

**A THEORETICAL FRAMEWORK OF SUSTAINABILITY IN AIR TRANSPORTATION
PLANNING AND FUTURE PROSPECTS OF AIRPORT INFRASTRUCTURE UPGRADING: A
CASE STUDY OF KUALA LUMPUR INTERNATIONAL AIRPORT 2
(KLIA 2)**

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ABSTRACT

Air transportation has become the fastest growing mode of transportation in adapting with the transportation facilities and services provided. The developments of air transportation have surrounded with the introduction of much larger transport aircraft and rising airport infrastructure upgrading nowadays. Due to the increasing importance of enlargements in airport facility, this has become a concern for policy makers and academics. Although the time value and greatest cost efficiency are obtained from the airport facilities, there are negative externalities produced by airport developments. Due to the increasing importance of enlargements in airport capacity, it should also regard as the management of the environmental impact on surrounding areas. Literature has found that airport operations may produce various regulated pollutants, including volatile organic compounds (VOCs), carbon monoxide (CO), and particulate matter (PM) (Luther, 2007). This paper aims at identifying the sustainability in air transportation planning and future prospects of airport infrastructure upgrading; using the KLIA 2 as a case study. At most airports, the major environmental concerns embrace local air quality, noise, sustainability and recycling along with habitat and wildlife management. Issues relating to the sustainability of specific industrial sectors such as aviation are relatively under researched. Procedures and technologies for environmental protection, environmental efficiency and impact mitigation receive a considerable degree of attention from industry, government and academia alike has to be increased. Even though the airport expansion is very important to cater the demand, however, there are some policies and strategies that need to be considered to balance the need and the future. Conventionally, the planning of airport infrastructure upgrading has only focused on elements surrounded by the airport; such as supply and demand forecasts and other aeronautical and engineering. But the recent airport framework presents new situations that cannot be solved by traditional methods since new and external variables are intrinsic to the decision-making process (Graham and Guyer, 1999). The study will focus on the environmental impacts of the KLIA 2 constructions which are ongoing. However, this paper highlight the literature background on impact of airport expansion on air pollution and noise issues to the environment as well as to the community.

Keywords: *sustainability, particulate matter (PM), aircraft noise, aviation, airport expansion*

1.0 INTRODUCTION

Transportation is important in order to have the great infrastructure, industrialisation, or massive production. The global society would not have experienced comfort and convenience had it not been for advancements in the transportation sector such as trailers, cargo ships, or large aircrafts to carry them to different places. In short, transport is important since it enables trade between people, which in turn establishes civilizations (Hall, 2003 and Bachok, 1996). The wide modes of transport can be broadly divided into three categories based on the medium they exploit: land, water and air. Each mode of transport has a fundamentally different infrastructure, operations, and often has some unique regulations (Rodrigue et al., 2006). The most challenging issues in transportation nowadays are how to improve the transportation system with the concept of sustainability development. However, this research only aims on the aviation infrastructure, especially airport facilities and air navigation services that have significantly expanded and improved to meet the increasing demands. This research identifies the conventional methods of airport planning that indicated with the parameters of sustainable transport. With phenomenal growth in air traffic, the importance of air transport in the whole economy has increased considerably. Furthermore, the air transportation growth and development impacts of Kuala Lumpur International Airport 2 expansion will be further discussed in this paper.

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Additionally, planning and constructing new airport infrastructure and facilities takes an extremely long time and history has shown the construction of new airports and the expansion of existing ones to be highly controversial to the public as well as the environment. The aviation system produces significant economic and social benefits to communities. In general, the aviation system continues spurring economic both locally and globally. However, the airport expansion must face environmental and community planning challenges in order to come out with an innovative and sustainable approach to the world. Although they create a lot of jobs opportunity and bring in money to local and national economies, airports also create noise, pollution and transport problems as well as taking up vast tracts of land. Studies have also shown aircraft noise, particularly at night, can have damaging health effects on those continually exposed to it (Thomas, 1995). As such, proposals for new airports or to expand existing ones consistently generate enormous public argument, and require the balancing of economic against environmental concerns.

