, an environmental good refers to the favourable environmental quality which has two prominent characteristics, i.e. it is intangible and it does not have a price in the market. The 'good' is a broiler meat produced with a higher regard for the environment (chicken-HRE). The relationship of this good with economics and society arises from the demand of society in obtaining a better quality of life. Society is generally aware of the negative impacts to the environment arising from development activities (in this case broiler production), thus society may demand an alternative product that can produce at least equivalent, if not better, physical and economic performance but can be achieved through environmentally-friendly production techniques.

Chicken-HRE was selected as a proxy for environmental good to represent society's opinions and endorsement of efforts to promote favourable environmental quality. Environmental economic valuation was employed to measure the value of this good by using stated preference in a contingent valuation method (CVM). CVM was performed to estimate the value placed on a good for which no obvious price exists, as outlined in Section 2.10. Therefore respondents in the survey, were asked to state their WTP for chicken-HRE after taking into consideration all economic and socio-demographic information including broiler production techniques, job creation opportunities, current and future projections for economic performance, and benefits in the future as a result of using more environmentally-friendly production. They were also cautioned on some possible weaknesses and challenges arising from changes in broiler production techniques, especially regarding market sale price of the product.

The CVM analysis of WTP for chicken-HRE generated two parameters, namely mean and median values which bring with them different interpretations. The mean WTP value was meant to determine the benefit value of the goods and is relevant for economic analysis. On the other hand, the median value indicates likely public motivation and choices, since it corresponds to the value which represents the endorsement of the majority of the respondents. Thus the median WTP value was chosen as the most useful indicator to illustrate the willingness of respondents to pay for the environment good, i.e. lower environmental impact.

Notwithstanding the limitations of the CVM survey used in the current study (highlighted in Section 4.4.6), the median WTP value can be extrapolated to Malaysia as a country, to gain some indication of the potential impact of these results. For the purposes of illustration, if we assume that the majority of consumers are willing to pay a 10% premium (i.e. an additional 70 cents) for chicken meat which is produced with a lower environmental impact, that the total annual production of chicken meat in Malaysia is 1,295,600 tonnes (output for 2010), and that approximately 60% of broilers are produced in the OH system (the commercial system which currently produces the highest environmental impacts), then the value that consumers would be willing to pay towards improved environmental quality is RM5,532,212. Expressed in another way, society could benefit from improved environmental quality which is estimated to be worth RM5,532,212 for the whole country. This scenario can be described as the willingness to pay for the marginal change in environmental quality associated with the improvement of production techniques.

6.4 Integrated Conclusions

The overall aim of the current study was to identify policy approaches to promote sustainable broiler production in Malaysia, i.e. systems of broiler production that give high output with low environmental impacts and fulfil the criteria for food security and human health. Therefore a holistic perspective was required to draw together elements of social, economic and environmental dimensions together with inputs from consumers, producers, integrators and the Government. Since the study required both quantitative and qualitative evaluations, a mixed method of integration into a single study was chosen to address the four dimensions of sustainable development in broiler production in Malaysia.

Findings from the environmental economic valuation, (i.e. CVM and the socio-demographic and economic survey) complement the estimated values of environmental impact assessment, particularly regarding the housing system which gave lower burdens to the environment as explained in Chapter 4. As suggested by ISO (2006) and Bryman (2008), a qualitative method is required to measure subjective aspects, such as opinions from producers, integrators and the Government. Thus, as mentioned in the integration findings section of Chapter 5, qualitative findings were incorporated to complement the quantitative results to address four themes of findings, namely environmental awareness status, credibility of WTP for chicken produced with a higher regard for the environment, reliability of environmental impact values and the readiness of different stakeholders to move towards more environmentally friendly broiler production.

A broiler production system that allows for increased efficiency of inputs, control systems and improved manure handling can be expected to require substantial technological investment. Thus a system such as the CH system investigated in the current thesis will generally have a higher capital requirement, yet farm management surveys in Malaysia and the LCA analysis in the current study suggest that the efficiencies offered by this system could yield broiler chickens with a lower cost of production and less environmental impacts. However more detailed financial assessment of representative farms over an appropriate length of time would be necessary to confirm the potential of the system, and to investigate consequences for the broiler industry of Malaysia as a whole. The findings of the current study imply that improvement in a production technique, i.e. greater resource-use efficiency, lower environmental impact and reduced cost of production, could help to persuade society, producers and integrators to participate in more sustainable forms of production, albeit subject to the availability of resources and the effective governance. Thus to complement the efforts of producers and integrators, the involvement of Government and support of consumers are key in promoting more sustainable forms of broiler production. More accurate estimates of the value that society in Malaysia would be prepared to place on chicken meat produced with a higher regard for the environment (i.e. the passive value of the product, as defined in Section 2.10) will better inform development planning and thus assist decision makers in government to balance economic and environmental aspects.

6.5 Policy Recommendations to Promote More Sustainable Forms of Broiler Production

This section examines a number of policy recommendations to promote more sustainable forms of broiler production, covering selected aspects along the production chain. Based on the discussion above, the following recommendations are proposed to strengthen existing efforts by the Government and to address weaknesses in the poultry industry.

6.5.1 Unleashing economic potential

i. Streamlining vertical and horizontal collaboration at the production stage

There is a need to strengthen the competitiveness of broiler production in Malaysia through improvement in productivity and efficiency. Contract farming in Malaysia generally adopts a horizontal integration approach, where relatively-small scale producers collaborate together. This could be streamlined into a vertical integration approach, which is an effective method to reduce transaction costs and diversify outputs. Serin *et al*. (2011b) reported on this increasing trend towards a vertically integrated approach in broiler contract farming in Peninsular Malaysia, suggesting that this could contribute to greater productivity. Broiler producers could enjoy a number of benefits from participation in a vertically-integrated chain (e.g. reduced transaction costs, dissemination of knowledge and technology etc., as discussed in Section 2.5.2(1.iii)) in order to ensure the industry remains competitive and to reduce environmental impacts. Vertical integration may also benefit the integrators, by providing them with a more consistent supply of broiler chickens and a greater degree of control over the whole production system, as seen in other countries where vertically-integrated broiler production has become the norm.

ii. Acquisition of strategic resources of broiler feed

It is estimated that 71% to 73% of farm costs are associated with feed and 90% of raw materials for feed are imported (MARDI, 2011). Therefore, the following considerations are necessary in respect of broiler feed.

a. Accelerate R&D activities and active commercialisation of research findings on the substitution of imported maize with new-PKC and new-PKE (see Section 5.6.4.2). In addition, collaboration with oil palm plantations to provide a consistent supply of high quality PKC and PKE (in terms of standard extraction procedures) through a contract farming concept should be intensified. However, there are concerns about the environmental impacts of oil palm production (e.g. deforestation to increase land available for cultivation), so that any research in this area should include an environmental and economic impact assessment. Indeed, such an undertaking should be made a requirement for investigation of any of the potential policy recommendations made in this section.

b. Strengthen and accelerate investigation of the potential to source raw materials for animal feed from low cost countries in Asia, through alliance of investors from Malaysia with local farmers/farmer groups in those countries. Close interaction between the governments of both countries is needed to ensure agreements on important issues such as tariff and non-tariff barriers, e.g. taxes on imports of commodities as well as foreign levy and other regulations, have been identified and clearly stated in the agreement between governments.

c. As mentioned in Section 2.5.2(2.i), small scale animal feed manufacturers face difficulties in obtaining a consistent supply of raw materials. Government intervention could help to address important issues related to price and distribution mechanisms, to the benefit of both grower and feed manufacturer. Although this may seem unusual in many European countries, this is not unusual in Malaysia where the relatively low number of feed companies means that there is some concern over monopoly of price, so that independent and/or Government representation at board level of these feed compounders may be helpful.

d. The long term strategy of creating stockpiles of raw materials for animal feed should be realised by providing an integrated action plan taking into consideration the fluctuation in international market prices. The stockpile approach may be in the form of carefully timed field operations (i.e. well-scheduled cultivation times of crops to ensure a spread of harvesting dates) rather than a physical stockpile which requires high maintenance cost in which the quality of raw materials can easily deteriorate in an unfavourable climate (due to high humidity).

iii. Land conversion and urbanisation

Due to the growing proportion of people living in cities, conversion of land for residential purposes will expand and encroach on urban areas, resulting in problems of public health (e.g. risk of contracting avian flu) and inconvenience from smell. The creation of designated poultry production areas, known as TKPAs (see Section 2.5.2(1.i)), which are some distance away from urban areas, is one solution and already over 800 ha has been developed for poultry production, with a further 800 ha identified for poultry production. This should be implemented not only for the benefit of the public, but also to ensure disease-free zones can be established, especially for HPAI and Newcastle disease, providing that this does not create further negative environmental impacts (e.g. if deforestation takes place to create the parks).

iv. Strengthen marketing with emphasis on Sanitary and Phytosanitary measures

Enhancing market intelligence to maintain existing export destinations is crucial. Even though Singapore is still a major market for chicken products from Malaysia, the Malaysian share of the market has declined from 20% in 2008 to 14% in 2010 (Global Trade Information Service, 2010; MoA, 2010a). Reasons behind this drop should be investigated and, at the same time, efforts made to penetrate new markets where high standards of meat quality and safety are crucial, attention should be given to sanitary and phytosanitary measures at farm level to ensure bio-security and traceability systems are in place and reliable (see 2.5.2(2.iii)).

