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Aviation Impacts on Property Values and Management: The Case of Suvarnabhumi International Airport

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ABSTRACT

Many countries have developed policies and measures to deal with the external impact of aviation on the wider community. There is, however, often controversy and lack of acceptance of some measures, such as compensation, in the communities affected by aviation. Such measures are often felt to be ineffective and perceived as unfair. A clear and objective model for determining compensation would be helpful to reduce controversy. The objective of this study is therefore to examine the relationship between aviation impacts and property values in the case of Thailand's Suvarnabhumi Airport for application to the possible improvement of compensation packages. Multiple regression analysis was used to determine the relationship between five common impacts of aviation (safety, noise, scenery, air pollution, and traffic) and property value change, with data from a survey of sample communities around the airport. The results, both for the overall neighborhood and for separate land used types, show that only noise and air pollution demonstrate significant negative relations with property value. The effect of noise drives a higher impact on property price than the effect of air pollution. The main contribution of this research is to improve developing country compensation models by applied measurement from regression analysis to identify factors with significant impacts, using property value change as proxy to measure the impact of the airport. For example, in the case of Thailand, a compensation model should consider noise and air pollution as the main factors rather than consider only noise contour area. The higher weight on noise should be designed to reflect land use types. Furthermore the market value of property loss should be taken into account when designing a compensation package. The survey and regression method used in this study can be adapted for finding relevant factors and suggesting appropriate compensation for other environmental and infrastructure development projects.

1. Introduction

With globalization, demand for air travel is expected to grow significantly, in turn driving an increase in flights and airport developments to provide sufficient capacity to handle this demand. This anticipated growth in aviation infrastructure has increased concern about aviation-related environmental impacts. Although, economic development can be driven by aviation, the environmental impacts are also a critical concern. The U.S. has placed addressing environmental and energy issues at the heart of the Next Generation Air Transportation System (Next Gen) plan with 5 strategies including cost-beneficial solutions to meet environmental targets from aviation in a verifiable manner [12]. In parallel to the problems, appropriate compensation for these negative externalities has become a common discussion topic and is a reason for this study. In the U.S., it has been estimated that aviation noise negatively affects 2.3 million people while noise nuisance at the UK's Heathrow Airport costs 37–66 million pounds per year in uncompensated loss of human wellbeing. In Thailand, the Airports Authority of Thailand set the budget for noise effect compensation at just over 11.2 billion baht (~USD 366 million[2]). The initial compensation package

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of 736 million baht was paid when Suvarnabhumi Airport opened. As of February 2011, the actual accumulated compensation for Suvarnabhumi Airport had reached 1.25 billion baht for the NEF[3] > 40 and NEF 30–40 zones [1], 11.13% of the total budget for noise compensation. Notwithstanding these payments, there have been disputes and public debates about appropriate compensation packages which would properly compensate for the negative environmental effects on property value changes in the vicinity of the airport.

Although there are various studies discussing the impact of aviation on property values [7,15,19], most of them mainly focus on aviation noise impact on real estate values [3,10,13,18], while potentially ignoring other crucial impacts or factors. There are both negative and positive impacts found by the various studies of residential property and airport noise. A sample of empirical studies on the negative impacts on residential property values due to airport noise can be found in [23]. The study found a decrease in property values linked to the dBA increase in noise level. Aviation noise impact is also a critical form of pollution studied in environmental justice theory. An empirical study used tobit and logit multivariate regression to analyze pollution exposure from a major commercial-service airport and found that ethnicity is the primary cause of the disproportionate burden of aviation noise pollution. [20]. On the other hand, there are also some studies which indicate that the impact of airports on the residential property market can be positive. For example, proximity to London City Airport is highlighted as a positive factor in promotional material for new housing developments in the surrounding area. One benefit suggested for living in close proximity to an airport is enhanced access for those who use the airport frequently [22].

Despite a variety of studies on the relationships between aviation factors and property values, there are limited studies on how to incorporate these relationships into implementation of environmental policies, the design of appropriate compensation packages or models, and the determination of influencing factors. In the case of Suvarnabhumi Airport, evidence from international standards for airport management and practice has shown that environmental policies, especially those using economic instruments such as compensation schemes, are both ineffective and poorly implemented, causing many problems for the government, businesses, and the community. Appropriate compensation schemes need to be adjusted in order to fit with the local context and should capture all relevant factors. A study of Suvarnabhumi Airport found that new properties in the area affected by severe noise before 2006 tend to decline substantially in value. Prices of new properties sold after airport operations began in 2006 were 19.15% lower in the most severely affected area and 8.55% lower in the outer noise contour zone [5]. In addition, a broad study of noise impact on renters of apartments and dormitories in affected areas around Suvarnabhumi Airport shows that willingness to accept compensation in Thailand when the noise level increases is lower than in European studies [5]. Similar research of traffic noise impact on high-rise buildings and areas surrounding a new motorway that links Bangkok to Suvarnabhumi Airport and Pattaya indicated that there is a high traffic noise impact on the foreground and front façade of buildings, implying that these areas are inappropriate for residential purposes [17].

The purpose of this study is to investigate the property value impact of aviation, the relationship between various aviation impact factors, and the overall impact in order to develop a concept for a suitable compensation scheme based on the case study of Suvarnabhumi Airport, Thailand. This particular case is interesting because it allows a comparison between before and after situations for a brand new airport in a part of Bangkok previously unaffected by an airport. In most situations the airport has been in place for many decades, so the "before" case is very difficult to measure.

The data used for the impact examination was mainly derived from primary data e.g., questionnaire surveys and key informant interviews in communities near the airport. In addition, we considered evidence about the effect of aviation obtained from official databases and secondary research. Moreover, comparison and analysis of aviation policies among major international airports in several countries were carried out to investigate their effectiveness and identify relevant input factors. The discussion and recommendations in this paper can provide practical guidance for improving the compensation scheme and aviation policies for the study area and also for other cities.

2. Overview of the study area

2.1. The Suvarnabhumi International Airport, Thailand

Suvarnabhumi Airport is an international airport serving Bangkok, Thailand covering an area of about 8000 acres (3300 ha). It is managed by the Airport of Thailand Public Company Limited (AOT), which has an agreement with the government granting it all businesses, rights, assets and staff, and liabilities. The airport was designed to accommodate 45 million passengers per year; however the AOT expects that its future capacity will be about 100 million passengers per year. It is a centerpiece of Thailand's transportation infrastructure and services with the investment amount of 188.8 billion baht (US$ 4.979 billion[4]), by which it was built with the purpose of enhancing Thailand to become an aviation hub for the region. The airport site is geographically located in Racha Thewa in BangPhli district, Samut Prakan Province. It was officially opened for limited domestic flight services on 15 September 2006, and for most domestic and all international commercial flights on 28 September of the same year.

The growth of aviation activities has manifestly changed the patterns of land use near airports, especially the development of real estate, residential, commercial and industrial enterprises, and has been observed to substantially affect property values in the vicinity of airports. In terms of the corporate social responsibilities operations according to AOT's CSR Report (2011), AOT has provided for the monitoring of environmental quality through the use of an Environmental Impact Assessment (EIA). AOT set up its emergency fund to compensate communities which have potential noise impacts based on surveying the affected areas by AOT staff; however, the choice of compensation is still not effective in satisfying the impacted communities, and has caused disputes. AOT's EIA shows that two years after the Airport opening, compensation of only 402 million THB had been paid by AOT for purchasing in the areas with NEF more than 40 (220 million THB) and improving 10 buildings in areas with NEF 30–40 (182 billion THB) [18]. This compensation amount was allocated by AOT through following the compensation process and criteria based on the EIA, which included an operational plan for mitigating noise impact.