2.0 DEVELOPMENT IMPACTS OF AIRPORT EXPANSION

This research aims to assess the development impacts of airport infrastructure upgrading towards the environment and community. However, this research still at the study methodology stage and there are several development impacts that have been identified. Particularly, this study only focused on the two types in identifying the impacts of airport developments namely particulate matter (PM) and noise levels at KLIA 2. Hence, all the findings were being pertinent to the specific scope. This research derives several development impacts of airport expansion on why the study should be carried out which includes:

Noise fears over airport expansion

One of the most severe problems is that of aircraft noise in and around an airport. All transportation systems create noise pollution (Nelson, 1982). The aircraft noise is related to the frequency and noisiness of aircraft movements and the proximity of communities relative to the airport's arrival and departure routes (Upham P. et al., 2003). The control and monitoring of aircraft noise are issues that have received significant attention, and aircraft and engine manufacturers have made significant technological improvements over the years. However, the benefits of such actions have been offset by the growth in air travel such that today most of the world's major airports have operational constraints or capacity limits based upon aircraft noise. For an example, Luton Airport's proposal to expand the number of passengers to 18 million a year has had local residents fearing the worst as they expect the noise pollution that comes from planes to increase and give their lives hell (White, 2012).

Declining of air quality level due to airport expansion

Major sources of pollution are ground transport, aircraft emissions and apron activities such as aircraft refueling. Airport operations may produce various regulated pollutants, including volatile organic compounds (VOCs), carbon monoxide (CO), and particulate matter (PM) (Luther, 2007). Because globalization and the concomitant increase in air travel has been accompanied by rising energy consumption and emissions, environmental protection and efforts to prevent climate change have become the modern scientific challenge of our times. Like all human activities involving combustion, most forms of aviation release carbon dioxide (CO₂) and other greenhouse gases into the Earth's atmosphere, contributing to the acceleration of global warming (Anderson, 2008) and (in the case of CO₂) ocean acidification (McNeil and Matear, 2008). Both indoor and outdoor pollution can have adverse health effects. Exposure to air pollutants may lead to short term effects such as reduced visibility, headaches, allergic reactions, irritation to the eyes, nose and throat, and longer term effects such as breathing difficulties, asthma and various chronic respiratory illnesses such as lung cancer and heart disease.

Community Severity

Airports contribute for economic activity, create direct and indirect employment and may act as inventive centres for new technologies within a region. As such, they are recognized as clusters from a general spatial perspective and "airport cities" in specific if they show the qualitative features of a city: density, access, quality, environment services (Güller & Güller, 2003). In fact, they are major changes to the land use and activities surrounding the airport to adapt with the development. This may lead to an impact to the community severity. The airport service also gave a sleep disturbance caused by nighttimes' air traffic (Fast, 2004).

3.0 SUSTAINABILITY DEVELOPMENT AND AIR TRANSPORT

Although there is no unified definition and interpretation of sustainability, most studies have the common feature of quantifying it by the indicators that are related to the three key dimensions of environmental, economic, and social (Hardi and Tzdan, 1997). A new approach has been introduced to the general public of Malaysia. Besides incorporating the elements of relationships between man and man (socio-economical), man and the environment (environmental) and man and technology (physical), there exists a new dimension of relationship between man and His creator (spiritual) (The Federal of Town and Country Planning Department, Malaysia, 1997). This principles leads to the integration of transportation planning and sustainability. Despite of its key role in economic and social development, transportation has many spillover effects such as congestion, safety, pollution and non-renewable resource depletion.