6.5.2 Valuing the environmental endowment: Focusing efforts towards sustainable poultry production

i. Fiscal incentives to boost sustainable poultry production systems

a. Re-establishment of fiscal incentives to encourage producers to upgrade their production system, from the OH to the more efficient and environmentally-friendly CH, in the form of tax allowance through the Reinvestment Allowance under Income Tax scheme (see Section 2.5.2 (3.ii.a)). Although there are no reports available analysing the effectiveness of this scheme, it was considered popular with the industry and over the years that it was in operation (2003-1010) allowed for 46 new farms to be built, representing a Government investment valued at RM595 million. Not surprisingly its reintroduction would be welcomed by those producers and integrators wishing to expand production. However, an effective performance monitoring system is needed to reduce leakage (i.e. misappropriation at implementation stage, such as mis-match of incentive approval with actual investment due to false declaration) from this scheme to maximise its effectiveness and to ensure that the new systems are capable of delivering substantial environmental benefits. Loss of national revenue could thus be minimised. Efforts to stimulate and expand domestic demand by active participation in economic activity, as well as private investment and consumption, are necessary due to uncertainty of the global economy growth.

b. There is a need to review the current tax scheme on import duties for machinery spare parts which is currently set at 15% - 30% (as mentioned in Section 2.5.2(3.ii.b) import duties are varied based on type of goods). Producers wishing to invest in housing systems with a high level of mechanisation (such as the CH system) will benefit from the reduced capital cost along with increased production efficiency. However, the Government may require a feasibility study to investigate the trade-off between loss of tax revenue with positive economic and environmental benefits for the poultry industry.

ii. Both types of tax incentives suggested above could help address the problem of ineffectiveness of waste handling, i.e. the collection and disposal of chicken manure. Another important practical effort would be to strengthen enforcement of the existing guidelines, namely the Poultry Farming Enactment 2005 which provides comprehensive procedures relating to release of emissions, odour, flies or pests from poultry units which are likely to cause nuisance or to be a hazard to public health (see Section 2.5.2). Thought should be given to strengthen enforcement systems, such as increasing the number of trained enforcement personnel or the penalties for offences. However, as with the other potential schemes/indicatives described in this section, increased policing is not without cost and thus may not be possible in the current economic climate.

iii. Optimising operational cost: Reducing dependency on foreign labour

To overcome the dependency on foreign labour which causes national currency outflow, besides difficulties to retain foreign skilled labour due to restriction in renewal of working permits, the CH system is one of the best options since it will be able to reduce labour use by 50% (DVS, 2011b). However, the social and political implications of such a change should also be investigated.

6.5.3 Consumers' concern and satisfaction: Improving the quality of farms and poultry products

i. Halal and Comprehensive Quality Issues

Based on the background of halal food production outlined in Section 2.5.2 (2.iv), the Government could consider increasing institutional capacity and enforcement to address consumer concerns, particularly concerning the slaughtering technique and halal-based products. Currently only 21% of poultry products are certified as HALAL by JAKIM (Malaysia Department of Islamic Development). Since the authority to certify religion- related matters comes under state jurisdiction, standardisation of halal certification among states should be facilitated by establishing more centralised slaughtering stations. Standardisation of halal certification by JAKIM should also incorporate Good Animal Husbandry Production (GAHP), Good Manufacturing Practice (GMP) and the Hazard Analysis and Critical Control Point (HACCP) elements. These are very important for a 'clean' food production chain which prevents environmental degradation. Adoption of these elements would also assist with penetration of new export markets.

ii. Retail price of chicken in Malaysia

Although the Government abolished the ceiling price of chicken in 2008, allowing price to fluctuate with supply and demand, the policy to maintain the ceiling price during the festive season is still needed to ensure the needs of consumers are taken care of. Thus, improvement of mechanisms to generate a reliable estimate of poultry meat demand which could reduce imports and any opportunity for price manipulation. At the same time, further studies could be undertaken on a wider and more representative cross section of the population to estimate the price that consumers would be willing to pay for meat produced with less environmental impact.

6.5.4 Inclusive socio-economic development: Enhancing economic participation of the Bumiputera

The Government development policy which aims to ensure all ethnicities are able to participate in and benefit from economic growth (Section 2.5.2 (3.iii)) includes the Bumiputera (indigenous race) to address include imbalances in employment, ownership of assets such as property and corporate equity, and participation in value-added activities. Low financial capacity, as a result of a long socio-demographic isolation policy of the Bumiputera in the past, has largely precluded them from engaging in high-impact businesses which require substantial capital investment. Therefore, thought should be given by policymakers as to how best to assist Bumiputera to become more involved in the value-added aspects of poultry production, e.g. by facilitation of a co-operative slaughter and processing plant.

Nonetheless, recognising the different levels of Bumiputera capabilities, strategies of Bumiputera involvement in the agriculture sector could be divided into two categories: first, micro (small and medium) and second, large enterprises. For the micro enterprise, capability development through multiple policy instruments such as incubators and TKPA, besides micro financing and capital for start-ups, are still relevant to be implemented, even though these are old approaches. These facilities should be effectively applied and monitored. For the macro enterprises, scaling up production with the provision of equity funding and venture capital could accelerate the progress and allow for expansion of high efficiency-low environmental impact broiler housing systems and infrastructure and ultimately yield equality for all ethnicities.

6.6 Conclusions

In conclusion, the environmental assessment study showed that different production systems produced different levels of environmental impact values. The CH system produced lower environmental burdens than the OH system, by 6% to 7% for GWP, AP and EP impact categories, while the energy use was marginally greater in the CH system. The environmental economic assessment using CVM analysis estimated the value that consumers in Malaysia might be prepared to pay for chicken meat produced with a lower environmental impact. Although there were a number of deficiencies in the design of the survey which means that the data should be interpreted with caution, this pilot study suggests that a substantial proportion of consumers would be willing to pay an increment of 10% above market price for chicken which is produced with a lower environmental impact. Of the two housing systems evaluated, and based on the best available data, this suggests that greater adoption of the CH system would yield environmental benefits for the population. The results also revealed that socio-demographic and economic factors play a major role in influencing consumers' understanding about environmental issues, including those related to broiler production.

To obtain a holistic understanding of the potential to develop sustainable broiler production in Malaysia, a qualitative approach incorporating opinions and perspectives from producers, integrators and government was taken. Results showed that all stakeholders had some degree of interest in moving towards more sustainable broiler production, subject to concerns about economic impact on the industry and improvement in governance necessary to ensure effective participation from industry players and the public. Even though the economic aspects explored in this study give only an indication of the likely societal attitudes to broiler chicken production, they nevertheless provide an indication of the growing stakeholder interest in methods of food production and implications for the level of environmental quality to be experienced by future generations.

Others aspects of sustainability which should be investigated in future research of new broiler housing systems and technologies include a detailed assessment of the economic impacts (cost of production and competitiveness), social implications (effects on employment both local, national and indigenous people) and animal welfare. Only by integrating all of the pillars of sustainability development can recommendations be made about what is the most suitable housing system for housing broilers in Malaysia.

Meanwhile, from a methodological aspect, since the LCA analysis is considered a relatively new research tool in most developing countries, there is scope for refinement and improvement of the assessment process including strategies to obtain more accurate foreground data.

Appendix 1

The impact values for various stages of the closed house system associated with production of one tonne live weight of broiler chicken

Breeder Feed (for a FU)

Impact category	Unit	Total	Maize	Soybeans	Palm oil	Limestone	Dicalcium-phosphate	Palm kernel meal	Wheat pollard	Freighter oceanic	Land transport
Energy Use	MJ eq.	**881.66**	294.58	59.36	4.72	0.12	46.70	10.07	82.53	304.57	79.01
GWP	kg CO_2 eq.	**151.80**	36.27	61.75	1.40	0.01	4.09	2.98	17.74	22.46	5.10
AP	kg SO_2 eq.	**1.31**	0.26	0.17	0.01	0.00	0.07	0.01	0.11	0.65	0.03
EP	kg PO_4 eq.	**0.77**	0.34	0.24	0.00	0.00	0.00	0.01	0.14	0.03	0.01

Breeder Hen (for a FU)

Impact category	Unit	Total	Breeder Feed (+ drinking water)	Electricity	Gas	Water	Bedding
Energy Use	MJ eq.	**952.95**	882.47	68.25	0.14	0.01	2.14
GWP	kg CO2 eq.	**157.16**	151.87	5.13	0.01	0.00	0.15
AP	kg SO2 eq.	**1.33**	1.31	0.02	0.00	0.00	0.00
EP	kg PO4 eq.	**0.78**	0.77	0.01	0.00	0.00	0.00

Broiler Feed (for a FU)

Impact category	Unit	Total	Maize	Soybeans	Fishmeal	Wheat	Palm oil	Wheat pollard	Freighter oceanic	Land transport
Energy Use	MJ eq.	**9473.39**	3695.37	752.51	273.81	182.62	311.42	162.21	3249.81	845.65
GWP	kg CO_2 eq.	**1698.37**	455.01	782.82	12.31	39.25	92.14	22.60	239.69	54.54
AP	kg SO_2 eq.	**13.56**	3.25	2.14	0.06	0.25	0.39	0.18	6.94	0.36
EP	kg PO_4 eq.	**8.39**	4.24	3.06	-0.12	0.32	0.24	0.23	0.36	0.07

Finished Broiler (for a FU)

Impact category	Unit	Total	Broiler Feed (+ drinking water)	Breeder Hen	Lorries	Electricity	Gas	Water	Bedding
Energy Use	MJ eq.	**12,002.28**	9,482.03	952.95	81.13	1,463.95	1.63	1.15	19.44
GWP	kg CO_2 eq.	**1,973.17**	1,699.19	157.16	5.22	110.03	0.09	0.11	1.37
AP	kg SO_2 eq.	**15.31**	13.57	1.33	0.03	0.38	0.00	0.00	0.01
EP	kg PO_4 eq.	**9.31**	8.39	0.78	0.01	0.13	0.00	0.00	0.00

Land Application (for a FU)

Impact category	Unit	Total	Emissions	Lorry	Fertiliser Credit
Energy Use	MJ eq.	**- 3,589.58**	0	142.55	-3,732.14
GWP	kg CO_2 eq.	**- 652.43**	28.18	9.64	-690.24
AP	kg SO_2 eq.	**2.08**	4.13	0.04	-2.08
EP	kg PO_4 eq.	**0.94**	1.27	0.01	-0.34

Total Impacts (for a FU)

Impact category	Unit	TOTAL
Energy Use	MJ eq.	**8,412.70**
GWP	kg CO2 eq.	**1,320.74**
AP	kg SO2 eq.	**17.40**
EP	kg PO4 eq.	**10.25**

