

Indonesian Airport Activities Analysis by using Agglomerative Clustering Method

¹Purba Daru Kusuma and ²Helmy Widyantara

¹Department of Computer Engineering, Faculty of Electrical Engineering,
Telkom University, Bandung, Indonesia

²Department of Computer Engineering, Faculty of Electrical Engineering,
Institute Teknologi Telkom Surabaya, Surabaya, Indonesia
purbodaru@telkomuniversity.ac.id, +6282225283186

Abstract: Air transportation is the most important transportation mode in wide archipelagic country like Indonesia, especially for transporting people. It provides fast and safe travel time rather than sea transportation. So, developing the air transportation industry in Indonesia is very important. One aspect in air transportation industry is airport. Many activities occur in the airport, so that, airport activity can be used to reflect the air transportation activity. As part of air transportation development in Indonesia, analyzing the airports activities is very important, so that, the policy makers can make better decision. Basically, Central Bureau of Statistics of Indonesia in collaboration with Ministry of Transportation of Indonesia has published the air transportation statistics. Unfortunately, most of this statistic data is presented in tabular and lacks of deep and broad analysis. In this research, we use computational technology to analyze the Indonesian airports activities. Parameters that are analyzed include: passengers, baggage, cargo and mail. In this research, there are 185 airports in Indonesia that we analyze. The analysis process is started by clustering these activities by using agglomerative method. Then, the clustering result will be analyzed by relating it with the geographic, demographic and economic aspects. In this research, we find that there is positive relationship between air transportation and economy, especially, industrial and tourism activities where the relationship characteristics is reciprocal. Pioneer airports play significant role to establish connectivity between remote area and the main area.

Key words: Airport, clustering, agglomerative method, Indonesia, air transportation, Pioneer airports

INTRODUCTION

Air transportation has important role in archipelagic country like Indonesia. With more than 18,000 islands has horizontal length approximately 5,000 km and most of its area is covered by the sea (Hall, 2009) air transportation plays significant role to integrate local, national, regional and global connectivity (Button and Taylor, 2000). Compared with sea transportation, air transportation provides faster and saver choice (Collings, 2013). In shipping industry, air transportation is better option to send goods where speed and time is important such as document or perishable goods (Collings, 2013). These conditions become reason why there are hundred airports in Indonesia (Aunurrofik, 2018).

Air transportation also plays significant role in economic development. International air transportation becomes one aspect to make rapid international and global economic growth (Button and Taylor, 2000) or in other word, air transportation becomes important catalyst

to the global economy (Nwaogbe *et al.*, 2013). Nowadays, air transport industry generates approximately 29 million global jobs based on its direct, indirect, catalytic and induced influence (ATAG., 2004). Aunurrofik (2018) noted that there are positive correlation between air passenger, air cargo and GDP growth.

Air transportation also plays important role in tourism. International connectivity through air transportation has become the key factor for the success in tourism in many countries (Button and Taylor, 2000). Competitive price and increasing offer to various destinations in the world have made the demand for tourism grow (Zajac, 2016). Spasojevic *et al.* (2018) noted that there is mutual dependency between air transport and tourism (Forsyth, 2006; Duval, 2013). Tourism growth has also been boosted and stimulated by the existence of low cost carriers (Chung and Whang, 2011).

Based on its significant role, studies in air transportation, especially in Indonesia is very important to give better perspective for government, industry and

other stakeholders, so that, growth, continuity and sustainability in air transportation can be maintained. Banuara and Purba noted that studies in air transportation are very important for strategic planning in developing market and determining proper public policy. There are several studies in air transportation in Indonesia. Gunadi and Martono (2016) provided the air transportation condition in Indonesia in year 2016. They provided analysis in regulation, passenger characteristic, tariff and the business landscape, especially, during Idul Fitri holidays (Gunadi and Martono, 2016). Aunurrofik (2018) focused on the air transportation impact in regional economic development. Nasution *et al.* (2018) also studied about the impact of air transport on the Indonesia economy. In their research, Nasution *et al.* (2018) divided the benefit into three groups: primary, secondary and tertiary effect. Banuara and Purba (2018) have studied and analyzed the domestic passenger growth based on data from last 12 years to forecast the domestic demand for 2016-2021. Meanwhile, Sugiyanto *et al.* (2017) have classified the Indonesian airports based on the freight ratio and the federal aviation administration. In their research, they classified 34 airports (Sugiyanto *et al.*, 2017).