The concept of sustainable transportation is derived from these general terms that imply movement of people and goods in ways that are environmentally, socially, and economically sustainable (Gudmundsson and Hojer, 1996). Airport transportation becomes one of the important assets in a country that compose a enormous investment of public funds. Airport planning is a systematic process used to establish guidelines for the efficient development of airports that is consistent with local, state and national goals. A key objective of airport planning is to assure the effective use of airport resources in order to satisfy aviation demand in a financially feasible manner (AIP Guide, 2010). Three basic interdependent elements of airport planning are airlines, airport and territory. Airlines been determine the achievement of the airport and subsequently give an economic growth on the territory. Finally, airport features attract airlines and provide benefits to the territory, as well as creating tensions with the hinterland (Sánchez, 2007). Therefore, the responsible airport managers and authorities have to dynamically adjust their design and plans can accommodate the diversity of possibilities in the future. Future methodologies for forecasting air traffic should be based on the role and viability of specific airlines at particular airports in order to come out with sustainable development.

4.0 PLANNING AND DEVELOPMENT OF AIR TRANSPORT

Airlines, airport and territory are three basic interdependent elements. Territorial features are those affecting airport performances and attracting particular types of airline (Sánchez, 2007). Air transport may be classified as domestic and international air transport. While domestic air transport mainly facilitates movement within the country, international air transport is used for carrying goods and passengers between different countries. Air transport is carried out in fixed air routes, which connect almost all the countries. However, air transport requires huge investment for construction and maintenance of airport system. It also requires trained, experienced and skilled personnel which involves a substantial investment.

A fixed-wing aircraft, typically airplane, is a heavier-than-air craft where the movement of the lift surfaces relative to the air generates lift. This concept has been identified as aerofoil and aerodynamics. The way of the aerofoil works, in the shape of birds that are similar to airplane's wing. Fixed-wing aircraft range from small trainers and recreational aircraft to large airliners and military cargo aircraft. The shape of the wing causes air to travel faster over its upper surface. This reduces air pressure above the wing. It also helps increase the pressure on the wing's lower surface, pushing it upward and creating lift. Feathered tail and muscled wings propel the bird forward, maneuvering it upon the sky (Lopez, 1995). The focus in airport planning is to provide sufficient capacity with respect to future traffic, in the meantime environmental issues and financial need to be taken into consideration. The challenge is not only a matter of new technology and smart spatial planning; but it is also a matter of cooperation with the stakeholder. If this cooperation are not taken into account, the policies of the airport system will getting delayed, changed, or never implemented due to the lack of support from the stakeholder.

Airport master plan is the concept of the ultimate development of a specific airport, graphically presented with written report to effectively convey the research and logic from which the plan was evolved (ICAO Manual, 2009). Long-term development concept of an airport is an embodiment of the airport's strategic framework and concept depicted graphically and documents the data and logic upon which the plan is based. Guidelines for future airport development is important to satisfy aviation demands in a financially feasible manner, while addressing aviation, environmental and socioeconomic issues in the local community Based on AIP Guidelines (2010), an airport master plan represents the airport's blueprint for long-term development. A good Airport Master Plan represents the most efficient framework with flexibility,

expandability and optimum balance of all individual airport services to provide the required capacity for aircraft, pax, cargo and vehicular movements with max facilitation for pax, operator and staff at lowest capital and operating costs and max revenue (ICAO Manual, 2009). This will generate higher capacity and efficiency through a series of compromises than would otherwise be attained without reconciliation of individual facilities plans. The master plan need to be annually and adjust plans according to prevailing conditions. The airport operation need to be forecast in order to produce the master plan that fit the demand (refer Figure 1).



Figure 1: Forecast Relationship versus Master Plan

Source: ICAO Manual, 2009

Basically, the airport expansion is by adding the new runways to the area. Number of runways depends on volume of aircraft movements. The orientation of runway depends on direction of prevailing winds. The runway length is influenced by temperature, runway slope, airport altitude, runway pavement condition, and visibility (ICAO Manual, 2009). Furthermore, the airport site selection is very important to ensure that the airport expansion is compatible to the area and surrounding. The airport selection is to determine the purpose for which airport is required and consider forecast future demands of the operational and economic as well as the quantity and type of traffic.