Appendix 2

The impact values for various stages of the open house system associated with production of one tonne live weight of broiler chicken

Breeder Feed (for a FU)

Impact category	Unit	Total	Corn	Soybeans	Palm oil	Limestone	Dicalcium-phosphate	Palm kernel meal	Wheat	Freighter oceanic	Land Transport
Energy Use	MJ eq.	**906.61**	302.92	61.04	4.85	0.13	48.03	10.35	84.87	313.19	81.24
GWP	kg CO2 eq.	**156.10**	37.30	63.50	1.44	0.01	4.21	3.06	18.24	23.10	5.24
AP	kg SO2 eq.	**1.35**	0.27	0.17	0.01	0.00	0.07	0.01	0.11	0.67	0.03
EP	kg PO4 eq.	**0.80**	0.35	0.25	0.00	0.00	0.00	0.01	0.15	0.03	0.01

Breeder Hen (for a FU)

Impact category	Unit	Total	Breeder Feed (+ drinking water)	Electricity	Gas	Water	Bedding
Energy Use	MJ eq.	**979.92**	907.38	70.18	0.15	0.01	2.21
GWP	kg CO2 eq.	**161.61**	156.17	5.28	0.01	0.00	0.16
AP	kg SO2 eq.	**1.37**	1.35	0.02	0.00	0.00	0.00
EP	kg PO4 eq.	**0.80**	0.80	0.01	0.00	0.00	0.00

Broiler Feed (for a FU)

Impact category	Unit	Total	Maize	Soybeans	Fishmeal	Wheat	Palm oil	Wheat pollard	Freighter oceanic	Land Transport
Energy Use	MJ eq.	**10,166.31**	3,965.67	807.55	293.83	195.98	334.20	174.08	3,487.51	907.50
GWP	kg CO2 eq.	**1,822.59**	488.29	840.07	13.21	42.12	98.88	24.26	257.22	58.53
AP	kg SO2 eq.	**14.55**	3.49	2.30	0.06	0.26	0.42	0.19	7.45	0.38
EP	kg PO4 eq.	**9.01**	4.55	3.28	- 0.13	0.34	0.25	0.25	0.39	0.07

Finished Broiler (for a FU)

Impact category	Unit	Total	Broiler Feed (+ drinking water)	Breeder Hen	Lorries	Electricity	Gas	Water	Bedding
Energy Use	MJ eq.	**11,746.23**	10,175.35	979.92	83.43	501.79	1.68	1.19	2.87
GWP	kg CO2 eq.	**2,028.55**	1,823.45	161.61	5.37	37.72	0.09	0.11	0.20
AP	kg SO2 eq.	**16.09**	14.56	1.37	0.03	0.13	0.00	0.00	0.00
EP	kg PO4 eq.	**9.86**	9.01	0.80	0.01	0.04	0.00	0.00	0.00

Land Application (for a FU)

Impact category	Unit	Total	Emissions	Lorry	Fertiliser Credit
Energy Use	MJ eq.	**-3,441.82**	0.00	158.68	-3,600.50
GWP	kg CO_2 eq.	**-624.47**	30.70	10.73	-665.90
AP	kg SO_2 eq.	**2.54**	4.51	0.04	-2.01
EP	kg PO_4 eq.	**1.08**	1.39	0.01	-0.33

Total Impacts (for a FU)

Impact category	Unit	TOTAL
Energy Use	MJ eq.	**8,304.41**
GWP	kg CO_2 eq.	**1,404.08**
AP	kg SO_2 eq.	**18.63**
EP	kg PO_4 eq.	**10.94**

Survey of Poultry Production Systems in Malaysia

-to estimate the willingness to pay for favourable environmental quality

School of Agriculture, Food
and Rural Development
Newcastle University, United Kingdom

June-July 2011

Consumer | | | |

Objective of the Survey

To estimate the Willingness to Pay for favourable environmental quality

General

I would like you to look and read several statements below as an introduction to questions about environmental issues in our country. The statements contain a principle, status and information on sources of the environmental problems.

The management and conservation of the environment in our country is implemented within the context of sustainable development, which consists of three pillars, namely economic development, social development and environment protection.

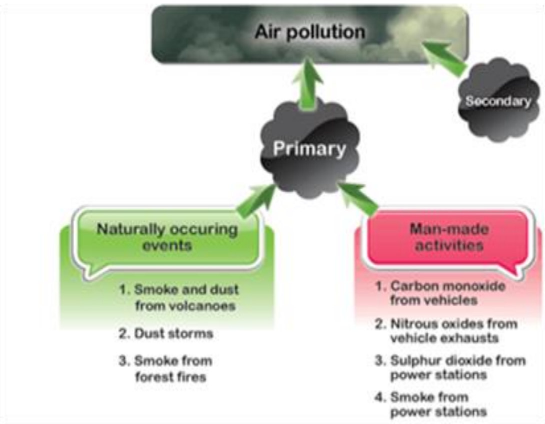
Over the last five decades, our country has undergone rapid economic, social and environmental change, a process which is still continuing. The demanding efforts of socio-economic progress have been accompanied by increasing negative impacts in the natural environment. In parallel to this, the Government has plans to address emerging environmental problems through several policies and action plans.

*Three major types of pollution are **waste, water and air**. **Waste and water pollution** occurs when toxic substances enter lakes, streams, rivers and other water bodies. The substances are dissolved into the water. The effects of water pollution are not only devastating to people but also fish, and other parts of the ecosystem. Polluted water is unsuitable for drinking, recreation, agriculture and industry. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability. Ultimately, it is a hazard to human health. Today, many people dump their garbage into streams and rivers which* *make water bodies the final resting place of cans, bottles, plastics and other household waste.*

Air pollution *results from a variety of causes of which some is beyond human control. Air pollution can cause health problems, damage the environment and has already caused thinning of the protective ozone layer of the atmosphere thereby adding to the climate change phenomenon. Industries, vehicles, increase in population, agriculture and urbanization are some of the major factors responsible for air pollution. Examples of major air pollutants are carbon monoxide, carbon dioxide and chlorofluorocarbons.*

Environmental Pollution

Air pollution



Water pollution

Waste pollution

1. What do you understand about environmental pollution?

1. Understand: *(Tick all that apply)*

1. Type of pollutions	☐	4. Source of pollutions	☐
2. Concept of pollutions	☐	5. Impacts of the pollutions	☐
3. Lifecycle of pollutions	☐		

2. Do not understand

Please give reason(s): --

----

2. Below is the list of economic activities in our country. Please state the ranking of sectors which you think contributes the most significant negative effects to our environment, from the greatest (as #1) to the least important sectors (as #2 until #6).

1. Manufacturing	☐	4. Construction	☐
2. Transportation	☐	5. Chemical	☐
3. Agriculture	☐	6. Mining	☐

3. In your opinion, is the progress of economic development in our country in line with efforts to prevent environmental degradation?

1. Yes ☐   2. No ☐

A statement below contains information specifically on National Policy on the Environment.

As mentioned in the introductory statement above, our country has formulated several policies such as National Policy on the Environment which provide guidance to all government agencies, the industrial sector, local communities and other stakeholders in ensuring the environment is clean, safe, healthy and productive.

There are eight inter-related principles in the Policy which aims at continued economic, social and cultural progress besides enhancement of the quality life of its people, through environmentally sound and sustainable development. The principle of ***sustainable use of natural resources*** *is directly related to the agriculture sector. At a macro perspective level, the principle is aimed to manage natural resource utilisation in a sustainable way and to prevent degradation of the environment.*

The Concept Of Sustainability

4. Some national goals are more important to people than others. Based on the information above, how important to you personally is the national goal on protecting nature and controlling pollution?

   1. Very important ☐
   2. Somewhat important ☐ → go to Q5
   3. Not very important ☐ → skip to Q6
   4. Do not know ☐

5. You said the national goal of protecting nature and controlling pollution is 'very important' to you. Which level of priority is very important for you? Please select one.

Less Priority ◯1 ◯2 ◯3 ◯4 ◯5 Very top priority

I will go into detail about environmental quality in **Section C.**

Section A: Background Information

The following questions ask for some information about you to help us to classify the results of our survey. Your answers will be treated as **STRICTLY CONFIDENTIAL** and individual persons cannot be identified in the result of the study.

6. Are you: Male: ☐
   Female: ☐

7. Date of Birth: ☐☐ ☐☐ ☐☐

8. What was the last grade of regular school that you completed?

   1. Secondary school ☐
   2. Tertiary level ☐
   3. Refused ☐

9. What is your occupation? (i.e. the one that accounts for more than half your work time). If retired or unemployed, please state your previous occupation. Please describe your occupation as fully as possible.

----

10. To the best of your knowledge, what was your total household income last year before taxes?

1. Under RM 15,000 ☐
2. RM 15,001 – RM 31,000 ☐
3. RM 31,001 – RM 40,000 ☐
4. RM 40,001 – RM 65,000 ☐
5. Above RM 65,000 ☐
6. Don't Know ☐
7. Refused ☐

Please give the following information about where you live:

11. Name of District: ---------------------------

12. Name of State: ---------------------------

Section B: Household Status, Chicken Meat Consumption and Purchasing Pattern

13. How many people – both children and adults live in your household including you?

1. Children ☐
2. Adults ☐
3. Total ☐

14. How often do you or/and your household eat chicken meat per week?

1. Everyday ☐
2. 3- 6 times/week ☐
3. Less than 3 times/week ☐
4. Don't Know ☐

15. How much chicken meat do you and/or your household consume every week?

---------------- kg/week

16. How important do you think chicken meat is for you/your household's food consumption? Please select one

Not important ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 extremely important

17. Can you tell me more about the type of chicken meat that you buy? Please give a ranking on various factors which normally people use when they select food items. Please start with *#1* for the most important factor to the less important sectors (*as #2 until #6*) when you purchase chicken meat?