2.2. Possible aviation impacts and mitigations based on EIA

According to the Suvarnabhumi Environmental Impact Assessment (EIA) study by TEAM [21], it investigated an area affected by noise which encompassed 70 sq km around the airport, dividing it into a high-impact noise zone (Noise Exposure Forecast, NEF is over 40 dB) and a moderate-impact noise zone (NEF is between 30 and 40 dB). Noise levels during both construction and operational phases were collected. For the construction phase, construction equipment created the

[3] NEF is a noise descriptor to contribute in the calculation of airport noise levels and contours map for determining the airport noise mitigation measures and monitoring plan. NEF 30–35 means Noise Exposure Forecast at Leq 60–65 dB this is the Airport noise affected areas and noise insulation shall be applied, NEF 35–40 means Noise Exposure Forecast Leq 65–75 dB this is more severe airport affected areas and noise insulation or other mitigations shall be applied, and NEF > 40 means Noise Exposure Forecast at Leq > 70 dB this is most severe airport noise affected areas, none of any residential areas or sensitive receptors are allow to be inside of this areas, the compensation or land purchase shall be applied.

[4] Exchange rate year 2006 from BOT 37.9286 Baht/USD.

highest noise levels (e.g. pile driver, rock drill, and paver). In addition, there were noise levels in various ranges, the highest average noise level from monitoring being 61.6 dBA. The EIA report also shows the effect of noise pollution by NEF and type of community.

The EIA report shows a total of 15,888 buildings in the affected area, and a large budget was accordingly set to fund compensation packages. However, many problems have arisen since, both before and during the opening, with aviation noise and compensation being a major one of those problems, especially in terms of the compensation amount and the number of targeted households. In addition, the compensation schemes of the Suvarnabhumi International Airport have focused only on the mitigation of noise impact. These unanticipated events can be viewed as the result of both ineffective policies and also inefficiencies in implementing environmental policies.

3. Concept and methodological framework

3.1. Concept

The study aims to evaluate aviation impacts and test their relationships to property value changes through the application of regression analysis in order to find an appropriate compensation model based on the case of Suvarnabhumi International Airport. The primary focus of the study was to address the question of which aviation impacts might affect changes in property values. In addition, it focused on addressing the question of which suggestions and recommendations could provide appropriate compensation schemes which are responsive to the needs of vicinity communities consisting of people residing and working near the airport. The study considers limited cases of how the airport might provide effective policy implementation given that evidence has shown its environmental policies to be both inadequate and poorly implemented, causing many problems to the government, businesses, and nearby communities. Even though the airport has international standards for airport management and practices and benefits from modern aircraft developments which reduce aviation pollutions, some environmental policies (e.g. economic instruments such as compensation scheme) need to be adjusted in order to fit the local context. Many previous studies of factors affecting property values have focused only on the relationship of noise impacts on the changes in property prices or residential values, but this study considers multiple factors and their relationships to different types of land use. The study uses questionnaires to evaluate impact levels for each factor that might affect property values. In keeping with various other studies, this research is expected to find a negative impact on property value due to aircraft noise and is expected to have a practical contribution to existing and further research on compensation models, aviation impacts and factors affecting them, as well as appropriate environmental management concepts through integrating environmental theories, economic concepts, government policy formulation, and strategic management concepts and practices.

3.2. Methodological framework

The scope of the study takes into account factors influencing aviation impacts (whether the aircraft is taking off or landing, power setting and speed, flight path, weather conditions and surrounding terrain, etc.) that were tracked at selected stations near the airport in two zones (NEF 30–35 and NEF 35–40), as well as consideration of stakeholder participation. In addition, secondary research was carried out, primarily using official documents and databases. An investigation of policy effectiveness in a number of countries was also carried out to generate additional discussion and recommendations. The study also takes into account government and airport instrumentals such as strategic environmental plans in line with the environmental policy of the Thai government and other countries that include significant measures and regulations, economic (compensation package, tax, etc.), voluntary programs and technology (e.g. insulation and aircraft technology).

3.2.1. Data collection design

Data obtained by this study were derived from both secondary data (official measurements and assessments, and public data on property) and primary data based on data collection from interviews and surveys.

Collection methodology was divided into the following categories:

1. Public surveys (questionnaires): This study surveyed 300 samples covering the entire segment of the population consisting of those who live, work, or do business in the areas of 30–35 NEF (120 samples) and 35–40 NEF (180 samples) by using random sampling.
   - The study's questionnaire was designed to identify the impacts that affect the communities and businesses both before and after Suvarnabhumi operational phase. The main goal of the questionnaire is to identify "How does the aviation impact around Suvarnabhumi Airport affect your household?" The questions start with bio-data, type of respondent and time staying in the area. Then the questions focus on the level of impact of Suvarnabhumi Airport, level of ranking from noise, air pollution, traffic, safety and visual, and magnitude of those impacts on property value changes. In addition, questions related to awareness of government measures and opinions on their effectiveness, as well as suggestions, were included.
     Due to the limitation of descriptive data of explanatory variables, the study evaluated the level of impact by using the perception of the sample population from questionnaire, divided into 5 levels: Very high = 5, High = 4, Medium = 3, Low = 2, Very low = 1, No impact = 0.
     Questionnaires outline can be summarized as follow

Outline of survey form

- Biodata
  - Covering both male & female
  - Covering all age range more than 20 years old
  - Covering both resident & business
  - Covering people who live more than one year to capture the affect of Suvarnabhumi Airport to them
- Suvarnabhumi impact to respondent (ranking in order)
  - Noise–traffic–safety–visual impact–air pollution–property value–other impacts
- Level of impact to respondent for each factor (Likert scale level from no impact to very high 0–5)
  - Noise–traffic–safety–visual impact–air pollution–property value–other impacts
- Noise impact to respondent (Likert scale level from no impact to very high 0–5)
  - Sleep–work concentration–health impacts–daily activities–property value–shaking
- Government measures on noise pollution to respondent awareness (Yes/No/Don't know)
  - Rules & regulations–tax & fees–compensation–other measures
- Level of efficiency of government measures (Low/Medium/High)
  - Rules & regulations–tax & fees–compensation–other measures
- Others

1. Suvarnabhumi Airport has more positive than negative impacts
   (Agree/Not agree/No opinion)
2. Noise level will not increase in the next five years
   (Agree/Not agree/No opinion)

(*continued on next page*)

Box (*continued*)

3. Government policies are enough to deal with the impacts and effects
   (Agree/Not Agree/No Opinion)
4. Airport authority has enough policies to deal with the impacts and effects
   (Agree/Not agree/No opinion)
5. The magnitude of airport pollutions to property value
   (Range from − 25% to + 25% with 5% increase in each level)

- For survey design, the study compared the neighborhoods from selected 63 villages/locations near the airport (e.g., Pracha Ruam Chai Community, Manasiri Village, Soi Ladkrabang 44, Soi Ladkrabang 46, Soi Dee Dee, Weruwan Wattana Community, Kehanakorn Village, and Happy Place Village). In addition, data were collected on Suvarnabhumi property values, based on the three noise level areas including NEF 30–35, NEF 35–40, and NEF > 40[5].
  There are some studies that also applied the survey of residential real estate agents to evaluate the factors influencing house prices. A recent survey of residential real estate agents in England indicated that the airport flight path adversely affected by house values 15% [25].