5.0 AIRPORT INFRASTRUCTURE UPGRADING : A CASE STUDY OF KLIA2

As demand for air transportation continues to grow, it will become increasingly difficult to accommodate the resulting traffic levels without significantly expanding airport infrastructure. However, many larger airports are already constrained in their ability to expand, and surrounding communities often strongly resist the construction of additional runways. As for demand management, some regions have succeeded in general aviation that are less expensive to improve and that have the least environmental impacts. The oil price, flu epidemics, and financial and economic woes further add to the volatility of aviation demand development (Kwakkel, Walker, & Marchau, 2009). The demand management approach also might be relevant in addressing congestion at major commercial service airports (Bolczak et al., 2007).

More studies are needed to document the effectiveness of demand management, and to develop guidelines so that this approach can be better understood. Furthermore, airport ground access, facility development, and project funding will continue to be important challenges for aviation planners because of the complex institutional environment. Commercial service airports typically serve passengers and freight from a wide geographical area. Many local government jurisdictions and other agencies, including transit and rail authorities, environmental agencies, and transportation departments, have responsibilities that overlap and affect airport ground access (Gosling G, 1999). The appropriate future role of each mode must be defined, and connectivity between modes must be addressed.

Air Transportation Growth in Malaysia: Kuala Lumpur International Airport 2 (KLIA2)

Airport expansion gives an impact to the economic growth of the region. Basically, air connectivity increases with the number of destinations served and the frequency of flights along these routes. This in turn will make a location more attractive to foreign to invest and this will increase the potential for business competence, and eventually generates a virtuous cycle of connectivity and economic growth. Connectivity is generated by an airport's ability to attract passengers, and also the efficiency and availability of routes provided to international locations by the growing complexity of air networks and the importance of hub airports for economic development of the region (BCC, 2009). Looking at the bigger picture beyond the real-estate crunch and the threat it poses to the general aviation relievers in terms of potential closures, there is a clear need across the board for more capacity at the nation's busiest airports. With sales picking up, more than a thousand aircraft are being added to the overall fleet every year, and operators are flying more than ever before, this increasing the pressure on airport infrastructures for more runways and runway extensions. (Elser D, 2006).

As for Malaysia, the airport expansion of Kuala Lumpur International Airport 2 (KLIA2) is in order to cater the demand of the passengers for the future and also for the economic growth to the region. The GDP of economic activity at current prices from year 2006-2010 shows that it increases from year to year on transport, storage and a communication (refer Table 1). Therefore, analysis of the interaction between the airport and the territory should be made in a comprehensive manner, considering the airline's route pattern, airport development and territorial impacts (AIP Guide, 2010). The present site for KLIA2 was selected based on the recommendation in the National Airport Master Plan (NAMP) (2008) after a detailed and comprehensive study involving all stakeholders including Ministry of Transport, Department of Civil Aviation, Ministry of Finance, Ministry of Home Affairs and all airlines.

The original KLIA Master Plan was reviewed so as to take into account the latest development in the aviation industry such as growth of low fare airlines and their specific requirements, rationalisation of routes, liberalisation of air service agreements and aviation security requirements. Major issues such as location, soil condition, landside connectivity and existing infrastructure were also taken into consideration in the study (MAHB, 2011). From the Figure 1 below, we can see that the services sector cover about 61.1% from the GDP in 2015 and expected to growth at 7.2 % annually until 2015. The GDP of economic activity at current prices from year 2006-2010 shows that it increases from year to year on transport, storage and communication (refer Table 1). Therefore, analysis of the interaction between the airport and the territory should be made in a comprehensive manner, considering the airline's route pattern, airport development and territorial impacts (AIP Guide, 2010).

