Current assessment and future projections of landing movement area capacity

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Abstract. The significant shifting in the number of aircraft traffic volume of Kualanamu Airport, Indonesia at the magnitude of 510% in the period of 2017-2030. It was calculated that in 2017 the number of aircraft take-off and landing in this airport was 83,859, and in 2030 was projected to become 171,000. These study objectives were to evaluate the capacity of the existing landing movement in 2017 and to project the capacity requirements of this landing movement for 2030. Based on ICAO 2013, it was identified that the minimum runway length for the new runway for 2030 would be 3,666 m and the required apron area would be increased 780,000 m² (twice times from the existing one in 2017).

1. Introduction
Air transportation is a service that is in great demand today, besides saving time it is also very efficient compared to land or sea transportation modes, especially the entry of a low-cost carrier onto a route leads to lower prices and higher passenger counts, both on other routes at the same airport and on competing routes at neighboring airports. These indicated that the aircraft consumer has gained an advantage from the entry of low-cost carriers [1]. Another factor of steady growth at the air traffic is that regional income tends to be positive. Some studies have reported that there was a strong positive correlation between local air transportation and economic development. However, the evidence of causation between air traffic and economic development has not been entirely understood. It also reviewed that a regional economic development driven by other factors can lead to boost more air traffic users; however, it is also possible that by supporting the policy in developing air traffic operations, airports act as a catalyst for local investment may also improve regional economic of a country [2].

Based on the data from 2012-2017, it was identified that the regional income growth in the province of North Sumatra, Indonesia has increased every year. The average percentage growth per capita income every year is 9.1 %, this is also in line with the growth of passenger movements and aircraft movements in the same period of time which also increases every year with an average growth of 4.87 % and 5%. One of the causes of the increase in regional income is the rate of growth of the population which continues to increase each year this is expected to continue to increase in the following years. With increasing air traffic, this will have an impact on the need for movement area capacity at an airport, so it is necessary to find out whether the current movement area capacity will be able to serve air traffic in the following years, also need to know development planning for the movement area.

A movement area is defined as some parts of an aerodrome area to be used for takeoff, landing, and taxiing of an aircraft, which are consisting of the maneuvering areas and the aprons [3]. The runway is a certain rectangular field within an airport location which is reinforced with pavement and equipped with landing and take-off apparatus and traffic signals including traffic marking and runway lamps. The runways are also constructed with the reinforcement pavement structures, ground shoulders, grounding
pads, and safety areas [4-5]. A taxiway is dedicated to facilitating as an access way to an aero lane from runway taxi line, apron and terminal building [6]. An apron is an air-side facility which is provided as a designated location of aircraft to load and unload passengers, post and cargos, also to conduct refueling activities, aircraft parking, and maintenance.

In order to develop an apron, a number of parameters should be put into consideration such as aircraft parking configuration, terminal construction configuration, aircraft characteristics, parking requirements, wingtip clearances.

The objectives of this article were to forecast the required landing movement areas and apron based on econometric projections using a number of data such as population, regional income, per capita income, cargo movement, passenger movement, aircraft movements.

2. Method
This research was conducted at Kualanamu International Airport, which is 39 km from Kota Medan, North Sumattra Province. This airport has runway dimensions which are 3,750 m x 60 m, 2 parallel taxiways with the first Taxiway dimension is 3,750 m x 30 m and the second Taxiway dimension is 2,000 m x 30 m, and apron dimension is 250,000 m² with apron PCN 109, R / C / W / T, rigid pavement.

![Kualanamu International Airport location](source: Google Earth).

2.1. Data collection
There are some data that which were collected during this study including: population, regional income, per capita income, cargo movement, passenger movement, aircraft movements influencing the use of air transportation services. The data were then used to forecast the demand for aircraft movement in this study.

| Years | Population | Regional Income | Per Capita Income | Cargo Movement | Passenger Movement | Aircraft Movements |
|-------|------------|-----------------|------------------|----------------|--------------------|--------------------|
| 2012  | 13,215,401 | 417,120,000,000,000 | 31,109,349 | 42,794 | 7,991,914 | 65,970 |
| 2013  | 13,326,307 | 469,467,000,000,000 | 34,599,950 | 44,273 | 8,358,705 | 70,461 |
| 2014  | 13,766,851 | 521,954,000,000,000 | 38,045,851 | 42,370 | 8,059,796 | 63,937 |
| 2015  | 13,937,797 | 571,722,000,000,000 | 41,019,539 | 41,629 | 8,004,791 | 63,607 |
| 2016  | 14,102,911 | 628,394,000,000,000 | 44,557,762 | 43,761 | 8,987,110 | 70,050 |
| 2017  | 14,262,147 | 684,069,000,000,000 | 47,963,990 | 54,125 | 10,041,568 | 83,859 |
2.2. Problem formulation
In order to make projections of the aircraft and passenger movements, table 1 data are analyzed using both linear and multilinear regression.

2.2.1. Linear regression
Linear regression is a model with one X independent variable that has a relationship with Y forming a straight line [7]. Relations, in general, can be stated in the equation:

$$Y = A + BX$$  \hspace{1cm} (1)

with

- $Y$ = non-independent variable
- $A$ = constant (the intersection of the curve to the Y-axis)
- $B$ = regression coefficient
- $X$ = independent variable.