2. Measurement and analysis of noise levels in the airport and neighborhoods around the airport are carried out by 15 noise monitoring stations at Suvarnabhumi.
   - Area noise: The noise levels (L90, Leq24, Lmax, Ldn) are monitored continuously 24 h for 13 stations. The monitoring results are conducted monthly and the monitoring report is submitted every 6 months.
   - Noise generated from east and west runways: The noise levels (Leq) (5 min), Sound Exposure Level (LAE) and Perceived Noise Level (PNL) are monitored continuously for 24 h a day during project operation.
   - Limitations: Noise levels at only 15 noise stations can be collected; therefore this study uses perception levels of noise impact from public surveys as an explanatory variable.
3. Measurement and analysis of air pollution levels around the airport are carried out by 2 air monitoring stations nearby Suvarnabhumi Airport: Keha Chumchom Bangplee Sumutprakan Area and Thai Meteorological Department Area. Thailand Air Quality Index is calculated by 5 categories of Air Quality Standard: 1) Ozone (O_3), 2) nitrogen dioxide (NO_2), 3) carbon monoxide (CO), 4) sulfur dioxide and 5) dust < 10 μm (PM_{10}). However, there were some limitations of the air pollution data as air pollution monitoring stations were not exactly the same as the study area, leading to the use of public survey of air pollution impact levels as an explanatory variable.
4. Safety, visual, and traffic impacts had no descriptive data to be collected during the study period. Therefore the study used the impact level of each factor from public survey as explanatory.
5. Property values changes
   Property values were collected from the Land Department, the Treasury Department, property developers, property advertisements, and surveys of land plots.
   Regarding property value assessment, the data values that belong to the official database of the Treasury Department and the Land Department are used as an official baseline for market businesses, tax purposes and collateral assessments by local financial institutions as well as survey results.
   These assessment values are revised every four years on a nationwide basis, with the newest values to be used from 2013 to 2016 (based on assessing survey of property prices during the year 2008–2010). Official assessment values for the period of 2004–2007 and 2008–2012 (based on survey and analysis during 2–3 previous years for those periods) were not changed for the areas studied. Therefore, those values were used as "Before-Suvarnabhumi Airport" values.
   For "After-Suvarnabhumi Airport", this study used official assessment values from the Treasury Department and the Land Department. These official values come from three sources: 1. Actual buying/selling transaction prices from the Land Department, 2. prices from surveys of land plots during the period 2007–2009, and 3. prices from property advertisements. The median of prices from these three sources is then calculated and used as representative "After" price for each area. The prices from surveys of land plots which include housing, housing prices were deducted from total prices to get only property prices. In some cases, furniture prices were also excluded.
   During the study period year 2010, only limited official assessment values were available. The study collected property prices both before and after Suvarnabhumi Airport from selected 63 villages/locations near the airport cover area NEF > 40 dB, NEF 35–40 dB, and NEF 30–35. However only 8 locations can be collected. The property prices change with the range −58% to 1%. Therefore, this study used survey values as dependent variable data for the regression model instead of official assessment values. However, some impartial measures show similar trends as the survey results. In addition, the survey study covers 300 samples which are large enough to be normal distribution based on the Central Limit Theorem.
6. In-depth interviews: Interviews with stakeholders were drawn from political sectors, government sectors, municipal/local authorities, ENGOs, NGOs, CBOs, civil society sectors (formal and informal sectors), mass media authorities, migrants that were forced or chose to move out from the airport vicinity, and beneficiaries.
7. Compensation package: Information was obtained from the Airports Authority of Thailand, National Environmental Board's resolution, The Cabinet's resolution and The Airports of Thailand Public Company "AOT" Board's resolution. The compensation payments will be made by The Airports of Thailand Public Company based on the actual flight situation according to the Cabinet's resolution and the AOT Board's resolution. The compensation for noise impact can be categorized into two groups 1) NEF > 40 areas and 2) NEF 30–40 areas.

4. Regression analysis

Regression analysis was used to assess aviation noise impact and other impacts as well as their relationships to property value changes. Data used for the analysis were obtained from the survey study of neighborhoods located near Suvarnabhumi Airport. In the analysis, the study modeled the percentage change in property values around Suvarnabhumi Airport as a dependent variable (Y) that may be tentatively expressed as a function of a number of aviation factors that might affect Y, including noise, traffic, air pollution, safety and visual impacts. These factors are treated as independent variables and denoted by X_1, X_2, X_3, X_4, and X_5, respectively.

The regression equation can be expressed as follows:

$$Y = F(X_1, X_2, X_3, X_4, X_5) + \xi_t \quad (1)$$

- Dependent variable Y = the percent change in property value changes[6]
- Independent variable X_1 = noise impact

[5] NEF 30–35 means Noise Exposure Forecast at Leq 60–65 dB, NEF 35–40 means Noise Exposure Forecast Leq 65–75 dB and NEF > 40 means Noise Exposure Forecast at Leq > 70 dB.

[6] The percent change in property value changes collected from interviewed person survey.

- Independent variable X_2 = traffic impact
- Independent variable X_3 = air pollution impact
- Independent variable X_4 = safety impact
- Independent variable X_5 = visual impact
- the regression residual = ξ_t

The results from the regression analysis can be used in determining whether there is a significant linear relationship between 2 variables. The hypothesis is a statement about the value of a population parameter developed for the purpose of testing a theory or belief [19]. The relationship between an independent variable, X, and the dependent variable, Y, can be expressed as a coefficient, beta, or the slope. T-tests are also used to determine that the relationship differs significantly from zero. The values of the coefficients, or beta values, resulting from the regressions to be performed would represent the change in property value per unit change in their corresponding independent variables. The study also checked for the existence of multicollinearity[7] and heteroscedasticity[8] using White's heteroscedasticity test.[9] Survey study[10] and regression analysis were applied to explore the relationship between aviation factors and property value changes. Based on many arguments in the literature related to the impacts on residential property due to airports, this research is expected to find a negative relationship between property value change and aircraft noise.

Furthermore, cross-country comparison was applied to compare the effectiveness of environmental policies and measures of selected countries including the United States, the United Kingdom, Japan, China and Hong Kong, where international airports meet international standards (Appendix A). Combining regression analysis and cross-country analysis, tentative factors (aviation impacts) influencing property value changes were selected based on the criteria of common use in both worldwide compensation package design and the Thailand case. Through literature review, potential factors to be used for formulating the appropriate compensation model and providing the recommendations to improve Thailand aviation policies were determined.

5. Results

The overall results mainly focus on the regression analysis outcomes of three compensation models for neighborhood areas, residents, and businesses.

5.1. Survey results

According to survey results, the number of buildings in the 30–40 NEF zones is around 15,000 buildings, which represent the majority of affected buildings (96% of total affected building). This study surveyed 300 samples covering the entire population who live, work, or do business in the areas of 30–35 NEF (120 samples) and 35–40 NEF (180 samples) by using random sampling. The bio-data of the sample groups are illustrated in Table 1.

The survey results show that the most crucial aviation impact is noise, which has the highest impact from all areas, with 22% of responses. As can be seen from the bar chart, 21% and 22% of people who live in NEF 30–35 and NEF 35–40 areas agreed that the noise impact is the most severe of the factors. Traffic and property value impact are also a high priority to the residents around the airport, with both factors receiving 17% of responses. These impacts (noise, traffic and property value) aggregated to more than half the total impact to the population. Noise impact, as well as traffic impact, from the airport ranges from medium to very high. In particular, noise impact in NEF 30–35 and NEF 35–40 areas ranges from medium to high and medium to very high, respectively; while other impacts varied from low to very high. The levels of aviation impacts from the surveys are illustrated in Fig. 1.

Table 1
Bio-data of sample group.

Category		
Sex	Male	49%
	Female	51%
Age group	20–29	31%
	30–39	30%
	40–49	28%
	50+	11%
Type of activities	Resident	74%
	Work/employee	13%
	Business owner	13%
Time staying in Suvarnabhumi Airport area	>1 yr	26%
	1–3 yr	16%
	>3 yr	58%

Based on the survey results of level of impacts, from having Suvarnabhumi Airport, the negative impacts that affected respondents due to each factor were ranked with noise being reported to have the most negative impact, followed by traffic and property value loss, and air pollution, respectively. Regarding the NEF 30–35 dB area, the magnitude of impact ranges from medium to high for noise and traffic, medium to very high for property value loss, and low to high for air pollution. For the NEF 35–40 dB area, the magnitude of impact ranges from medium to very high for noise, traffic and pollution and from low to very high for property value loss.