Gross Domestic Product by Kind of Economic Activity at Current Prices, 2006-2010, Malaysia RM (Million)	
Transport, Storage, and Communication	
2006	38,882
2007	42,652
2008	46,205
2009	46,649
2010	50,802

Table 1: Gross Domestic Product by Kind of Economic Activity at Current Prices, 2006- 2010, Malaysia
RM (Million)

Source: Department of Statistics

The development of airport like KLIA as one of Southeast Asia's largest airports was due to the need of the region and development. Designed to be a regional hub, the KLIA is built with features that allow flexibility for future expansion, well into the next century. Table 2 below shows the air traffic statistics from year 2008 until 2011. The number of passengers for domestic and international of air traffic increases every year. Therefore, responsible airport planning anticipates a wide range of possible futures, giving airport managers and operators the authority to dynamically adjust their plans and designs so that over time they can

accommodate the variety of possibilities that may occur. Future methodologies for forecasting air traffic should be based on the role and viability of specific airlines at particular airports. The economic growth and globalization have seen demand for air travel grow rapidly in the last 20 years, and all the economic and demographic evidence points to this trend accelerating (Burghouwt,2007) .

		2008	2009	2010	*2011
No. of Passengers					
Domestic	Million	27.5	29.1	31.1	33.2
International	Million	21.4	23.5	28.0	29.9
TOTAL (including transit)	Million	48.9	52.6	59.1	63.1

*2011= Projection

Table 2: Air Traffic Statistics by year (2008-2011*)

Source: Department of Statistics

Airport operators need to begin to plan now for the long term, to visualise the ultimate runway, apron and terminal infrastructure which can be realistically anticipated for a particular site, and the ground transport infrastructure likely to be needed to serve it in order to meet anticipated demand and to address environmental constraints. Some of the planning issues that can be identified are demand management and landslide access (Gosling, 1999). In resolving conflicting and competing demands for land the aim should be the three-dimensional progress namely physical, economic and social, both at present and in the future. Having established itself as one of Asia’s leading airports since opening in the summer of 1998, the multi-award-winning KLIA has enjoyed rapid passenger growth (refer Figure 2). KLIA can be said amongst the best performing airports in the region in 2009-2010. In fact, in the first nine months of 2010, the airport handled 24.8 million passengers, a 17% year-on-year increase with the low-cost sector enjoying growth of 18.5%. In order to cater for this continued increase in demand, the temporary Low-Cost Carrier Terminal (LCCT) was constructed in 2006, but as it approaches its capacity of 15 million annual passengers, 2012 will see the introduction of the brand new, permanent facility (MAHB).