1. Quality : *Appearance, texture and freshness* ☐
2. Convenience: *Availability, ease of preparation* ☐
3. Price ☐
4. Nutritive value: *Nutrient content, calorific value* ☐
5. Safety : *Free from disease* ☐
6. Ethics : *Welfare issue, production method used* ☐

If respondents choose 'Price" as the most important factor (i.e. #1), please go to Q 18. Others go to Q20.

18. If there is a kind of chicken meat which is cheap and tasty but low quality, will you buy it?

1. Yes ☐ → skip to Q 20
2. No ☐ → go to Q 19

19. You said **NO** for Q18. This means, there are different factors other than price which are important factors for you when purchasing chicken meat. Please state your reasons, starting with your highest ranking item as #1, moving through to your lowest ranking item.

1. Price is the most important decision ☐
2. Criteria of price is always in mind, but quality must fit the price, and vice versa ☐
3. Satisfaction on certain factors such as taste and nutritive value must also be accommodated. Price may take 70% in mind ☐
4. Price is vital but not decisive ☐
5. Other, please specify ------------------------------

SECTION C: Environmental Quality Level

Because of growing environment pollution problems nationwide, the Government has formulated policy in an effort to provide guidelines in order to overcome and improve the situations described previously in Question 4. Quality of Environmental Index (QEI) in Malaysia can be classified into 2 elements, namely water and air. QEI is highly related and indicates the Quality Life Index level for our country.

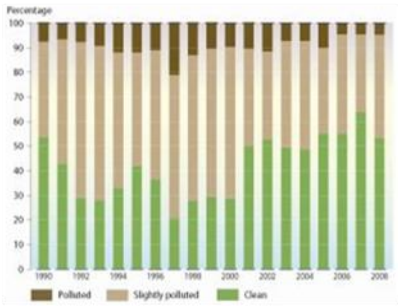
*i)**Water:** The quality of water, which is reflected by the percentage of clean rivers as classified by the Water Quality Index. It is measured in terms of organisms, gaseous, safety level and particles in the water. These measurements are consolidated into an overall water quality index which has 4 categories:*

- *Class 1- water can be drunk without treatment*
- *Class 2 – water requires normal treatment,*

- *Class 3 – the water seems clean but the quality is polluted; Public cannot swim in such water but can do some activities at the edge of rivers.*
- *Class 4 – Contaminated water and likely to result in poison for those who drink it (bad smell and black in colour)*

*ii) **Air:** Air Pollutant Index (API) is used to measure air quality and was developed based on scientific assessment to indicate the level of pollutants. Air pollutants include haze (smoke from forest fires), dust, pollen and gaseous emissions from organic waste. API is divided into five categories namely Good (0-50), Moderate (51-100), Unhealthy (102-200), Very Unhealthy (201-300) and Hazardous (>301).*

i. Water quality : River



i. The status of river basins in Malaysia

ii. Contaminated water

iii. Require normal treatment

ii. Air quality : Haze

Haze in Kuala Lumpur (mid-day)

A clear evening after the haze in Kuala Lumpur

For a better understanding of the issue of air pollution, haze has been used as an indicator of API due to its significant importance not only to human health but also to our economy. API can influence peoples' horizontal *visibility distance. There are five classes of haze thickness which are related and influence the public's ability to see. Below are categories of haze thickness with horizontal visibility used in our country:*

Haze Thickness (Metres)	***Horizontal visibility***
Extremely thick	*<500*
Very thick	*500 -2000*
Medium thickness	*2000 - 5000*
Less thick	*5000 - 10000*
Clear	*>10000*

As we read the above statements, I hope you have thought about the quality of water bodies and air in your area. What do you think is the index for both resources in your area?

20. Water:
    1. Class 1 ☐
    2. Class 2 ☐
    3. Class 3 ☐
    4. Class 4 ☐
    5. Do Not Know ☐

21. Air:
    1. Extremely thick ☐
    2. Very thick ☐
    3. Medium thickness ☐
    4. Less thick ☐
    5. Clear ☐
    6. Do Not Know ☐

22. Please give your opinion on the above indicators and specifically whether it is easy to understand and use them, and thus, to increase the level of public awareness about environmental issues?
    1. Easy ☐
    2. Difficult ☐

After we read and understand the general situation of environmental pollution, from now on, I would like to focus on environmental pollution arising from poultry production.

Poultry production also contributes significant effects to environmental quality if the production is not implemented according to the best practice. Poultry production has changed from small flocks to large scale intensive production which has resulted in an increased potential for emission of pollutants. These pollutants are emitted from the production sites, manure storage as well as importation of animal feed.

The competition for land use for other activities such as residential and industrial has increased and, as a result, the land availability for agricultural activities has become scare. ***The volume of manure*** *generated especially from intensive production may become a major obstacle if it is not properly managed and controlled. Several kinds of pollutants from poultry manure have negative effects on natural resources, such as ammonia and nitrous oxide to the air and nitrate into water.*

From production site*, the emission of pollutants such as ammonia and nitrous oxide gaseous are emitted from the poultry house. Factors such as good location with a good water source and a well-insulated building equipped with proper ventilation, heating, lighting, feeding and watering systems are the basic requirements in all types of poultry house and will determine the amount of gaseous pollutants.*

*Besides that****, importation of poultry feed*** *which accounts for 85% of total feed ingredients also contribute to pollution through the release of* CO_2 *to the atmosphere from fuel consumption due to ocean freight.*

23. Based on the above statements, to the best of your knowledge, please indicate the ranking from the greatest to the least contributor to pollution from poultry production (*as #1*) to the less important factor (*as #2 and #3*)?

1. Production of birds (including housing system) ☐
2. Manure management ☐
3. Production of feed (including growing crops) ☐

24. To the best of your knowledge, do you realise that animal production in general can contribute a significant proportion of environmental pollution?

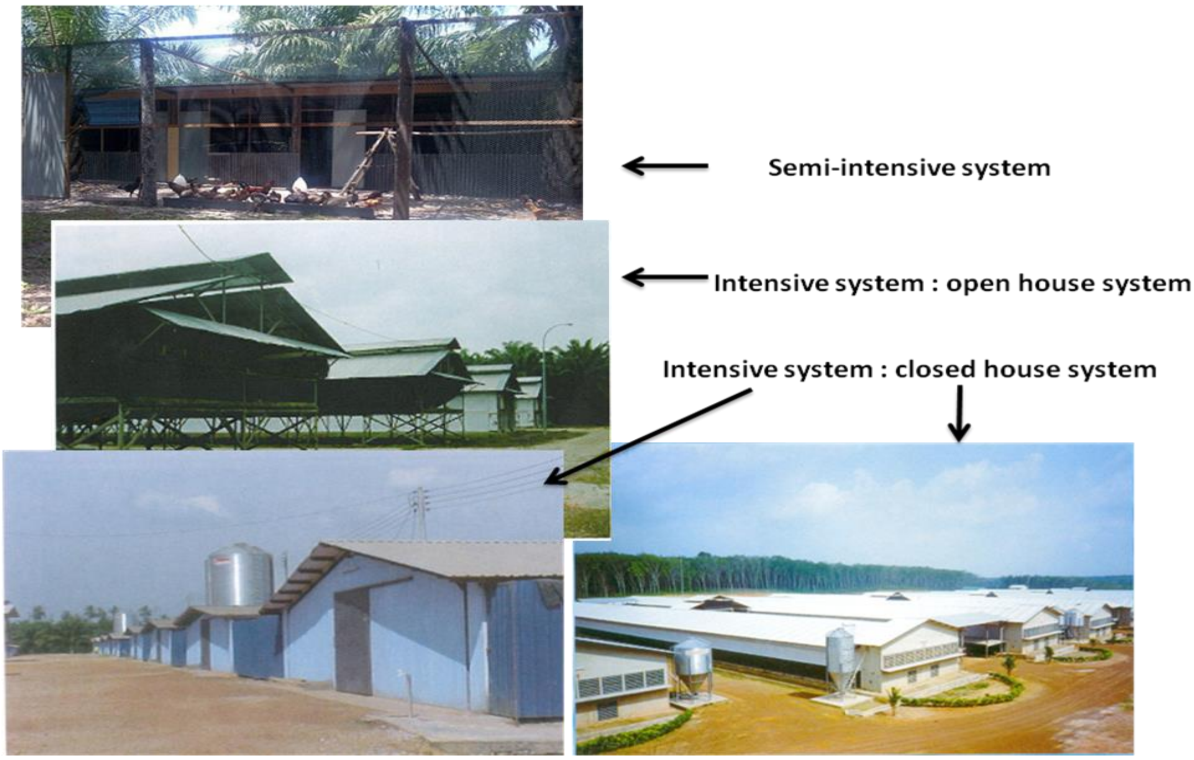
1. Yes ☐ 2. No ☐

Section D: Environmental Quality Valuation

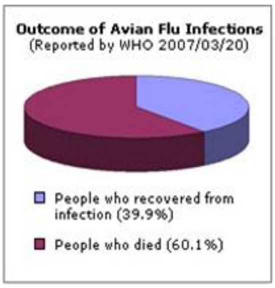
Statistics show that the production of chicken meat has increased due to demand from people for consumption as well as for the food processing industry. From 1998 until 2007, per-capita consumption of poultry meat has increased by 2.25% per year reaching 30.28 kg/person/year. This situation has led to an expansion of the area used for poultry production. The current supply of production comes from intensive, semi-intensive and extensive systems. At the same time, environmental study has shown that non-intensive systems contribute a significant amount to environmental pollution also known as Environmental Burdens (EBs). Therefore, in order to ensure both objectives, i.e. to increase poultry production without sacrificing environmental quality, ***<u>the utilization of environmentally friendly production systems such as Closed House Systems should be expanded.</u>***