As for the awareness of government policies and measures on various perspectives (including rules/regulations, tax scheme, compensation and public relations), it was found that people in the area had a low awareness and recognition of the tax scheme, compensation, and rules/regulations, while policies related to public relations generated more awareness among the survey respondents. The majority of the population agreed that the policies related to rules and regulations are moderately effective while economic instruments have some

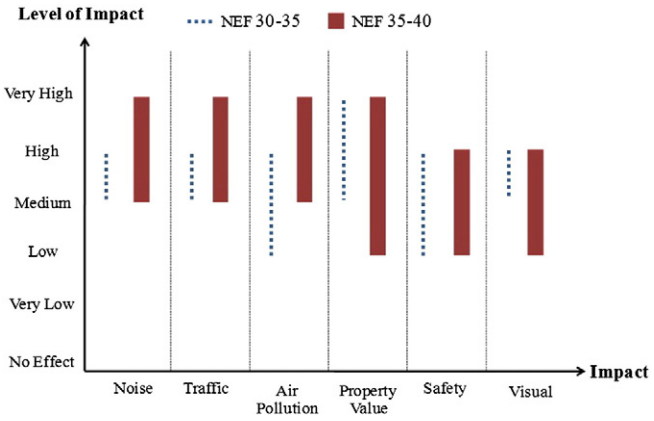

Fig. 1. Level of aviation impacts to respondents after Suvarnabhumi Airport operational phase. X axis implies impact factors affected to respondents after Suvarnabhumi operational phase. Y axis implies level of each impact factor affected to respondents after Suvarnabhumi operational phase. Source: Analyzed from survey results after Suvarnabhumi Airport operational phase, 2009.

[7] Multicollinearity refers to the existence of a relationship between the independent variables in a multiple regression. Ideally, in a multiple regression model, different independent variables should be uncorrelated.

[8] Heteroscedasticity refers to non-constant variance of residuals. The effect of heteroscedasticity is that the t-tests and *F*-tests for the coefficients are not valid.

[9] White's heteroscedasticity test = a statistical test to determine the presence of homogeneity of variance of residuals in a regression model.

[10] Public surveys (questionnaires) for 2 sample groups of 300 total samples: (a) affected people in NEF 30–35 area with 120 samples and (b) affected people in NEF 35–40 area with 180 samples.

effectiveness, and policies related to aircraft technology are believed to have low to moderate effectiveness levels.

5.2. Regression variables analysis

5.2.1. Property value changes

There are some impartial measures that show similar trends in property values to survey results after the construction of Suvarnabhumi Airport. This analysis attempts to compare property prices around the airport area for each noise level area (30–35 NEF, 35–40 NEF, and >40 NEF) both before and after the airport's development. Before the construction of Suvarnabhumi Airport, prices of land near the airport had risen by around 47% since 1998, compared to 29.7% for other plots in Bangkok. During the construction, land prices around the airport rose 6% during the period due to improving facilities and the government's planned transport links (compared to average 4% increase in Greater Bangkok during 2005–06). However, in 2009 overall land prices around the airport area decreased 6–15% compared to 16% increase for the Bangkok area. The findings were obtained from both official assessment values announced by the Treasury Department and survey values.

The effort focused on comparing the neighborhoods which have both "Before" and "After[11]" property prices, based on the three noise level areas and found the change in property prices to be as shown in Table 2.

Table 3 shows downward trends on property values, comparing the before and after periods in most of the areas. The survey results in Table 3 also show a similar trend to the descriptive data. Most respondents perceive that aviation impacts led to property value loss.

In addition, one study of Suvarnabhumi Airport indicated that prices of new properties sold after 2006 are 19.15% lower in the most severely affected area and 8.55% lower in moderately affected areas [5].

Moreover, there is some evidence that shows a similar trend to that from the survey results. The Federal Aviation Administration [24] indicated that there was a negative impact on residential property market values based on regression of data from three airports Baltimore/Washington International Airport (BWI), Los Angeles International Airport (LAX), and John F. Kennedy Airport in New York. A recent survey of residential real estate agents in England indicated that the airport flight path adversely affected house values 15% ([14]).

5.2.2. Noise levels

After the official opening of the airport, there were approximately 700 flights per day. Not surprisingly, this led to an aircraft noise problem. The residents who lived around the airport complained to the government and media that they were affected by noise pollution. This was especially true with the villages located to the north and south of the airport, such as Romsook Villa, Wat Ladgrabang Community, Green Valley Village and Wat Bang Chalong Community.

During the period of 4–10 October 2006, the Pollution Control Department of Thailand and the Department of Environmental Quality Promotion examined noise levels in the areas around the airport and found that, after the official opening of the airport, the average noise figures rose about 3.9 to 13.3 dB as shown in Table 4.

According to Table 5, respondents perceive the level of noise impact on them to be high and very high, at approximately 72%. This can imply that after the official opening of the airport, noise pollution is the crucial impact to people nearby the airport area. Although perception data by itself cannot be represented, the average noise figures in Table 4 rose similarly as respondents perceived in Table 5.

Additional support of this trend can be found in research on 'An Estimate of the Global Impact of Commercial Aviation Noise', based on 181 airports around the world (these airports are located in 38 countries plus Taiwan, with 95 of the airports located in the United States by [25]). The APMT Noise Module by the FAA's Model for Assessing Global Exposure to the Noise of Transport Aircraft (MAGENTA) is used to examine the trend. Population data were collected in the years 2000 and 2001, depending on the country, whereas house prices and rents are 2006 estimates, and noise levels are for the year 2005. This particular study concluded that the noise resulted in a total of $21 billion of housing value depreciation (which is equivalent to about $1.1 billion per year using a 30-year life of the house and a 3% discount rate) and an additional $800 million of lost rent each year.

Table 2
Percent change of property price around Suvarnabhumi Airport by different noise zones. Source: Data were collected by the study from three sources including the Land Department, surveys, and property advertisements.

Village/location	Zones	Property value (THB/square wah)		% changes
		2004–2007 (before)	2012–2015 (after)	
Pracha Ruam Chai Community	NEF > 40	10,000	6771	−32%
Manasiri Village	NEF 35–40	17,000	11,111	−35%
Soi Ladkrabang 44	NEF 35–40	13,000	13,125	1%
Soi Ladkrabang 46	NEF 35–40	15,000	15,000	0%
Soi Dee Dee	NEF 35–40	13,000	10,417	−20%
Weruwan Wattana Community	NEF 35–40	6800	4000	−41%
Kehanakorn Village	NEF 30–35	12,000	5000	−58%
Happy Place Village	NEF 30–35	10,000	10,000	0%

Note: For survey values which include housing, housing prices were deducted from total prices to get only property prices. In some cases, furniture prices were also excluded.

5.2.3. Air pollution levels

The monitoring of air pollution levels around the airport is carried out by 2 air monitoring stations nearby Suvarnabhumi: Keha Chumchom Bangplee Sumutprakan Area and Thai Meteorological Department Area. However there were some limitations of air pollution data as air pollution monitoring stations were not exactly the same as the study area. This might have led to the inclusive results after the official opening of the airport in the year 2006. There were no explicit trends of increase in air pollution after 2006. In addition, during the construction period some air pollution such as dust might have increased as shown in Table 6.

The survey result on level of air pollution impacts in Table 7 indicates that level of air pollution impacts was perceived by 36% of respondents to high to very high. This result is quite inconclusive compared to data from air pollution stations.

Moreover, an empirical study of health impact assessment of aircraft noise exposure found that residents nearby Don Mueang and Suvarnabhumi Airport were exposed to aircraft noise at a level that could negatively impact aspects of health, such as quality of life, general health problems and memory ability [26]. The Suvarnabhumi Airport EIA report shows the environmental impacts related to transportation, public health and safety. During the construction phase the report indicated impacts of degraded road, accidents, noise, increased traffic and unsafe conditions in worker camps. During the operation phase the report indicated impacts of traffic congestion and air pollution which can impact public health. Similarly to the EIA report of Washington National Airport, the study concluded that noise is a serious problem for some individuals, affecting behavior and perhaps even health. However, other impacts, such as air pollution and safety, were also listed as significant concerns for the national airport. Therefore these factors might impact expectations of property values for residential areas.

[11] Property prices used during 2012–2015 were surveyed and calculated in 2007–2009.

Table 3
Summary of survey results of respondents' perceptions on magnitude of impact on property value changes.