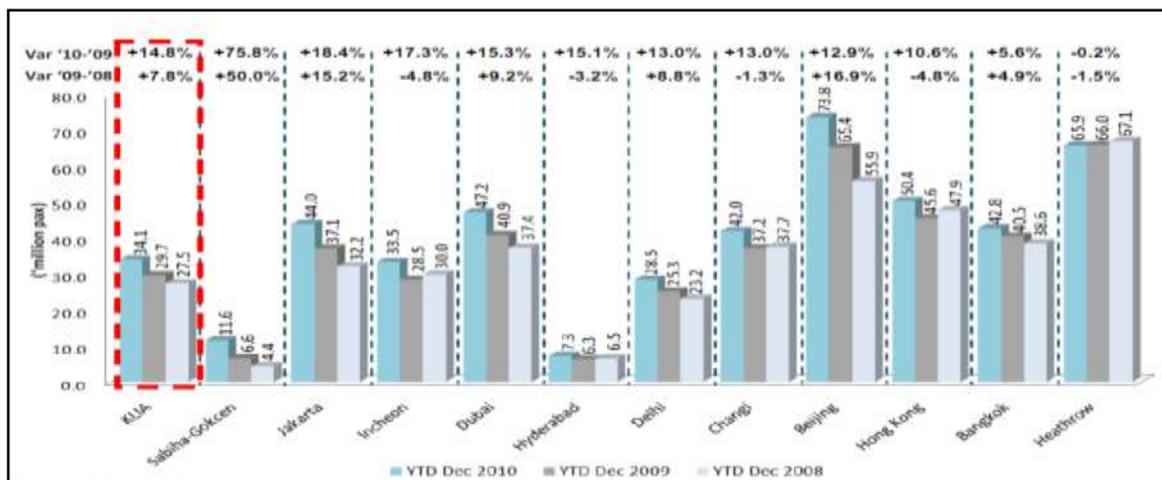


Figure 2: KLIA amongst the best performing airports in the region in 2008-2010

Source: Malaysia Airports Holdings Berhad (MAHB) Power Point, 2011

Malaysia’s very own low-cost carrier, AirAsia, has grown in correlation with KLIA itself and the investment by Malaysia Airports Holdings Berhad (MAHB) is largely a direct result of the airline’s aggressive expansion. KLIA 2 is predominantly for AirAsia but also open to the possibility of other low-cost airlines eventually operating from the facility. It’s being constructed to cater for the expansion of AirAsia because by the end of next year, the existing LCCT will handle 15 million passengers (ACI Europe, 2011). Airport

expansions are costly, complex, and controversial. The key component of this project is the construction of a new runway. KLIA2 will be the much talked about budget terminal LCCT in Kuala Lumpur for 2012. This modern airport is also set to open by April 2013 and according to owners, Malaysia Airports Holdings Berhad (MAHB), the total cost to build this new LCCT is estimated at RM4 Billion which is currently 52% completed. Located just two kilometers from the main KLIA Terminal, this will be the largest Low Cost Carrier Terminal in the region of Southeast Asia with a total area of 242,000 square meters (refer Figure 3). There will be a total of 68 aircraft parking bay while the new budget terminal will cater to around 30 million passengers. There will also be a third runway which is located 1.5 km from the second runway.



Figure 3: Construction of permanent second terminal to replace current LCCT
Source: Malaysia Airports Holdings Berhad (MAHB) Power Point, 2011

The development of KLIA Sepang is to be implemented in three phases:

➤ PHASE 1 (1998 - 2003)

Phase 1 call for the construction of facilities to handle 25 million passengers (about 80 flights per hour) and 1.2 million tonnes of cargo per annum. The major facilities to be constructed include

- Two 2.5-mile parallel runways (4000m x 60m)
- A mega terminal building with a satellite - 83 aircraft stands (contact and remote).
- Sixty contact piers, 20 remote parking bays with 80 aircraft parking positions, one mega terminal, one satellite, two runways and other facilities will be made available to accommodate a throughput of 25 million passengers per annum. The runways will be on a staggered configuration 2535m apart to allow for simultaneous operation. The runways will be equipped with Category II navigational and lighting aids and will be complemented by a taxiway system for the efficient and expeditious flow of aircraft on the ground.
- The terminal building, designated to allow for its expansion for the next two phases.

➤ PHASE 2 (2003 - 2008)

To handle 35 million passengers per annum by 2008.

➤ PHASE 3 (2008 & beyond)

Further expansion of the airport to handle 45 million passengers per annum by 2013. There is sufficient land and capacity to develop facilities to handle up to 100 million passengers a year, four runways by the year 2020 and two mega-terminals, each with two linked satellite buildings.

Items	Provisional (Feb' 2009) RM 2.0 Billion	Revised RM 3.6 - 3.9 Billion
1. Terminal Building	GFA – 150,000 m ²	GFA – 257,000 m ²
2. Aircraft Stands	Area – 500,000 m ² 50 semi contact stands	Area – 803,709 m ² 68 gates & 8 remote stands (80 aerobridges)
3. Earthworks	Area – 4.85 mil m ²	Area – 11.19 mil m ²
4. Runway 3, Taxiway Pavement & AGL System	Code C Length : 2.50 km, Width : 45 m	Code E Length : 3.96 km, Width : 60 m
5. DCA Facilities	Apron Control Tower Height : 77 m	Air Traffic Control Tower Height : 93 m
6. Public Infrastructure	Length : 8 km with 1.5 km elevated road	Length : 15 km with 5.4 km elevated road