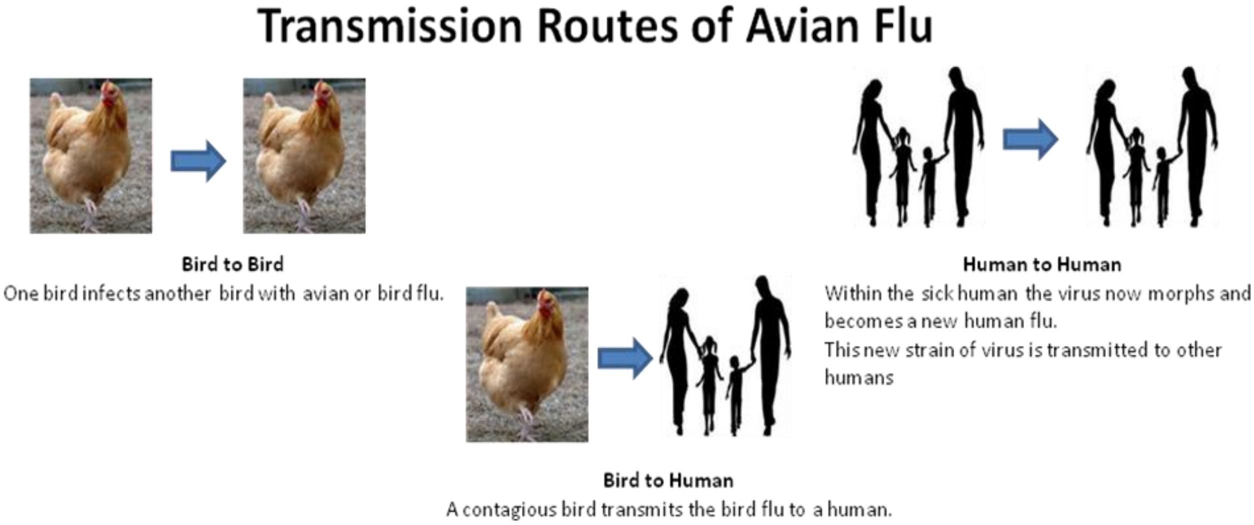
As far as we are aware, the transition from conventional production to modern and environmentally friendly systems will cause an increase in the cost of poultry production ***BUT*** *for long term benefits, we will be able to secure both above objectives. Therefore,* ***<u>to ease this situation</u>****, you and* *your household as consumers can contribute through willingness to buy the product with higher price than current sale price. Once production becomes stable, the market price will adjust accordingly depending on supply and demand.*

To remind you, our target for Quality of Life Index is ***at least*** *to live in Class 2 for the Water Quality Index and Moderate Quality (medium thickness and less of haze) for the Air Pollutant Index.*



25. Please refer to photos provided which show the occurrence of new and existing diseases in poultry which can transmit disease to humans such as Avian Influenza-Highly Pathogenic (HPAI), ***<u>which started from backyard flocks and non-systematic housing systems.</u>*** This disease has a sporadic occurrence; therefore, the best approach to avoid outbreaks is through the improvement of production techniques. Human deaths associated with HPAI result from direct exposure to infected birds on farm or in markets.





What is your opinion on the importance of this scenario to your household consumption and healthy status?

Not important ◯1 ◯2 ◯3 ◯4 ◯5 extremely important

26. Using intensive systems such as closed house systems, issues of air and water pollution can be reduced. Many producers use lime and sawdust to reduce odours. In addition, there is increasing use of Effective Micro-organism (EM). EM has been used as a treatment for the manure and feed to boost the health of chicken, improve feed conversion (FCR) and eliminate ammonia and odours in the house.

EM changes protein in poultry feed into smaller molecules that are easily absorbed by the digestive system and so reduce the protein content in manure. This will increase FCR and weight of the chicken. With EM, the smell from manure will be reduced and the problem of flies is diminished.

However, EM treatment ***can only be implemented effectively in properly controlled environment housing systems***. Such Research & Development will give great positive impacts not only to industry but also to people through good environmental quality.

Manure Handling in Closed House System

Do you agree that ***controlled environment housing systems such as Closed House System*** will increase the quality of the environment as well as economic expectation?

1. Yes ☐ 2. No ☐

27. From the aspect of well-being, to achieve our target in Quality Life Index, these two pictures show us the potential impacts from poultry production systems to our environmental quality especially from ***poor manure handling*** which can lead to eutrophication. Eutrophication is a process of over-enrichment by mineral nutrients (i.e. phosphorus and nitrogen) of surface waters resulting from animal feed and manure.

The type of manure handling is greatly influenced ***by the design of housing system.*** Manure handling technique can poses significant environmental burdens for both air and water qualities.

Picture A

Lake Kenyir, Malaysia.

Picture B

Algal bloom in Orielton Lagoon, Australia.

Picture A represents a good quality of water body which can be used at least for recreation and family activities. **Picture B** represents the condition of water which is contaminated due to a high amount of nitrate dissolved into water.

From the above statement, how important is ***good practice in poultry production through the appropriate selection of housing system*** in avoiding those potential pollutions?

Not important ◯1 ◯2 ◯3 ◯4 ◯5 extremely important

28. Based on your concern and information from Q24 – Q26, what is the **MAXIMUM AMOUNT OF MONEY** that you or your household are willing to pay (WTP) compared to the existing sale price for chicken meat, **as your contribution to favourable environmental quality to society?**

1. RM ---------------------------- OR
   Extra percentage from current sale price ----------- %
2. Zero or nothing ☐ → go to Q 29
3. Do Not Know ☐

If respondent choose #1, go to #33

29. People have different reasons for saying Zero or Nothing, Do Not Know or Cannot Answer the question. I am going to read you some reasons. Please tell me whether or not they represent your feelings about your response.

Did you give this answer because you consider that you/your household is already paying too much for chicken meat and so do not want to spend more?

1. Yes ☐ → go to Q 30
2. No ☐
3. Do Not Know ☐ → skip to Q 33

If respondent choose #2 and 3, go to #33

30. What do you mean by 'paying too much'?

1. Do not have more money to spend on chicken meat ☐
2. Intend to spend the money on something else which is more important ☐

If respondent choose #1, go to #33

31. You said that you intend to use your excess money for other purposes. Can you state three preferences of how you intend to spend the money according to your priorities?

1. --------------------------------

2. -------------------------------

3. -------------------------------

If the respondent answered one of the priorities is related to environmental protection such as visiting historical places or buying items from recycled materials as a main component, then go to Q32. If not, proceed to Q33.

32. You said that you and/or your household has paid high price for chicken. At the same time, you indicated that you want to spend the extra money you have on something related to environmental pollution protection item. It is important to us to learn what is the **MAXIMUM VALUE YOU PLACE** in achieving our goal in environmental protection in general when you are given a chance to make the choice yourself.

RM -------------- **OR** Extra percentage from normal price ----------- %

33. Did you give this answer because you think the Government should be able to meet this target with the money they have?

1. Yes ☐ 2. No ☐

ACKNOWLEDGEMENTS

Thank you for taking your time to complete this questionnaire. The information you have given will help us to learn about the value of the environmental pollution in Malaysia.

Use the space below to provide additional comments you would like to tell us about your interest in protecting environmental quality from a poultry production point of view.

…………………………………………………………………………………

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Should you have any further questions or concerns about this survey, please contact Noraisah Spahat at noraisah.spahat@newcastle .ac.uk

	NEW PARAMETER	STEP
1	**Recode WTP**	WTP1 >> Transform >> Recode into Different variables >> Numeric Variable (WTP1) >> Output Variable (Recode WTP1) >> >> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = with value; 2 = zero/ nothing; 3 = Do Not Know New Values: 1 = with value; 0 = Do Not now
2	**Recode type**	Type of Pollution >> Transform >> Recode into Different variables >> Numeric Variable (Type) >> Output Variable (Recode Type) >> >> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Understand; 2 = Do Not Understand New Values: 1 = Understand; 0 = Do Not Understand
3	**Recode concept**	Concept of Pollution >> Transform >> Recode into Different variables >> Numeric Variable (Concept) >> Output Variable (Recode Concept) >> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Understand; 2 = Do Not Understand New Values: 1 = Understand; 0 = Do Not Understand
4	**Recode LC**	Lifecycle of Pollution >> Transform >> Recode into Different variables >> Numeric Variable (Lifecycle) >> Output Variable (Recode Lifecycle) >>>> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Understand; 2 = Do Not Understand New Values: 1 = Understand; 0 = Do Not Understand
5	**Recode source**	Type of Source >> Transform >> Recode into Different variables >> Numeric Variable (Source) >> Output Variable (Recode Source) >>>> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Understand; 2 = Do Not Understand New Values: 1 = Understand; 0 = Do Not Understand

6	**Recode impact**	Impact of Pollution >> Transform >> Recode into Different variables >> Numeric Variable (Impact) >> Output Variable (Recode Impact) >>>> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Understand; 2 = Do Not Understand New Values: 1 = Understand; 0 = Do Not Understand
7	**Score Understanding (score)**	Transform >> Compute Variable >> Target variable (Score Understanding) >> >> Numeric Expression (Recode Type + Recode Concept + Recode Life cycle + Recode Source + Recode Impact) >> OK
8	**Average Understanding1 (score)**	Transform >> Compute Variable >> Target variable (Average Understanding) >> >> Numeric Expression ((Recode Type + Recode Concept + Recode Life cycle + Recode Source + Recode Impact)/5) >> OK
9	**Average Understanding2 (categorical)**	Manually : based on decimal principle
10	**Recode EM**	EM >> Transform >> Recode into Different variables >> Numeric Variable (EM) >> Output Variable (Recode EM) >> >> Old (1) and New Values (1) >>Old (2) and New Values (0) >> Continue >> OK Old Values : 1 = Yes; 2 = No New Values: 1 = Understand; 0 = Do Not Understand
11	**Recode Diseases**	Diseases >> Transform >> Recode into Different variables >> Numeric Variable (Diseases) >> Output Variable (Recode Diseases) >> >> Old (1) and New Values (0) >>Old (2) and New Values (1) >>Old (3) and New Values (2) >>Old (4) and New Values (3) >> Old (5) and New Values (4) >>Continue >> OK Old Values : 1 = Not Important; 2 = Less Important; 3 = Important; 4 = Very Important; 5 = Extremely Important New Values: 0 = Not Important; 1 = Less Important; 2 = Important; 3 = Very Important; 4 = Extremely Important
12	**Recode Wellbeing**	Wellbeing>> Transform >> Recode into Different variables >> Numeric Variable (Wellbeing) >> Output Variable (Recode Wellbeing) >>>> Old (1) and New Values (0) >>Old (2) and New Values (1) >> Old (3) and New Values (2) >>Old (4) and New Values (3) >> Old (5) and New Values (4) >>Continue >> OK Old Values : 1 = Not Important; 2 = Less Important; 3 = Important; 4 = Very Important; 5 = Extremely Important New Values: 0 = Not Important; 1 = Less Important; 2 = Important; 3 = Very Important; 4 = Extremely Important