Survey results										
No. of respondents perceive about magnitude on property value change from aviation impacts										
Property value change	−25%	−20%	−15%	−10%	−5%	0%	5%	10%	15%	Total
Resident (no. of respondents)	35	67	73	38	9	1	0	0	0	223
Work (no. of respondents)	0	2	9	13	7	4	1	1	0	37
Business (no. of respondents)	0	1	10	13	8	3	2	2	1	40
Total (no. of respondents)	35	70	92	64	24	8	3	3	1	300
Percentage to total observations	12%	23%	31%	21%	8%	3%	1%	1%	0%	100%

5.2.4. Traffic, safety and visual

Due to the limitations of descriptive data on traffic, safety and visual nearby the Suvarnabhumi Airport area, this study applied the survey results as explanatory variables which are shown in Table 8.

According to the survey results in Table 8, 45%, 36%, and 31% of respondents perceive that levels of traffic, safety and visual impacts, respectively, to them are high to very high. It can be seen that less than half of respondents perceive these 3 factors as crucial impacts.

5.3. Relationship between aviation impact and property value changes

The level of aviation impact may be different depending on the segments of the sample because their expectation and sensitivity to noise, activities and beneficial impacts of the airport on property are different. Therefore, affected people in this study were divided into residential and commercial populations due to the fact that normal daily activities of these groups are impacted by airport operations in very different ways. Residents who experience more exposure to negative impacts from airport, particularly during leisure and night time, will have a negative perception from living in affected areas. Commercial users, on the other hand, may receive some advantage with respect to a healthier economic situation driven by airport activities. Hence, the regression models began by examining overall neighborhoods then focusing on residents and businesses respectively.

Three regression models, including models for overall neighborhoods, residents and businesses, were done. In each category, we first tested the state hypothesis to prove whether variable Y and X are dependent. The null hypothesis "Beta = 0" is the hypothesis that would be rejected for a variable X if Y and X are independent. The alternative hypothesis "Beta ≠ 0", if accepted, would then show that variable Y and X are dependent. As the significance level for this study is 5%, the null hypothesis will be rejected if the P-value of a variable X is less than 5%. Thus that variable X would have a significant effect on variable Y (percent change in property value).

5.3.1. Compensation Model I — overall neighborhood

For overall neighborhood regression analysis, two independent variables (noise and air pollution) have statistically significant relationships with the dependent variable. The remaining three independent variables are not statistically significant as defined by this study [2].

According to Table 9, the only two variables from the overall regression analysis that show significant effect on the percent change in property value are noise and air pollution impacts. The equation based on this conclusion is as follows:

$$Y = (-0.040)X_1 + (0)X_2 + (-0.014)X_3 + (0)X_4 + (0)X_5 + 0.041 \quad (2)$$

where the constant .041 is the residual value for this regression.

Based on the regression results, only two variables, X_1 and X_3, show P-values less than 0.05 which means that only two of the five variables examined have a significant effect on the percent change in property value. The beta coefficients of X_1 and X_3 are −0.04 and −0.014, respectively, which means that for each unit increase in the noise impact the property value decreases by approximately 4% and for each unit increase in the air pollution impact the property value decreases by approximately 1.40%, while keeping other factors constant in each case. The residual value of 0.041 implies that in the absence of noise and air pollution impact (X_1, $X_3 = 0$) the property value would still increase by approximately 4.1%.

In terms of economic significance, it can be observed that the noise impact variable, X_1, (absolute standardized coefficient = 0.538) has more impact on property price than the air pollution impact variable, X_3 (absolute standardized coefficient = 0.293). In order to detect multicollinearity, the study seeks independent variables which are insignificant at 5% level. However, it can be observed that the VIFs for the three insignificant independent variables (traffic, safety and visual impact) are not more than five which implies that multicollinearity is not a problem in this case.

White's heteroscedasticity test is also used to check the assumption of equal variance (homoscedasticity) as follows:

H_0: homoscedasticity
H_1: heteroscedasticity

The null hypothesis determines that the variances of the data are equal and the data is homoscedastic. The alternative hypothesis is that the variances are not equal, or the data is heteroscedastic.

The study also found that the null hypothesis of homoscedasticity of errors is not rejected because the value of $N * R^2$ ($300 * 0.013 = 3.9$), which follows a chi-square distribution, is less than the critical value of 18.31 at 5% significance level (Table 10). Therefore, there is no heteroscedasticity or non-constant variance of residuals.

5.3.2. Compensation Model II — residents

In the regression analysis for residents, the study found that two independent variables i.e. noise and air pollution have statistically significant relationships with the percent change in property value, having P-values is less than 0.05 just as in the overall neighborhoods regression analysis. The remaining three independent variables are not statistically significant at the 5% level. The model fit according to Table 11 is quite

Table 4
Comparison of noise level between before and after opening of Suvarnabhumi Airport. Source: Royal Thai Government (www.thaigov.go.th/pageconfig/viewcontent/viewcontent1.asp?pageid=451&directory=1782&contents=774&searchtxt=).

Location	Average noise level (decibel A)		
	Before	After	Increase of noise level
Nakarin Garden Village	52.0	65.3	13.3
Romsook Village	60.2	70.0	9.8
Town Houses on On-Nuch Road	68.7	73.2	4.5
Thana Place	46.3	55.8	9.5
Krirk Institution	63.6	67.5	3.9
Wat Bang Cha Long Nai	56.2	67.5	11.3

Table 5
Survey results on level of noise impacts.

Level of impact		No effect	Very low	Low	Medium	High	Very high	Total
		0	1	2	3	4	5	
No. of respondents perceive about noise impact on each level	Resident	0	1	5	50	84	83	223
	Work	1	0	2	13	8	13	37
	Business	1	2	2	9	18	8	40
	Total	2	3	9	72	110	104	300
	Percentage	1%	1%	3%	24%	36%	35%	100%

Table 6
Comparison of air pollution between before and after opening of Suvarnabhumi Airport.
Source: Pollution Control Department, Ministry of National Resources and Environment.

	Year										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Keha Chumchon Bangplee area air qualities											
Monthly average SO_2/h (ppb)	2.6	2.1	2.7	3.3	3.0	3.6	3.2	2.4	3.6	1.5	2.1
Monthly average NO_2/h (ppb)	11.4	12.3	13.9	15.7	14.8	12.6	11.7	12.8	14.1	13.1	17.9
Monthly average dust < 10 μm (PM_{10})/24 h (μg/m^3)	104.1	103.6	122.7	130.1	85.4	60.2	58.1	48.0	43.1	44.6	60.2
Thai Meteorological Department Bangna area air qualities											
Monthly average SO_2/h (ppb)	4.7	4.5	5.5	5.8	6.6	6.4	5.7	4.8	4.8	4.4	2.3
Monthly average NO_2/h (ppb)	20.0	15.4	17.5	14.3	16.	19.3	19.5	16.2	19.0	15.3	14.3
Monthly average CO/h (ppb)	0.9	0.9	0.8	0.8	0.7	0.5	0.5	0.5	0.7	0.8	0.5
Monthly average O_3/h (ppb)	11.3	13.5	14.3	6.6	13.9	13.7	13.7	17.6	18.2	13.5	13.5

reasonable since R^2 is 43.2% and adjusted R^2 is 41.9%. Adjusted R^2 is quite similar to R^2 which implies that there is not an excessive use of variables.

The equation obtained by the analysis of resident model can be illustrated as follows:

$$Y = (-0.035)X_1 + (0)X_2 + (-0.013)X_3 + (0)X_4 + (0)X_5 + -0.002 \quad (3)$$

where the constant −0.002 is the residual value for this regression.

The beta coefficients of X_1 and X_3 are −0.035 and −0.013, respectively, which means that, keeping all other factors constant, for each unit increase in the noise impact the property value decreases by approximately 3.5% while for each one increase in the air pollution impact the property value decreases by approximately 1.30%. Here the regression residual value of −0.002 would imply that in the absence of the aforementioned impacts (X_1 and $X_3 = 0$) the property value would decrease by approximately 0.2%.