To enrich the studies about air transportation in Indonesia, in this research, we analyze the Indonesian airports activities. Rather than done manually as in other researches, we implement computational technology and it is the clustering process. We use agglomerative method rather than k-means method as it has been used in our previous research by Kusuma (2019). The purpose of this research is to give deeper analysis about airport activities, especially in four parameters: passenger, baggage, cargo and mail. We also relate the result with other aspects such as: geographic, economic and demographic.

MATERIALS AND METHODS

We use airport activities data that is provided by Central Bureau of Statistics of Indonesia in collaboration with Ministry of Transportation of Indonesia (BPS., 2018). This book contains three aspects: methodology, data and analysis. In this research, we cluster 185 airports. The problem is that analysis that is discussed in this book usually focuses on five main airport: Kualanamu, Soekarno Hatta, Juanda, Hasanuddin and Ngurah Rai. In this research, we focus on four parameters: passenger, baggage, cargo and mail. It is because basically, air transportation object can be categorized into these four items. This data then is stored in MySQL database.

Basic method that is used in this research is data clustering. Clustering basically can be defined as grouping set of data into several groups based on its

similarity or closeness. In this research, we use agglomerative method rather than k-means method as it is used in our previous research by Kusuma (2019). k-means method is very popular method in clustering work and has been used widely such as by Aprilia *et al.* (2018). The reason is we try to eliminate the instability problem in k-means because of its stochastic process during initial centroid determination (Aprilia *et al.*, 2018; Kusuma, 2019). Meanwhile, basic agglomerative clustering method uses deterministic approach.

Agglomerative clustering method is member of hierarchical clustering that uses bottom-up approach. As hierarchical process, the iteration process is used to change the number of clusters until the intended number of clusters is reached. As bottom-up approach, the number of clusters is reduced in every iteration process.

The illustration of agglomerative clustering process is as follows. Suppose that the example is set of airports. The set of Airport (A) contains ten airports ($a_1, a_2, a_3, \dots, a_{10}$). These airports then will be clustered into two groups or clusters. So, the intended number of clusters (n_d) is 2. In the beginning, the number of clusters (n_c) is equal to the number of airports. The iteration process runs until the number of cluster is equal to the intended number of clusters. The main algorithm of this clustering process is shown in Fig. 1.

In algorithm, the merger procedure is procedure to merge two closest clusters. The cluster selection is formally determined by using Eq. 1. In Eq. 1, link (l) is connection between two clusters. The link is many-to-many and unidirectional. As it is shown in Eq. 1, the selected link is link that its distance is the lowest one. The distance link l, j is Euclidean distance between cluster i and cluster j . This distance is formalized by using Eq. 2.

$$l_{sel} = l_{i,j} \mid \min(d(l_{i,j}) \mid l_{i,j} \in L) \quad (1)$$

$$d(l_{i,j}) = \|c_i - c_j\| \quad (2)$$

This clustering model then is implemented into airport clustering application. This application is a web based

```

begin
  while  $n_d < n_c$  do
    begin
      merger()
       $n_d \leftarrow n_d - 1$ 
    end
  end

```

Fig. 1: Agglomerative clustering main algorithm

application. It is developed by using PHP language. The outputs of the clustering process are: number of airports in every cluster, airports list in every cluster, the average and total scores of every cluster. In this research, the intended number of clusters is ten.

RESULTS AND DISCUSSION

In this study, we will discuss the airport clustering result. There are five clustering results that will be analyzed: passenger, baggage, baggage-passenger ratio, cargo and mail.