13	**Score environmental impact elements (score)**	Transform >> Compute Variable >> Target variable (Score environmental impacts elements) >> >> Numeric Expression (Recode EM + Recode Diseases + Recode Wellbeing) >> OK
14	**Recode Occupation**	Transform >> Recode into Different variables >> Numeric Variable (Occupation) >> Output Variable (Recode Occupation) >> >> Old (1) and New Values (1) >>Old (2) and New Values (2) >>Old (3) and New Values (2) >>Old (4) and New Values (2) >> Continue >> OK Old Values : 1 = Group A; 2 = Group B; 3 = Group C; 4 = Others New Values : 1 = Group A; 0 = Others

Appendix 5 (i)

Producer | | | |

Objective of the Survey

Investigate potential changes in type of production and their impact to the industry from producers' perspective

Face to face interview (informal) and farm visit

1. Intensive Producers – Closed House System

Section A: Background

The first set of questions asks for some information about your enterprise in order to help us classify the results of our survey. Your answers will be treated as strictly confidential and individual companies will not be identified in the results of the study.

1. How long is your involvement in this business?

-------------------- year(s)

2. Can you give an estimation of the total annual production from your enterprise last year **OR** how many chickens does your enterprise produce per year?

-------------------- tonne / year

-------------------- head / year

3. What kind of chicken breed(s) do you use?

----

4. Have you previously used a different breed?

1. Yes ☐ 2. No ☐

If yes, please give reason(s): --------------------

Please state previous breed/strain used: --------------------

5. What type of feed do you use? (if possible, please provide some information on feed ingredient you used).

----

6. What criteria are used to maintain physical and financial performance and at the same time fulfil social obligation to society? (e.g. profit, environment aspect, welfare). Please list three (3) criteria according to your priorities.

1. --
2. --
3. --

Section B: Environmental Quality Valuation

i) Manure Management

7. How do you dispose of the manure? (You can give more than one method).

If more than one (1) method, then go to Q8.

8. What is the proportionate split between the different disposals methods used in your enterprise?

1. ------------------------ ☐ %

2. ----------------------- ☐ %

3. ------------------------ ☐ %

9. Did you use any type of treatment(s) to the manure to boost the health of your poultry and/or eliminate ammonia and odours in the house or in the environment?

1. Yes ☐ 2. No ☐

If yes, please specify what treatment(s) are used -----------------------------

10. Is it difficult to get supply of this treatment(s)?

1. Yes ☐ 2. No ☐

If yes, please state what are the difficulties in obtaining/applying these treatments.

----

11. From where are these treatments are usually obtained?

1. Private ☐ 2. Government Agency ☐

3. Others (*please specify*): ------------------

12. Are there any additional processes applied to the manure before it is sold?

1. Yes ☐ 2. No ☐

If yes, please specify --

13. Are you satisfied with the current method(s) of manure disposal used?

1. Yes ☐ 2. No ☐

If No, please give reason(s): ---

14. You said that you are satisfied with the method you are using now and I believe this method(s) has provided good returns for your company. Can you give some indication to the profit ratio between primary production (i.e. broiler chicken) and manure?

Broiler chicken: Manure = ------- %: ------- %

15. Are there any difficulties in finding buyers for the manure?

1. Yes ☐ 2. No ☐

16. What are the arrangement(s) between you and the buyer?

i. Long term /short term buyer : -------------------------

ii. Price : RM ------------------ / tonne

17. Are you aware of the potential negative effects of poultry manure on the environment?

1. Yes ☐ 2. No ☐

18. Have you attended any training or workshops related to the potential for environmental pollution from poultry production?

1. Yes ☐ 2. No ☐

ii) Production System

Besides manure handling, good house management is also considered as a fundamental factor in the poultry industry. Below are a few questions related to housing system management.

19. What type of poultry housing systems are you using in your enterprise?

1. Semi-intensive ☐
2. Intensive (closed house) ☐
3. Intensive (open house) ☐
4. Mixture ☐

Intensive System (Closed House)

Closed house system provides a comfortable environment by controlling internal temperature. With a comfortable environment, productivity can be optimized. By using closed house system, the space requirements of a chicken can be reduced by one third compared to the open house. In addition, costs of production become more efficient by reduced disease outbreak and increased efficiency in food conversion ratio (i.e. reduced FCR). The market opportunities also increased due to quality products.

20. Do you agree above mentioned factors lead you sustain in this industry, making some profit and achieve your business objectives?

1. Yes ☐
2. No ☐

If No, please specify the reason(s) -------------------------------------

21. Apart from all the benefits mentioned in the above statement, do you consider to be the other main challenges in using closed house systems?

----

22. Is the capacity of your broiler production facility today the same as it was at the beginning of your involvement in poultry industry?

1. Yes ☐ 2. No ☐

If no, please specify (whether increase or decrease) --------------------------------
If increase, then go to Q23.

23. How many additional houses are required to accommodate the increased number of chickens?

----

24. Are you satisfied with the cooperation received from the Integrator (in terms of quality of DOC, feed, marketing and technical assistant).

1. Yes ☐ 2. No ☐

If No, please specify --

25. Does the integrator provide any specific guidance to minimise environmental impact (e.g. satisfactory manure storage & handling)?

1. Yes ☐ 2. No ☐

If No, please specify --

26. Estimation of cost of production vs. net profit shows that feed contributes 85-88% of the total cost of production in intensive systems. Apart from this, the cost of vaccinations, medicines and electricity are also relatively high, i.e. 25% of the variable cost component. How do you view this scenario in order to enhance your business profitability?

____

27. As we are aware, this sector is capital intensive, thus are you facing any difficulties in obtaining financial assistance, especially to cover the construction costs for the house and barn equipment from financial institutions such as AgroBank, MARA or PUNB?

1. Yes ☐ 2. No ☐

If yes, please specify ---

28. Based on your experience, what aspects should the Government seriously look into to ensure this sector continues to survive and to attract more entrepreneurs to participate? Please give the three most important aspects?

1. --------------------------------------
2. --------------------------------------
3. --------------------------------------

29. Do you receive any financial support from financial institutions or gain any incentive from the Government?

1. Yes ☐ 2. No ☐

If yes, please specify --

30. Are you aware that the Government has provided several incentive schemes for selected agriculture production including poultry production?

1. Yes ☐
2. No ☐

Appendix 5(ii)

Producer | | | |

Objective of the Survey

Investigate potential changes in type of production and their impact to the industry from producers' perspective

Face to face interview (informal) and farm visit

2. Intensive Producers – Open House System

Section A: Background

The first set of questions asks for some information about your enterprise in order to help us classify the results of our survey. Your answers will be treated as strictly confidential and individual companies will not be identified in the results of the study.

1. How long is your involvement in this business?

    _________________ year(s)

2. Can you give an estimation of the total annual production from your enterprise last year **OR** how many chickens does your enterprise produce per year?

    ------------------------ tonne / year

    ----------------------------- head / year

3. What kind of chicken breed(s) do you use?

    ----

4. Have you previously used a different breed?

1. Yes ☐ 2. No ☐

If yes, please give reason(s): --------------------------------

Please state previous breed/strain used: ----------------------------

5. What type of feed do you use? (if possible, please provide some information on feed ingredient you used).

----

6. What criteria are used to maintain physical and financial performance and at the same time fulfil social obligation to society? (e.g. profit, environment aspect, welfare). Please list three (3) criteria according to your priorities.

Section B: Environmental Quality Valuation

iii) Manure Management

7. How do you dispose of the manure? (You can give more than one method).

If more than one (1) method, then go to Q8.

8. What is the proportionate split between the different disposals methods used in your enterprise?

------------------------ ☐ %
------------------------ ☐ %
------------------------ ☐ %

9. Did you use any type of treatment(s) to the manure to boost the health of your poultry and/or eliminate ammonia and odours in the house or in the environment?

1. Yes ☐ 2. No ☐

If yes, please specify what treatment(s) are used -----------------------------

10. Is it difficult to get supply of this treatment(s)?

1. Yes ☐ 2. No ☐

If yes, please state what are the difficulties in obtaining/applying these treatments.

----

11. From where are these treatments are usually obtained?

1. Private ☐ 2. Government Agency ☐

3. Others (*please specify*): -------------------

12. Are there any additional processes applied to the manure before it is sold?

1. Yes ☐ 2. No ☐

If yes, please specify ---

13. Are you satisfied with the current method(s) of manure disposal used?

1. Yes ☐ 2. No ☐

If No, please give reason(s): --

14. You said that you are satisfied with the method you are using now and I believe this method(s) has provided good returns for your company. Can you give some indication to the profit ratio between primary production (i.e. broiler chicken) and manure?

Broiler chicken: Manure = ------- %: ------- %

15. Are there any difficulties in finding buyers for the manure?

1. Yes ☐ 2. No ☐

16. What are the arrangement(s) between you and the buyer?

i. Long term /short term buyer : --------------------------

ii. Price : RM -------------------/ tonne

17. Are you aware of the potential negative effects of poultry manure on the environment?

1. Yes ☐ 2. No ☐

18. Have you attended any training or workshops related to the potential for environmental pollution from poultry production?

1. Yes ☐ 2. No ☐

iv) Production System

Besides manure handling, good house management is also considered as a fundamental factor in the poultry industry. Below are a few questions related to housing system management.