In terms of economic significance, from standardized beta coefficients it can be noticed that the noise impact variable, X_1, (absolute standardized coefficient = 0.543) has more impact on property price than the air pollution impact variable, X_3 (absolute standardized coefficient = 0.368). In order to detect multicollinearity, independent variables which are insignificant at 5% level are observed. However, it identifies that the VIFs for the three insignificant independent variables (traffic, safety and sceneric) are not more than five which implies that multicollinearity is not a problem. Moreover, White's heteroscedasticity test was also used to check the assumption of equal variance (homoscedasticity). It also found that the null hypothesis of homoscedasticity of errors is not rejected because the value of $N * R^2$ ($300 * 0.018 = 5.4$) which follows a chi-square distribution is less than the critical value of 18.31 at 5% significance level. Therefore, there is no heteroscedasticity or non-constant variance of residuals.

5.3.3. Compensation Model III — businesses

Similarly, the regression analysis for businesses indicated that the same two independent variables, noise and air pollution, have statistically significant relationships with percent change in property value, both with P-values under 0.05. The remaining three independent variables are not statistically significant at the 5% level. The model presented adjusted R^2 of 39.6%.

According to Table 12, it illustrated that two variables including value are noise and air pollution impacts according to regression analysis results for residents that have a significant effect on the percent change in property value. Hence, the equation is rewritten based on this conclusion as follows:

$$Y = (-0.033)X_1 + (0)X_2 + (-0.014)X_3 + (0)X_4 + (0)X_5 + 0.076 \quad (4)$$

where the constant .076 is the residual value for this regression.

Table 7
Survey results on level of air pollution impacts.

Level of Impact		No effect	Very low	Low	Medium	High	Very high	Total
		0	1	2	3	4	5	
No. of respondents perceive about air pollution on each level	Resident	19	19	48	51	47	39	223
	Work	0	6	5	13	3	10	37
	Business	4	6	12	7	8	3	40
	Total	23	31	65	71	58	52	300
	Percentage	8%	10%	22%	24%	19%	17%	100%

Table 8
Survey results on level of traffic, safety and visual impacts.

Level of impact		No effect	Very low	Low	Medium	High	Very high	Total
		0	1	2	3	4	5	
No. of respondents perceive about traffic impact on each level	Resident	9	18	38	54	66	38	223
	Work	3	7	7	6	12	2	37
	Business	4	1	7	13	8	7	40
	Total	16	26	52	73	86	47	300
	Percentage	5%	9%	17%	24%	29%	16%	100%
No. of respondents perceive about Safety impact on each level	Resident	29	25	44	49	47	29	223
	Work	3	3	5	13	10	3	37
	Business	3	4	2	11	10	10	40
	Total	35	32	51	73	67	42	300
	Percentage	12%	11%	17%	24%	22%	14%	100%
No. of respondents perceive about visual impact on each level	Resident	34	30	39	53	37	30	223
	Work	6	5	5	9	10	2	37
	Business	5	5	3	13	10	4	40
	Total	45	40	47	75	57	36	300
	Percentage	15%	13%	16%	25%	19%	12%	100%

Table 9
Overall neighborhoods regression analysis — Coefficient summary*.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Std. error	Beta			Tolerance	VIF
1	(Constant)	0.041	0.017		2.358	0.019		
	Noise impact	−0.040	0.003	−0.538	−11.904	0.000	0.985	1.015
	Traffic impact	1.06E−005	0.002	0.000	0.005	0.996	0.977	1.024
	Air pollution	−0.014	0.002	−0.293	−6.501	0.000	0.988	1.012
	Safety	0.004	0.002	0.083	1.840	0.067	0.992	1.009
	Visual impact	0.001	0.002	0.031	0.696	0.493	0.977	1.024
Adjusted R^2		0.398						
F-test		40.539				0.000		

* Dependent variable: Property value changes.

Here the beta coefficients of X_1 and X_3 are −0.033 and −0.014, respectively, which means that, with all other factors held constant, for each unit increase in the noise impact the property value decreases by approximately 3.3% while for unit one increase in the air pollution impact the property value decreases by approximately 1.40%. This regression's residual value of 0.076 indicates that if there were no impact from noise and air pollution (X_1 and $X_3 = 0$) the property value would increase by approximately 7.6%.

In terms of economic significance (from standardized beta coefficients as shown in Table 6), it verified once again that the noise impact variable (absolute standardized coefficient = 0.517) has more impact on property price than the air pollution impact variable (absolute standardized coefficient = 0.275). Multicollinearity was not a problem for the 3 insignificant variables. However, in this case, we found that the null hypothesis of homoscedasticity of errors is rejected because the value of $N * R^2$ ($300 * 0.232 = 69.6$), which follows a chi-square distribution and is more than the critical value of 18.31 at 5% significance level. According to Cai and Hayes [6], the problem of heteroscedasticity can be solved by employing a heteroscedasticity-consistent covariance matrix (HCCM) estimator.

Table 10
Overall regression analysis — White's heteroscedasticity test model summary.

Model	R	R^2	Adjusted R^2	Std. error of the estimate
1	0.114[a]	0.013	−0.021	0.00501

[a] Predictors: (Constant), Visual impact, Noisesq, Safetysq, Air pollution, Trafficsq, Visualsq, Safety, Airsq, Traffic, Noise.

5.3.4. Summary of regression analysis

The most common factors which affect property value are noise, air, and traffic pollution. From the abovementioned analysis, the results show that all groups (overall neighborhood, residents, and businesses) demonstrate similar results — that is, noise and air pollution are considered to be significant factors to percentage change in property value, as compared with traffic, safety and scenery. The comparison of each group is summarized in Table 13.

6. Discussion

Although many previous studies of factors affecting property values have focused only on the relationship between noise impact and changes in property prices or residential values, this study provides additional consideration of multiple factors and their impact on different types of land use. One such example of a typical existing study is that of the Toronto Airport case [8] in which the "Surrounding Airport Area" was compared to "non-airport areas".[12] Furthermore, other studies suggested that not only a Hedonic Model,[13] a common technique used to compare the changes in property prices [4,11,16], but also multiple-regression can be applied. It is suggested from the results of this study that the weight of each factor in compensation models might be

[12] Crowley [8] found statistically significant differences in the changes of prices in surroundings airport area when compared to non-airport areas including (1) North York area; (2) Scarborough area; and (3) the aggregate of North York and Scarborough area.

[13] The hedonic model was originally initiated by Griliches (1971). It reflects the price relationship that specifies the price of brand as function of quantities of variety of features or characteristics.

Table 11
Regression analysis for residents — Coefficient summary*.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Std. error	Beta			Tolerance	VIF
1	(Constant)	−0.002	0.016		−0.093	0.926		
	Noise impact	−0.035	0.003	−0.543	−10.563	0.000	0.991	1.009
	Traffic impact	0.002	0.002	0.059	1.130	0.260	0.970	1.031
	Air pollution	−0.013	0.002	−0.368	−7.174	0.000	0.995	1.005
	Safety	0.002	0.002	0.045	0.867	0.387	0.989	1.011
	Visual impact	0.001	0.002	0.042	0.817	0.415	0.975	1.025
Adjusted R^2		0.419						
F-test		32.975				0.000		

* Dependent variable: Property value changes.

Table 12
Regression analysis for businesses — Coefficient summary*.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
		B	Std. error	Beta			Tolerance	VIF
1	(Constant)	0.076	0.031		2.454	0.017		
	Noise impact	−0.033	0.006	−0.517	−5.504	0.000	0.902	1.108
	Traffic impact	0.003	0.005	0.057	0.619	0.538	0.946	1.057
	Air pollution	−0.014	0.005	−0.275	−2.935	0.004	0.905	1.105
	Safety	0.000	0.005	−0.010	−0.105	0.917	0.961	1.041
	Visual impact	−0.002	0.004	−0.032	−0.356	0.723	0.965	1.037
Adjusted R^2		0.396						
F-test		10.954				0.000		

* Dependent variable: Property value changes.

different according to different land use types i.e. the noise factor in residential areas should have more weight in the model than in business areas.