The first clustering result is the passenger clustering. In this process, airports are clustered based on the passengers that are departed from the airport. Number of passengers represents the people mobility in the related area. The number of passengers is presented in person. The result is presented in two tables. Table 1 shows the quantitative aspect of passenger clustering result. Table 2 shows the provinces list of passenger clustering result.

Table 1 shows that based on passenger aspect, most of airports in Indonesia are small airports. The 88% of airports in Indonesia is in the first cluster. Meanwhile, disparity among clusters is very wide. The average number of passengers in the first cluster is only 0.3% of the average number of passengers in the 10th cluster. The average number of passengers in the first cluster is only 7.6% of the average number of passengers in the second

cluster. The average number of passengers in the 9th cluster is only 36.1% of the average number of passengers in the 10th cluster. In total number of passengers, total number of passengers in the 10th cluster is 24% of total number of passengers in all clusters.

Table 2 strengthens result in Table 1. Cluster 7-10 contains only one airport. Two airports (Soekarno Hatta and Juanda) are in the Island of Java. Meanwhile, the two other airports are outside the Island of Java. Ngurah Rai Airport is in Bali. Hasanuddin Airport is in Makassar. Meanwhile, most of airports in the first cluster are outside the Island of Java.

The second clustering result is the baggage clustering. In this process, airports are clustered based on the baggage weight that is carried by the aeroplane that departs from the airport. Baggage represents load or things size that follows the passengers. The baggage is

Table 1: Quantitative aspect in passenger clustering result

Cluster No.	No. of airport	Average passenger (person)	Total passengers (person)
1	160	72.952	11,672.264
2	5	952.823	4,764.113
3	4	1,387.378	5,549.511
4	7	1,908.020	13,356.142
5	2	2,834.904	5,669.807
6	3	3,546.424	10,639.271
7	1	4,118.058	4,118.058
8	1	5,128.037	5,128.037
9	1	7,915.588	7,915.588
10	1	21,931.574	21,931.574