19. What type of poultry housing systems are you using in your enterprise?

3. Semi-intensive	☐	3. Intensive (open house)	☐
4. Intensive (closed house)	☐	4. Mixture	☐

Intensive System (Open House)

20. For X year(s), what is your satisfaction on this business especially in term of productivity and returns?

----

21. What is your opinion on the type of housing system you are using now (i.e. whether it has achieved your business objectives)?

----

22. Is the capacity of your broiler production facility today the same as it was at the beginning of your involvement in poultry industry?

1. Yes ☐ 2. No ☐

If no, please specify (whether increase or decrease) --------------------------------

If increase, then go to Q23 & Q24.

23. What is the percentage of increase in the number of day old chicks (DOC) today compared to the beginning of your involvement in the poultry industry / last 5 years?

----

24. How many additional houses are required to accommodate the increased number of chickens?

I would like to share with you some information on some costs and potential profit of another type of housing system, called the closed house system. Maybe you have heard and with this information, it might give you a different perspective as you plan your business.

Based on the calculation of costs of production and estimated profits for large scale production, it clearly shows that the net profit for the chicken and its manure from closed house system is higher than open house system, at 3% and 13% respectively. The higher amount of manure is due to lower mortality rate in closed house system which is only 3.5%, compared to 6% in open house systems.

The difference in terms of cost is considered low; i.e. around 6%. However the difference of overall net profit is 32% between these systems. At the same time, research has shown that, environmental friendly system such as closed house system will be able to reduce pollution values compared to conventional systems.

25. Based on the above estimations of profit and environmental benefit, and assuming that you have adequate financial resources and support, do you have any plan to transform the production system to closed house system?

1. Yes ☐ 2. No ☐

If yes, go to Q26. If no, then go to Q28.

26. If you chose to transform the production system, what is the most important factor(s) that inspire your business to change the production system?

----

27. What do you think is the most important challenge to transform the production system?

----

28. Can you tell me the reason you want to maintain the current housing system even though you are aware of the potential of other systems to generate more profit for your business.

----

29. With the increasing demand for chicken meat, especially for the processing industry and a consistent demand for the manure, BUT at the same time, challenges such as increasing input prices and the risk of outbreak of the unexpected diseases, how do you see your involvement in this industry in the future?

----

30. Do you receive any financial support from financial institutions or gain any incentive from the Government?

1. Yes ☐ 2. No ☐

If yes, please specify ---

31. Are you aware that the Government has provided several incentive schemes for selected agriculture production including poultry production?

Yes ☐
No ☐

ACKNOWLEDGEMENTS

Thank you for taking your time to complete this questionnaire. The information you have given will help us to learn about the value of the environmental pollution in Malaysia.

Use the space below to provide additional comments you would like to tell us about your interest in protecting environmental quality from a poultry production point of view.

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Should you have any further questions or concerns about this survey, please contact Noraisah Spahat at noraisah.spahat@newcastle .ac.uk

Appendix 6

Integrator Company	Position	Venue	Date
Dindings Breeder Farm Sdn. Bhd.	Marketing Manger	FLFAM, Selangor	1st April 2013 (morning session)
Ayamas/KFC Breeder Farm Sdn. Bhd.	Operation Manger	FLFAM, Selangor	1st April 2013 (evening session)
Leong Hup Poultry Farm Sdn. Bhd.	Corporate Affairs Manager	Leong Hup Headquarters, Kuala Lumpur	23rd April 2013
CAB Breeding Farm Sdn. Bhd.	Business Development Manager	FLFAM, Selangor	18th April 2013
Charoen Pokhphand Farm Sdn. Bhd.	Assistant Vice President	FLFAM, Selangor	1st April 2013 (noon session)
Goldkist Sdn. Bhd.	Marketing Manger	FLFAM, Selangor	1st April 2013 (morning session)

** FLFAM: The Federation of Livestock Farmers' Associations of Malaysia*

Appendix 7

Integrator | | | |

Objective of the Survey

To investigate integrator roles and contribution towards the objective of promoting sustainable broiler production

A. General Aspects of Broiler Chicken Production

1. What are the major challenges currently facing the broiler industry in Malaysia?

----

2. What are the main costs involved in production of broiler chickens?

----

3. What is the basis of the agreement between your company and the producers who rear broiler chickens for you? (e.g. is it simply an informal agreement, or is there a year-long contract?)

----

4. What are the criteria upon which you select potential new broiler producers?

----

5. Do you face any challenges/problems in dealing with the producers? If yes, please give some details of the most prominent problems.

B. Specific Housing Systems

6. Do you have a preference for a particular type of housing system? (e.g. open house or closed house). If yes, please give your reasons.

----

7. As a company do you take any measures to minimize the environmental impacts from broiler chicken production?

----

8. Do you provide any additional advice to the producers to help them minimise the environmental impact of broiler production? If yes, please provide more details of the nature of this advice.

----

9. Do you think that it would cost more to produce broiler chickens with a lower environmental impact? If yes, please explain why

----

C. Future of Broiler Production

11. How do you view the future for the broiler chicken industry in Malaysia?

----

12. How do you think environmental regulations and animal welfare issues might influence the broiler industry in Malaysia?

----

13. Do you think that consumers in Malaysia (or a proportion of consumers) might be interested to purchase chicken meat with a particular additional marketing feature, such as higher welfare birds produced with access to outdoor pasture as has been developed in some European countries?

----

14. Do you think that consumers in Malaysia are interested in the environmental impacts of broiler chicken production?

If yes, do you think they would be willing to pay extra for this?

----

15. If your company was to take step to reduce environmental impact which lead to an increased in your cost of production, do you think this might impact on the competitiveness of your products and the ability to penetrate export market? If yes, please explain.

----

16. If you had the opportunity to change an aspect of the broiler industry, which area do you think is most important?

----

17. Do you think that the Government provides sufficient assistance to promote development of the broiler industry, particularly through improvement of housing system practices and effectiveness of implementation along the production chain? If yes, please specify.

----

18. Do you think that the Government provides sufficient assistance to promote effective manure handling strategies to reduce environmental impact? If yes, please specify.

----

19. Are there any issues related to broiler production that you want the Government to improve? If yes, please specify.

ACKNOWLEDGEMENTS

Thank you for taking your time to complete this questionnaire. The information you have given will help us to learn about the value of the environmental pollution in Malaysia.

Use the space below to provide additional comments you would like to tell us about your interest in protecting environmental quality from a poultry production point of view.

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Should you have any further questions or concerns about this survey, please contact Noraisah Spahat at noraisah.spahat@newcastle.ac.uk

Appendix 8

Ministry/Central Agency/Department	Position	Venue	Date
Major Ministry, Central Agency and Departments involved in Livestock/Poultry Policy*			
1. Ministry of Agriculture and Agro-based Industry (MOA)	i. Undersecretary Strategic Planning and International Division ii. Undersecretary Investment Promotion, Business Development and Privatisation Division	MOA, Putrajaya	12 August 2011
2. Economic Planning Unit, Prime Minister Department	i. Deputy Director Regional Development Division ii. Principle Assistant Director Environmental Economic Division	EPU, Putrajaya	16 August 2011
3. Department of Veterinary Services	i. Director Livestock Development Division ii. Head of Section Poultry Development Section	DVS, Putrajaya	15 August 2011
4. Malaysian Agricultural Research and Development Institute (MARDI)	i. Deputy Director Centre of Strategic Research of Livestock ii. Deputy Director Economic Research and Technology Management Division	MARDI, Selangor	22 August 2011

Supporting Departments*			
5. Department of Statistic Malaysia (DOS)	i. Deputy Director Prices, Income and Expenditure Statistics Division ii. Deputy Director Population and Demographic Statistics Division	DOS, Putrajaya	15 August 2011
6. Federal Agriculture Marketing Authority (FAMA)	i. Head of Analysis Section Marketing Information Division	FAMA, Selangor	25 August 2011

** All appointments have been scheduled and agreed upon prior to three months of data collection in Malaysia (June-August 2011)*

Appendix 9

Government Agency | | | |

Objective of the Survey

To investigate the Government roles and contribution towards the objective of promoting sustainable broiler production

A. Information From EPU

1. What is the role of your agency in maintaining a good environment for the public?

One of the policy thrusts in the 10th Malaysia Plan (MP) is Valuing Environmental Endowment. The main idea under this strategy is to ensure that the treasures we have now will not be affected by rapid development projects and that our natural resources have a proper value. Setting the value of the resources too low will result in excessive use and therefore this is sustainable. At the same time, we realise that there are potentials benefits that can be obtained from the resources and this can encourage people to conserve it.

2. From the above statement, can you give some examples of programs in which the government has been able to give a proper value to the natural resources?

----

3. To ensure this approach can achieve the target, I suggest that this policy thrust must be complimented with an action plan. How much financial support does the Government give (in the form of incentives or 'soft loans' from financial institutions) for these programmes?

RM -------------------

Please specify: ----------------------------

4. Can you tell me the increment of budget allocation for the same objective as compared to the 9th MP?

-------- %

5. From the macro figure of budget allocation for the 10th MP, what is the percentage of environmental allocation compared to other sectors? Listed below are few sectors as comparison. (*This information is very useful for public references to state their willingness to pay questions*).

Agriculture, Forestry and Fishing	RM ---------- billion / …… %
(Environment)	RM ---------- billion / …… %
Manufacturing	RM ---------- billion / …… %
Services	RM ---------- billion / …… %
(Education)	RM ---------- billion / …… %
Construction	RM ---------- billion / …… %
Mining	RM ---------- billion / …… %

6. Can you give some indication of the level of readiness of people in Malaysia to contribute towards these strategies?

Government Agency | | | |

B. Information From MoA, DVS & MARDI
i) General

We are self-sufficient in meeting the domestic demand for poultry meat with a level of 106% in 2007. Our production value for chicken meat between 1998 and 2007 recorded an increase of 55%, with an annual growth rate of 3.74%. Over this duration, per-capita consumption has increased by 2.25% per year, reaching 30.28 kg/year in 2007. In 2007, the poultry industry was a major contributor to the export value from livestock sector, which was 47.6% of all livestock exported. The value of exports of live chickens and chicken meat was RM375.35 million, equivalent to almost 70,000 tonnes.