6.1. Application of results

The current compensation packages of the Suvarnabhumi International Airport have been focused only on the mitigation of noise impacts, not truly reflecting the overall impact on affected communities based on the analysis of the study. This compensation package seems to be based on the environmental justice theory. However, many policy arguments about the compensation package issue are still ongoing in Thailand. Mainly compensation packages were based on the noise contour. According to the Cabinet's resolution on May 29, 2007 and the AOT Board's resolution on June 21, 2007, affected buildings were divided into two areas, NEF > 40 and NEF 30–40, which were compensated differently. As of February, 2011, AOT had already compensated 411 houses through either purchase or insulation in the NEF > 40 area, as well as 967 houses through insulation and provision of financial support in the NEF 30–40 area under the summer noise contour Fig. 2. The amount of 1.036 billion baht (~USD 34 million[14]) has been paid to both areas through which 93 houses were purchased, 1265 houses were insulated and 20 houses were provided with financial support. Moreover, 214 million baht has been paid to KMITL.

The following solutions should be taken into consideration by AOT and related authorities in designing appropriate compensation packages. The minimum compensation package should be based on true environmental justice. Therefore, compensation packages should include all factors which have a significant impact on affected people around the airport. The main contribution of this research is to improve Thailand's compensation model by indicating factors with significant impacts, using property value change as proxy to measure impacts on airport. Further improvement of compensation policy should consider the principle of reciprocal market exchange theory and the market value of property loss should be taken into account for designing the compensation rather than considering only impacting factors. The 3 regression models developed in this study indicated the significance of noise and air pollution factors that substantially affect the percentage change in property value. Meanwhile other impacts (e.g. traffic, safety, and scenery impacts) were shown to be statistically insignificant. This phenomenon can be explained that as the airport is located in a suburban area with low traffic congestion, meaning traffic impact is not a major factor which affects property value changes. Also, as Thailand is a developing country, it was expected that there would not be a strong focus or value placed on safety or esthetics, which is consistent with the survey results. At another airport in United States, WH Morse State Airport in Bennington County, noise and traffic pollutions are major concerns expressed at public meetings between the community and Bennington County Regional Commission (BCRC) to discuss runway expansion. This implies that airport location is one factor which can create different impacts on communities. The more traffic congestion nearby the airport location, the higher the level of impact it will have on communities. Nevertheless, noise pollution impact is still the leading factor affecting airport operation and expansion in several airports.

However, the effects from noise have higher impact on property price than effects from air pollution.[15] Separate studies for residents and businesses show similar results of significant negative impacts of noise and air pollution on property values, while noise has higher impact. Nevertheless, air pollution impacts on property values for residences were slightly higher than for businesses, while impact of noise pollution on property values was almost the same for both residences

[14] 1 USD ~ 30.7 THB.

[15] The effects from airport pollutions (independent variables) to property values (dependent variable) can be measured by coefficient of each independent variable since range from 1 to 5 (from very low to very high impact) is set as a unit of impact to property value in respondent viewpoints. Therefore, the higher absolute coefficient of each pollution is, the higher impacts to property value are.

Table 13
Summary of regression analysis (overall neighborhood, residents, and businesses).

Regression analysis		Overall neighborhood	Residents	Businesses
R^2		0.408	0.432	0.435
Adjusted R^2		0.398	0.419	0.396
Unstandardized coefficients	Noise impact	−0.040*,**,***	−0.035*,**,***	−0.033*,**,***
	Traffic impact	1.06E−005	0.002	0.003
	Air pollution	−0.014*,**,***	−0.013*,**,***	−0.014*,**,***
	Safety	0.004	0.002	−0.000
	Visual impact	0.001	0.001	−0.002
Standardized coefficients[a]	Noise impact	−0.538*,**,***	−0.543*,**,***	−0.517*,**,***
	Traffic impact	0.000	0.059	0.057
	Air pollution	−0.293*,**,***	−0.368*,**,***	−0.275*,**,***
	Safety	0.083	0.045	−0.010
	Visual impact	0.031	0.042	−0.032
Number of observations		300	223	77

[a] Standardized beta coefficients are used to determine which of the independent variables have more impact on the dependent variable.
* Significant at the 0.05 level or better ($P < 0.05$).
** Significant at the 0.10 level or better ($P < 0.10$).
*** Significant at the 0.01 level or better ($P < 0.01$).

and businesses. Also, the results of 99% significant level are exactly the same as the results of 95% significant level. Therefore, Thai compensation packages should have noise effects and air pollution effects as main factors, with higher weight on the noise factor. Moreover, findings related to respondents' opinions show how the impacts change according to land use. Affected people who reside around the airport have more concern about noise impacts than those who work in these locations due to the longer exposure to noise disturbance and especially the impact on their normal daily activities, including sleep. Therefore, aviation policies/management and compensation packages

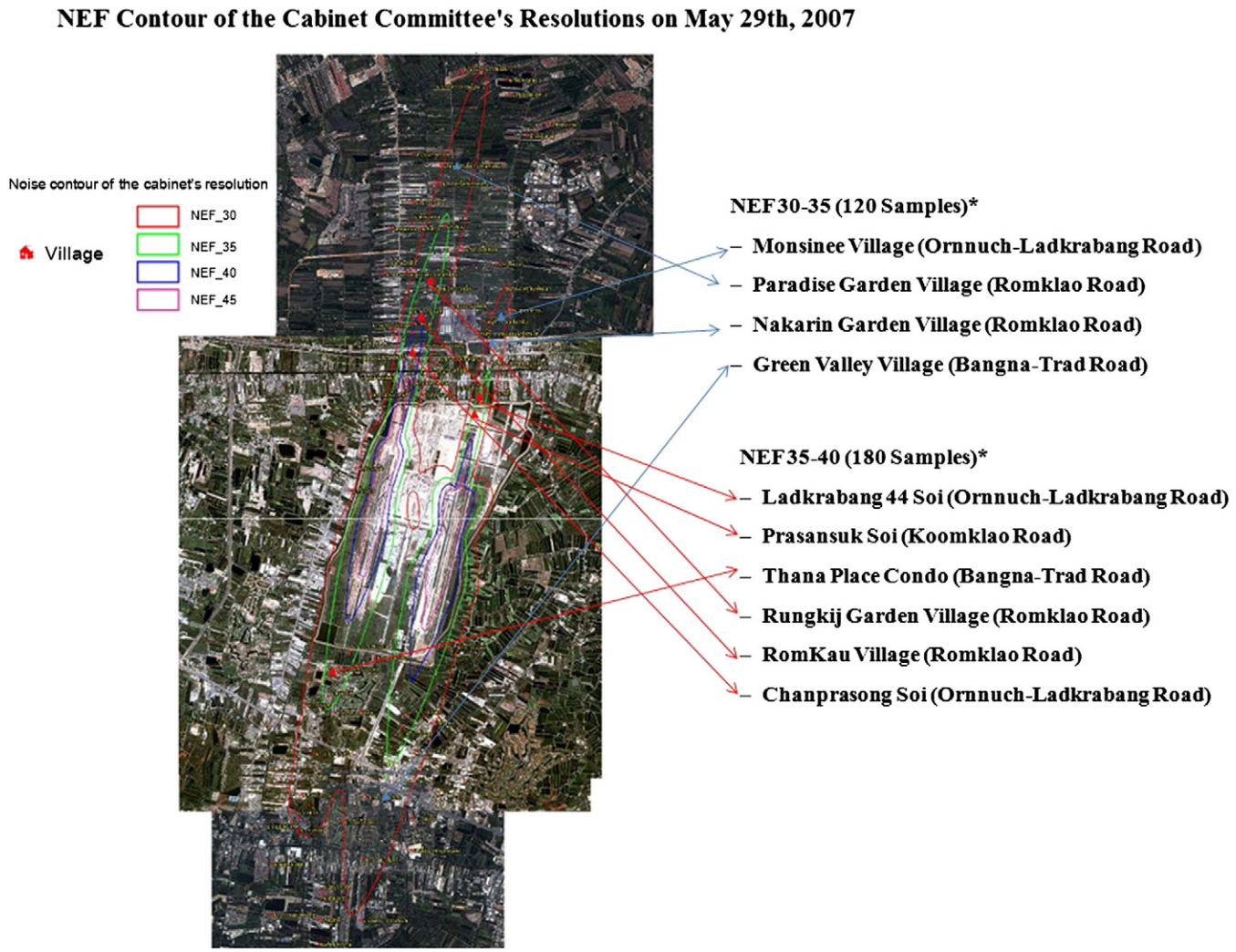

Fig. 2. Noise Contour of Suvarnabhumi Airport.

should be designed to consider the types of land use together with other conditions, such as the needs of each affected group. These findings would benefit aviation planners not only for the Suvarnabhumi International Airport, but also for other airports in Thailand and other cities. Other similar projects which have environmental impacts, e.g. construction projects like highways, can also use the results of this study by adjusting some factors and design criteria.