Table 2: Province list of passenger clustering result

Cluster No.	Ports list
1	Sultan Iskandar Muda, Lasikin Sinabang, Cut Nyak Dhien, Malikul Shaleh, Alas Leuser, Kuala Batu Blang Pidie, Teuku Cut Ali Tapak, Blangkejeren, Rembele Takengon, Syekh Hamzah Fansuri, Maimun Saleh, Silangit Siborong Borong, Binaka, Tobing Pinang Sori, Aek Gondang Sidempuan, Pinang Kampai, Tuanku Tambusai, Japura Rengat, Pasir Mayang-Muara Bungo, Depati Parbo, Silampari, Fatmawati Soekarno, Mukomuko, Enggano, As Hanandjoeddin, Raja Haji Fisabilillah, Ranai, Dabo, Sei Bati Tanjung Balai Karimun, Matak, Letung, Raja Haji Abdullah, Nusawiru, Cakrabhuwana Penggung, Tunggul Wulung, Dewa Daru, Rogojampi Blimbingsari, Jember, Bawean, Trunojoyo, Sultan Kaharuddin Brang Biji, Muhammad Salahudin, Komodo Labuhan Bajo, Hasan Aroeboesman, Fransiscus Xarevius Seda, Umbu Mehang Kunda, Torelelo Soa Bajawa, Tambolaka Waikabubak, Mali Kalabahi, Terdamu Sabu, Bere Tallo Haliwen Atambua, Gewayantana Larantuka, Wunopito Lewoleba, Frans Sales Lega Satar, David Constantijn Soudale Lekunik, Rahadi Oesman, Susilo, Pangsuma Putusibau, Nanga Pinoh, Iskandar Pangkalan Bun, Asan Sampit, Tjilik Riwut, Beringin Muara Teweh, Kuala Pembuang, Dirung Puruk Cahu, Kuala Kurun, Sjamsir Alam Stagen, Bersujud Batu Licin, Kalimantan, Temindung, Badak Bontang, Melak, Datah Dawai, Juwata, Nunukan, Tanjung Harapan, Seluwing, Yuvai Semaring, Melonguane, Naha Tahuna, Syukuran Aminuddin Amir, Mutiara SIS Al Jufri, Kasiguncu, Sultan Bantilan Lalos, Pogogul, Tanjung Api Ampana, Aroepala, Bone Mappalo Ulaweng, Mali Bua, Pongtiku, Andi Jemna Masamba, Seko, Rampi, Soroako, Sugimanuru, Wolter Monginsidi, Betoambari, Sangia Ni bandera, Matahora, Djalaluddin, Tampa Padang, Pattimura, Karel Sasuitubun Tual, Kufar, Rargwamar Dobo, John Becker Kisar, namrole, Larat LiwurBunga, Amahai, Banda Naira, Wahai, Matilda Batlayeri, Dumatubun, Saumlaki Olilit, Sultan Babullah, Kuabang Kao, Buli Maba, Pitu Morotai, Gamar Malamo Galela, Oesman Sadik Labuha, Gebe, Emalamo, Rendani, Jefman, Babo, Torea, Uтарum, Wasior, Bintuni, Kambuaya, Teminabuan, Inanwatan, Ayawasi, Kebar, Frans Kaisiepo, Mozes Kilangin, Wamena, Moppah, Nabire, Zugapa Bilorai, Tanah Merah, Illaga, Enarotali, Oksibil, Sinak, Beoga, Mindiptanah, Bade, Dekai, Karubaga, Mulia, Bomakia, Ewer, Towe, Moanamani, Okaba, Kamur, Senggo, Kimaam, Nop Goliat Dekai
2	Sultan Thaha Syarifuddin, Depati Amir, Abdul Rachman Saleh, Elitari, Sentani
3	Husein Sastranegara, Adi Sumarmo, Lombok Baru, Sam Ratulangi
4	Minangkabau, Sultan Syarif Kasim II, Sultan Mahmud Badaruddin II, Raden Inten II, Achmad Yani, Supadio, Syamsudin Noor
5	Hang Nadim, Sepinggan
6	Kualanamu, Halim Perdanakusuma, Adi Sucipto
7	Hasanuddin
8	Ngurah Rai
9	Juanda
10	Soekarno Hatta

presented in kilogram. The result is presented in two tables. Table 3 shows the quantitative aspect of baggage clustering result. Table 4 shows the provinces list of baggage clustering result.

Table 3 shows that condition in baggage clustering is similar to in passenger clustering. Most of airports are in the first cluster. But in baggage clustering result, the number of airports that are in the first cluster is smaller than the number of airports in the first cluster in passenger clustering result as it is shown in Table 1.

The average score comparison between passenger clustering and baggage clustering is as follows. The average baggage weight in the first cluster is 0.2% of the average baggage weight in the 10th cluster. The average baggage weight of the 9th cluster is 36.0% of the average baggage weight in the 10th cluster. It means that the disparity in average weight wider than in number of passenger.

In total baggage weight, disparity among clusters is also wide. The total baggage weight in the 10th cluster is 24.6% of the accumulation of total baggage weight of all clusters. It means that the domination of the 10th cluster is bigger. Meanwhile, the contribution of total baggage weight of the first cluster is only 9% of the cumulative total baggage weight of all clusters. This condition is rationale due to low passenger traffic in airports that are in the first cluster.

Table 4 shows that Soekarno Hatta Airport still dominates the baggage weight as this airport is the one that in the 10th cluster. Juanda Airport in Surabaya is in the second position. Meanwhile, Ngurah Rai Airport and Hasanuddin Airport are in the 8th cluster. This condition is different rather than in the passenger clustering result. It can be said that passengers from Hasanuddin Airport carry more baggage rather than passengers from Ngurah Rai Airport. In passenger clustering, Halim Perdanakusuma Airport is in the 6th cluster together with Kuala Namu and Adi Sucipto Airport. In baggage clustering, Halim Perdanakusuma is in the 5th cluster. Meanwhile, Hang Nadim, Adi Sucipto and Sepinggan airports are in the 6th cluster. It means that in average, passengers from these three airports carry more baggage rather than passengers from Halim Perdanakusuma.