2.2.2. Multi-linear regression
Multilinear regression is simply a model that has two or more independent variables X [8]. Expressed in the equation:

$$Y = A + B_1X_1 + B_2X_2 + \ldots + B_zX_z$$  \hspace{1cm} (2)

with

- $Y$ = variable is not free
- $X_i \ldots X_z$ = free variable
- $A$ = regression constant
- $B_i \ldots B_z$ = regression coefficient

2.2.3. Runway
The first step in planning the runway is to calculate the runway length based on the local conditions of the airport with the equation:

$$L_{ro} = ARFL \times Ft \times Fe \times Fs \times Fw$$  \hspace{1cm} (3)

By:
- $Lro$ = Long Runway plan (m)
- $Ft$ = temperature correction factor
- $Fe$ = elevation correction factor
- $Fs$ = slope correction factor
- $Fw$ = surface wind correction factor

Then evaluate the runway whether it needs development or not with the following equation:

$$IAP4_{air side} = \frac{Annual \ aircraft \ movement}{capacity \ of \ annual \ aircraft \ movement}$$  \hspace{1cm} (4)

2.2.4. Taxiway
In planning a taxiway, it is necessary to know the characteristics of the largest aircraft in operation in order to be able to calculate the taxiway dimensions needed. Taxiway calculations based on Annex 14 2013.

2.2.5. Apron
In apron planning, plan airplanes are determined as a reference for dimensions of aircraft aprons. As a planned airplane, the value based on the widest wingspan and the longest plane length. Taxiway calculations based on Annex 14 2013.
3. Results and discussions
The results will be discussed in 2 subsections, they are movements projection, Evaluation, and projection of the movement area.

3.1. Developing data projection
After calculating based on the linear regression for population and polynomials for regional income, per capita income and cargo, the projection results are obtained as follows:

| Year | Population | Regional income | Capita income | Cargo movements | Aircraft | Passenger |
|------|------------|-----------------|--------------|----------------|----------|-----------|
| 2018 | 14,542,018 | 779,400         | 50,953,998   | 60,359         | 94,294   | 11,016,508 |
| 2019 | 14,763,003 | 838,400         | 53,939,916   | 70,564         | 110,395  | 12,414,702 |
| 2020 | 14,983,989 | 898,600         | 56,923,956   | 82,933         | 129,896  | 14,080,126 |
| 2021 | 15,204,974 | 960,000         | 59,906,118   | 97,465         | 152,795  | 16,012,779 |
| 2022 | 15,425,959 | 1,022,600       | 62,886,403   | 114,160        | 179,094  | 18,212,661 |
| 2023 | 15,646,945 | 1,086,400       | 65,864,810   | 133,018        | 208,792  | 20,679,772 |
| 2024 | 15,867,930 | 1,151,400       | 68,841,339   | 154,038        | 241,890  | 23,414,113 |
| 2025 | 16,088,915 | 1,217,600       | 71,815,991   | 177,222        | 278,386  | 26,415,683 |
| 2026 | 16,309,901 | 1,285,000       | 74,788,766   | 202,569        | 318,282  | 29,684,483 |
| 2027 | 16,530,886 | 1,353,600       | 77,759,662   | 230,079        | 361,577  | 33,220,512 |
| 2028 | 16,751,871 | 1,423,400       | 80,728,681   | 259,752        | 408,272  | 37,023,770 |
| 2029 | 16,972,857 | 1,494,400       | 83,695,822   | 291,587        | 458,366  | 41,094,258 |
| 2030 | 17,193,842 | 1,566,600       | 86,661,086   | 325,586        | 511,859  | 45,431,975 |

Figure 2. The projection of aircraft movement up to 2030.

3.2. Evaluation and movement area projections
After the correction of the correction factor, the runway planning length was 3,627 m. Based on the Minister of Transportation Decree number KP 482 in 2018 [9] the existing condition of the Runway length was 3,750 m so that basically the runway length is still sufficient to service this type of aircraft.

In the year 2030 runway, the existing conditions were evaluated with annual aircraft movements of 511,859, IAP4 = 2.22. So, based on the table in KM 44 of 2002 [10] in 2027 until 2030 Runway capacity existing conditions were not able to serve the total movement of the existing aircraft, so it needed development planning for the addition of new Runways.

After an evaluation based on Annex 14 2013 and FAA [11], it is obtained that Taxiway Capacity is equal to 138. The movement of the aircraft at the peak hour of the existing year of 2017 was 21 aircraft. This figure is still far less than the capacity of the taxiway used, which was 138. Therefore, existing taxiway conditions do not need to be developed because they are still able to service existing aircraft. Meanwhile, the movement of aircraft during the peak hours of 2022 was 31 aircraft, in 2027 there are 43 aircraft, and in 2030 there are 52 aircraft, this figure is also still very far from the capacity of the
Taxiway used. This shows that the existing dimensions of the Taxiway are still capable of serving aircraft movements in the coming 2030, and the dimension of the taxiway is considered relatively similar to the existing one. Evaluation of the apron's needs for existing conditions was 321,000 m². Based on regulation from Indonesian Ministry of Transportation number 482 in 2018, the apron dimension of the existing condition was 250,000 m², meaning that the condition of the apron currently needs development. The projection of the apron requirement in 2030 was 738,000 m².

4. Conclusions
The result of the analysis conducted in this article there was a need an extension of the existing runway length up to 3,750 m (in 2030). The apron area required in accommodating 52 aircraft per hour would be 738,000 m². The taxi ways to be able to service the type of aircraft that will operate in 2030, while the apron must be increased to accommodate aircraft composition who will park there where the calculation must be a minimum of 738,000 m². The project taxiway dimension was no need to be extended.

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