The investigation of adaption and effectiveness of aviation policies and instruments to reduce noise impacts was found to vary by country. Some countries have set up noise action plans to deal with the noise impacts, such as noise mapping and monitoring, and land use and zoning. Moreover, from an economic viewpoint, the findings demonstrate common measures in most countries, such as compensation schemes and landing and take-off fees. Concerning the social aspect, the effectiveness of aircraft noise complaint management and technology improvements with more quietly designed aircraft was found the most popular. The detailed results of cross-country comparison obtained by mixed-tools are summarized in Appendix A.

In the case of the Suvarnabhumi International Airport, its regulation requirements incorporate ICAO and USFAA standards with the aims of combating noise impacts. Consequently, the airport's noise mitigation efforts, such as general and technology regulations as well as social responsibility, have been implemented. Even economic measures were found to be similar among countries; however, compensation schemes may greatly vary depending upon the circumstances in each country. In terms of compensation schemes considered as economic tools, Thailand is used as a representative developing country to compare with developed countries. This study found two main problems that should be taken into account: 1) Not enough funding to pay and 2) unfair treatment of noise-impacted residents. Therefore, the studies of funding in developed countries can be applied. For example, in France, compensation schemes are partially funded by noise tax on departing aircraft. In Chicago, the Federal Aviation Authority reimburses 80% of the costs of the SSIP and in the UK, the financial burden of compensation schemes has been borne more fully by the airports [2].

Furthermore, resettlement plans would be one of the other concerns that should be taken into account in compensation schemes during the start of any project for policy makers. The study Resettlement action plan on New Airport Construction by Department of Transportation and Communication Bohol Provincial Government [9] introduces an interesting issue for considering compensation schemes. The study indicated methods of compensation determined as including Direct Cash Payment (exemption for taxation), Barter/Exchange (exemption from registration fee) and Expropriation process stipulated by RA8974. The interesting issue is that the resolution set up clear standards of compensation.

6.2. Model limitations

Since models were established by selected NEF areas, the location with +40NEF area is omitted. This choice is based on the reason that the area is located at the inner zone of the airport area which is mainly occupied by airport facilities and related airport businesses (e.g. warehouses). The second limitation is data of noise levels and property prices were tracked in different neighborhoods; the analysis can only be done depending upon available data. Furthermore, the study did not include possible positive factors e.g., intrinsic values of being located near the airport (the airport's presence could generate more business in the area that might enhance economic growth affecting property prices). Another limitation is the study assumed that other macroeconomics factors are used consistently for all the areas during the study period, so the effects on property value changes are only from the airport. Based on these reasons, the model might not fully interpret the real situation. Despite, these weaknesses, the model and its factors are powerful tools as useful guidance for aviation policy improvement.

7. Conclusions

In order to alleviate the controversy of compensation schemes, the explicit measurement models of developed countries would be beneficial tools. Therefore, Thailand should design a proper scientific measurement model to evaluate the appropriateness of compensation schemes rather than consider only noise contour. The study tried to improve compensation schemes by applied regression model as an empirical tool, combined with a cross-country analysis in order to identify gaps. The main finding of this study is the discovery of the significant negative relationship between aviation noise and the property value. The highlight of the study was postulated by assumptions on 5 potential aviation impacts that might affect the changes of property value based on the case of the Suvarnabhumi International Airport, including aviation noise, traffic, air pollution, safety and visual impact. These impacts were hypothesized to have a relationship with the percentage of change in value of 3 types of property (all neighborhoods, residents and businesses) near the airport. Although the airport operation and management system have complied with the regulations of ICAO and USFAA standards and are similar to other airports in many countries according to cross-country policy comparison, three regression models similarly indicated that noise and air pollution are the leading factors that affect the property value changes and should be primarily considered in the compensation policy of the airport.

8. Recommendations

The application of results can be applied to the Suvarnabhumi International Airport as well as contribute to other airports. However, to improve the compensation package, further studies should consider additional aviation impacts or factors such as level of income, level of education, age, length of stay, and location of the airport. Additional compensation packages in terms of the market value of property loss should also be added to the compensation schemes. More detailed surveys on groups of residents with different characteristics around the airport may affect their perception and may alter the factors and their significance on property value. The location of the airport may also change the significance of factors affecting property value. In addition, other factors which have positive effects on property value should also be explored and added to the compensation package model.

Because there are some limitations on this study in terms of data collection and modeling assumptions, the model in this study can be improved further to enhance the accuracy of the results, which would give a better justification for the compensation policy formulation. The improvement in data management and data availability for both dependent and independent variables would yield more precision. The discussion of results can also be expanded to compare this study to the analyses of negative impacts from other types of infrastructure construction, both in terms of level of impacts and compensation methods.

In terms of compensation policy, overall instrument options in developing countries still lack a good, reliable and functioning public body which led to perceptions of unfairness in compensation schemes. A significant reason for this perception is the high concentration of government power. The power of local municipalities and courts is still relatively limited. In addition, practices of developed countries can be applied e.g., the design or restructuring of a broad set of institutions including property rights, legal systems, accountability and management of the public sector, and information systems. Therefore combining scientific measurement factors with environmental policy of developing countries can be expanded for further improvement of the compensation model.

Appendix A

Summarize table of cross-country comparison[16]

Countries	General instrument	Economic instrument	Social instrument	Technology instrument
Thailand	- Noise metrics and Mapping - Noise assessment and Monitoring - Noise level restrictions and curfews - Noise abatement at the receptors - Compatibility of land use	- Landing and take-off fees based on noise and emission level - Compensation Scheme	- Noise impact mitigation plan for complaint - Meeting by the offices at noise impact areas	- Airport design - Quieter aircraft
United States	- Noise Control and Compatibility planning such as Airport proprietor options - Reviewing program - Noise Control and Compatibility planning such as state/Local government options (to prevent new non-compatible development and to reduce existing non-compatible uses)	- Landing fee based on the noise level and standard single event noise rating - No direct compensation scheme	None	- Airport design - Quieter aircraft
United Kingdom	- European Noise Policy - Noise Mapping - Noise Action Planning - Noise abatement operational procedures and restriction - Compatibility of land use	- The Aerodrome (noise restrictions) such as economic incentives based on noise and emission level - Noise mitigation and compensation - Consultation documents	None	- Traffic Management such as suburb streets design - Airport design - Quieter aircraft
Japan	- The noise standard compatibility verification system - Noise Prevention Law - Improved airport layout	- Compensation for relocation - Landing charges for international flight	- Noise abatement tasks for airport surrounding areas	- Airport design such as noise reduction hanger - Improved airport layout - Quieter aircraft
Scotland	- Environment Noise Directive - Noise Action Plan - Prioritization matrix to evaluate strategic noise levels - Low noise flight procedures - Ground running of aircraft engines limitation - Noise mitigation schemes - Compatibility land use - Monitoring system	- Landing fee - Noise limits breaching fine - Compensation schemes - Airport community trust	- Relocation and assistance schemes - Free phone and flight track information system offering - Local community opinion survey	- Technology enhancement
China	- Flight number and time adjustment - The fly quit program - Land use optimization - Noise monitoring system	- Compensation schemes	- Relocation of sensitive receptors	- Selection of low noise aircraft - Sound insulation measures
Hong Kong	- Restricting the airport operation hours - Special flight procedure - Restricting the running of engines and auxiliary power units (APUs) on ground - Certification of aero plane - Land-use guidelines - Aircraft Noise Monitoring	None	- Aircraft Noise Complaint	- Noise lessening installations

Source: Information summarized from details of each country' policy.

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