7. From the encouraging figures above and the potential for continued growth in this sector, what are the strategic planning arrangements that your Department uses to expand the production?

----

8. How many new broiler integrators have begun operations in the past 5 years?

----

9. What are the roles of your Department in monitoring the integrators' performance?

----

10. From the encouraging figure shown above and the potential to expand broiler production, what is the financial allocation that the Ministry received for further development (include all forms of allocation)?

----

ii) Production Systems

Records show that almost 80% of chicken meat production is obtained from enterprises that use vertical and horizontal integration. At the same time, contract farming for broilers has increased from 1,243 farms in 2000 to 1,855 farms in 2007, whilst over the same period the number of small scale farms has decreased from 1,959 to 1,019.

11. Does the Ministry provide any kind of incentive schemes or financial support that can be offered to producers in order to encourage them to invest in modern and environmental friendly systems?

1. Yes ☐ → *go to Q10*

2. No ☐ → *skip to Q14*

If yes, please specify ---

----

12. If the assistance is in the form of financial incentive, how much expenditure has the Government provided in the past 5 years?

RM -----------------

13. If the assistance is the form of credit from financial institutions, how much disbursement was made in the past 5 years?

RM ------------------

14. You mention that the Government did not provide any form of assistance to achieve the target production. Does the Government have any plan to provide such assistance in the future?

----

iii) Manure Handling

However, the promising development of the poultry meat industry might be taxing to the environment because it is expected that much of this increased production will come from meat produced in intensive systems. Such systems give unavoidable waste products including faeces, urine, respiration and gaseous pollutants in higher quantities than for semi intensive systems. In recent years, attention to gaseous pollutants has risen due to their contribution to environmental hazards such as acid deposition, the impairment of the ozone layer and greenhouse effects. High concentrations of some of these gaseous pollutants have a direct health risk to humans.

In the past, manure was predominantly used as fertilizer; however the geographical landscape has changed. The competition for land for other activities such as residential and industrial use has increased and, as a result, the land availability for agricultural activities has become scare. The volume of manure generated, especially from intensive production, may become a major obstacle if it is not properly managed and controlled.

15. Does the MoA/DVS have any programmes related to the above statement, namely to monitor/advise on environmental pollution arising from manure?

    1. Yes ☐
    2. No ☐

    If yes, please specify --

16. Is there any special assistance that the Government provides to the producer on aspect of management?

    1. Yes ☐
    2. No ☐

    If yes, please specify ---

17. In Q8, you mentioned that the Government provided some kind of financial assistance to encourage the utilization of environmentally-friendly housing systems. Does the Government have any plans to expand the existing incentive scheme or other financial supports to cover the potential problems arising from manure aspect?

    1. Yes ☐ ⟶ *go to Q18*
    2. No ☐

18. Can you give some indications of the planning related to this matter?

(iv) Animal Feed

19. Can you provide the latest figures on the proportion of imported and local poultry feed raw materials?

Local ---------------- %
Export ---------------- %

20. From your experience, is there any incremental change in terms of relative used local poultry feed ingredients?

1. Yes ☐ → *skip to Q21*
2. No ☐

If no, then go to Acknowledgments section.

21. Which of the following factors might encourage greater use of local feed ingredients? *(thick all that apply)*

1. Availability of raw materials ☐
2. Advancement in research ☐
3. Others ☐

Please specify -----------------------------

22. How much budget allocation your Department receive for poultry feed research from the 10th MP?

RM ------------------

23. What was the increment of budget allocation compared to the same objective in the 9th MP?

---------- %

24. To the best of your knowledge and experience, what is the maximum amount of budget allocation that should be provided for R&D in poultry feed which will lead to reducing reliance on import and at the same time will contribute in protecting the environment from reduced feed miles?.

RM --------------------

25. Do you have any recommendations as to why you think that the Government should not increase the budget allocation for R&D for poultry feed?

ACKNOWLEDGEMENTS

Thank you for taking your time to complete this questionnaire. The information you have given will help us to learn about the value of the environmental pollution in Malaysia.

Use the space below to provide additional comments you would like to tell us about your interest in protecting environmental quality from a poultry production point of view.

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Should you have any further questions or concerns about this survey, please contact Noraisah Spahat at noraisah.spahat@newcastle.ac.uk

Appendix 10 (i)

Estimation of Income and Cost of Broiler Production for the Closed House System

Selection Parameters for Calculation

No. of birds per entry*	100,000/ cycle
No. of cycles*	6 time / year
Mortality rate*	3.5%
Average final weight (kg)*	2.00 kg/bird
Feed Conversion Ratio (FCR)*	1.75

**Data used in this calculation is a conservative average of the data and does not represent data used in LCA analysis which was obtained directly from the industry*

Analysis of Net Margin

Item	Unit	Price/ Unit	Quantity/ Cycle	RM / Cycle
(A) Sale				
Chicken sale	kg	4.35	191,000.00	830,850.00
'Unfit' chicken sale	kg	4.00	1,700.00	6,800.00
Manure	tonne	85.00	90.00	7,650.00
Sub-total				**845,300.00**
(B)Variable Cost 1				
Feed - Starter	kg	1.64	101,167.50	165,914.70
Feed - Grower	kg	1.59	236,057.50	375,331.43
DOC	bird	1.20	100,000.00	120,000.00
Sub-total variable cost 1				**661,246.13**
(C) Gross margin 1 (A_B)				**184,053.88**
(D) Variable Cost 2				
Medicine, vaccine and vitamin				12,000.00
Gas	cylinder	24.00	260.00	6,240.00
Electric and water				12,000.00
Saw dust	bag	2.00	560.00	1,120.00
Petrol				1,140.00
Transportation	bird	0.10	95,500.00	9,550.00
Catcher	bird	0.03	95,500.00	2,865.00
Asset and vehicle maintenance				6,000.00
Miscellaneous				1,800.00
Sub-total variable cost 2				**52,715.00**

(E) Gross margin 2 (C-D)				**131,338.88**
(F) Fixed Cost				
Employee				
Employee salary (7 persons)	monthly	6,300.00	1.50	9,450.00
Supervisor salary (1 person)	monthly	3,000.00	1.50	4,500.00
Rent for land (6 acre)	monthly	1,200.00	1.50	1,800.00
Depreciation	Original Cost	Depreciation %	Depreciation / year	Depreciation / cycle
House	1,600,000	10.00%	160,000.00	26,666.67
Equipment and ventilation machinery	400,000	10.00%	40,000.00	6,666.67
Vehicle (lorry)	60,000	10.00%	6,000.00	1,000.00
Tractor and wagon	45,000	10.00%	4,500.00	750.00
Other equipments	15,000	10.00%	1,500.00	250.00
Fence, access road and other infrastructure	40,000	10.00%	4,000.00	666.67
Generator	20,000	10.00%	2,000.00	333.33
Total for fixed cost				**52,083.33**
(G) Net margin (E-F)				**79,255.54**

Net margin / bird	RM 0.79 / bird
Estimates of monthly income	RM 39,628 / month
Average of cost of production	RM 3.94 / kg @ RM7.87 / bird

Appendix 10 (ii)

Estimation of Income and Cost of Broiler Production for the Open House System

Selected Parameters for Calculation

No. of birds per entry*	100,000/cycle
No. of cycles*	6 times /year
Mortality rate*	6%
Average final weight (kg)*	2.00 kg/bird
Feed Conversion Ratio (FCR)*	1.85

** Data used in this calculation is a conservative average of the data and does not represent data used in LCA analysis which was obtained directly from the industry*

Analysis of Net Margin

Item	Unit	Price / Unit	Quantity / Cycle	RM / Cycle
(A) Sale				
Chicken sale	kg	4.35	186,000.00	809,100.00
'Unfit' chicken sale	kg	4.00	1,700.00	6,800.00
Manure	tonne	85.00	80.00	6,800.00
Sub-total				**822,700.00**
(B) Variable Cost 1				
Feed - Starter	kg	1.64	104,173.50	170,844.54
Feed - Grower	kg	1.59	243,071.50	386,483.69
DOC	bird	1.20	100,000.00	120,000.00
Sub-total variable cost 1				**677,328.23**
(C) Gross margin 1 (A-B)				**145,371.78**
(D) Variable Cost 2				
Medicine, vaccine and vitamin				14,000.00
Gas	cylinder	24.00	260.00	6,240.00
Electric and water				2,500.00
Saw dust	bag	2.00	560.00	1,120.00
Petrol				1,000.00
Transportation	bird	0.10	93,000.00	9,300.00
Catching	bird	0.03	93,000.00	2,790.00
Asset and vehicle maintenance				2,500.00
Miscellaneous				1,800.00
Sub-total variable cost 2				**41,250.00**

(E) Gross margin 2 (C-D)				**104,121.78**
(F) Fixed Cost				
Employee				
Employee salary (7 persons)	monthly	9,000.00	1.50	13,500.00
Supervisor salary (1 person)	monthly	3,000.00	1.50	4,500.00
Rent for land (6 acre)	monthly	1,200.00	1.50	1,800.00
Depreciation	Original Cost	Depreciation (%)	Depreciation / year	Depreciation/ cycle
House	1,200,000	10.00%	120,000.00	20,000.00
Equipment and ventilation machinery	100,000	10.00%	10,000.00	1,666.67
Vehicle (lorry)	60,000	10.00%	6,000.00	1,000.00
Tractor and wagon	45,000	10.00%	4,500.00	750.00
Other equipments	10,000	10.00%	1,000.00	166.67
Fence, access road and other infrastructure	40,000	10.00%	4,000.00	666.67
Generator	20,000	10.00%	2,000.00	333.33
Total for fixed cost				**44,383.33**
(G) Net margin (E-F)				**59,738.44**

Net margin / bird	RM 0.60 / bird
Estimates of monthly income	RM 29,869 / month
Average of cost of production	RM 4.03 / kg @ RM 8.06 / bird

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