Figure 4: Major Upgrades in Specifications

Source: Malaysia Airports Holdings Berhad (MAHB) Power Point, 2011



Figure 5: Construction underway at the site (KLIA 2)



Figure 6: An artist impression of the terminal (KLIA 2)

Source: <http://www.yoyooh.com/2011/06/klia-2-the-latest-lcct-terminal>

According to MAHB, there is a land is a portion of the 6,750 acre land bank that is set aside for development adjacent to KLIA. Dubbed the KLIA Aeropolis, it is categorized under the wholesale and retail initiative under the National Key Economic Areas (NKEA). The KLIA2 area will be transformed as a catalyst for tourism, leisure and employment, thereby diversifying the airport city. Completion of the 50 acre development is scheduled for 2013 and there will be other phases in the development of KLIA Aeropolis which would include a commercial business district which houses office parks, retail/commercial centres, an auto mall, exposition/convention center, medical center, training center complex and service apartments. There are also plans to build golf courses, a boutique hotel and a theme park as well as agro-tourism tracts of land.

6.0 IMPLEMENTATION OF ENVIRONMENTAL IMPACT ASSESSMENT IN AIRPORT PLANNING

Enlarging the airport capacity should also consider the management of the environmental impact on surrounding areas in order to come out with the sustainability development. Externalities created by infrastructure projects in Europe were assessed by the Environmental Impact Assessment (EIA) after they were completed (Sánchez, 2007). This posterior assessment was often turned into a method for justifying decisions that had already been made. Environmental protection has come to play a major role in the strategy and development plans of many airports around the world and is also recognized by the Airport Council International (ACI) which represents 1679 airports in 177 countries (Schrenk et al., 2009). A major aspect of maintaining an airport resource is an accepted development strategy which includes the protection of land

for future airport development and operations, and provision of a noise buffer for the surrounding community.

EIA can be defined as a systematic activity designed to identify, predict and evaluate the environmental impacts of a particular action (Masera, 1992). It interprets and communicates information about these impacts, and details out the mitigating measure prior to approval and implementation. Even though EIA still was being considered, the Strategic Environmental Assessment (SEA) has been mandatory in airport planning. The SEA model considers several elements, including biophysics, economic, social, political, and territorial variables to evaluate the environmental consequences of several alternative future scenarios (Sánchez, 2007). SEA has the advantage of anticipating the inclusion of measures for environmental protection, since it obliges the plan, program or policy to make an environmental sustainability report in relation to the possible alternatives for development. Subsequently the plan, program or policy proposal will be written on the basis of the considerations of the environmental sustainability report, the community involvement process and the environmental assessment.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Issues relating to the sustainability of specific industrial sectors such as aviation are relatively under researched. Procedures and technologies for environmental protection, environmental efficiency and impact mitigation receive a considerable degree of attention from industry, government and academia alike has to be increased. For the sustainability, it involves the achievement of economic and social objectives within environmental limits designed to protect critical natural resources. Even though the airport expansion is very important to cater the demand, however, there are some policies and strategies that need to be done to balance the need and the future. Our study will focus on the environmental impacts of the KLIA 2 construction which is currently just started. This research focuses on two types in identifying the impacts of airport developments namely particulate matter (PM) and noise levels with still ongoing. It basically explains the planning of the KLIA2, the process of building the airport, its current state and position of future planning's for the airport. The study basically at the study methodology stage as this research aims to assess the development impacts of airport infrastructure upgrading towards the environment and community. Finally, this research will be discussed on how it affects its surrounding environment, the natives and the trade aspect of the area. It is recommended for the government of Malaysia through DOE to increase the level of the information on air pollutants and noise pollution. In comparison with other international standards for air pollution, Malaysia has supply the lowest information regards air pollutions. The implementation of EIA need to be consider for the future expansion of the airport facilities.

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