Table 3: Quantitative aspect in baggage clustering result

Cluster No.	No. of airport	Average baggage (kg)	Total baggage (kg)
1	156	418.187	65,237.189
2	10	6,877.147	68,771.474
3	7	11,171.989	78,203.923
4	2	15,670.407	31,340.814
5	2	18,259.341	36,518.681
6	3	26,519.369	79,558.107
7	1	33,207.478	33,207.478
8	2	43,975.506	87,951.011
9	1	64,178.564	64,178.564
10	1	178,212.658	178,212.658

Table 4: Ports list of baggage clustering result

Cluster No.	Ports list
1	Sultan Iskandar Muda, Lasikin Sinabang, Cut Nyak Dhien, Malikul Shaleh, Alas Leuser, Kuala Batu Blang Pidie, Teuku Cut Ali Tapak, Blangkejeren, Rembele Takengon, Syekh Hamzah Fansuri, Maimun Saleh, Silangit Siborong Borong, Binaka, Tobing Pinang Sori, Aek Gondang Sidempuan, Pinang Kampai, Tuanku Tambusai, Japura Rengat, Pasir Mayang-Muara Bungo, Depati Parbo, Silampari, Fatmawati Soekarno, Mukomuko, Enggano, As Hanandjoeddin, Raja Haji Fisabilillah, Ranai, Dabo, Sei Bati Tanjung Balai Karimun, Matak, Letung, Raja Haji Abdullah, Nusawiru, Cakrabhuwana Penggung, Tunggul Wulung, Dewa Daru, Rogojampi Blimbingsari, Jember, Bawean, Trunjoyo, Sultan Kaharuddin Brang Biji, Muhammad Salahudin, Komodo Labuhan Bajo, Hasan Aroeboesman, Francisus Xarevius Seda, Umbu Meheng Kunda, Torelelo Soa Bajawa, Tambolaka Waikabubak, Mali Kalabahi, Terdamu Sabu, Bere Tallo Haliwen Atambua, Gewayantana Lantutuka, Wunopito Lewoleba, Frans Sales Lega Satar, David Constantijn Saudale Lekunik, Rahadi Oesman, Susilo, Pangsuma Putusibau, Nanga Pinoh, Iskandar Pangkalan Bun, Asan Sampit, Tjilik Riwt, Beringin Muara Teweh, Kuala Pembuang, Dirung Puruk Cahu, Kuala Kurun, Sjamisir Alam Stagen, Bersujud Batu Licin, Kalimara, Temindung, Badak Bontang, Melak, Dajah Dawai, Nunukan, Tanjung Harapan, Seluwing, Yuvai Semaring, Melonguane, Naha Tahuna, Syukuran Aminuddin Amir, Kasiguncu, Sultan Bantilan Lalos, Pogogul, Tanjung Api Ampara, Aroepala, Bone Mappalo Ulaweng, Mali Bua, Pongtiku, Andi Jemna Masamba, Seko, Rampi, Soroako, Sugimanuru, Wolter Monginsidi, Betoambari, Sangia Ni bandera, Matahora, Djalaluddin, Tampa Padang, Karel Sasutubun Tual, Kufar, Rargwarnar Dobo, John Becker Kisar, namrole, Larat Liwur Bunga, Amahai, Banda Naira, Wahai, Matilda Batlayeri, Dumatubun, Saumlaki Olilit, Sultan Babullah, Kuabang Kao, Buli Maba, Pitu Morotai, Gamar Malamo Galela, Oesman Sadik Labuha, Gebe, Emalamo, Rendani, Jefman, Babo, Torea, Utarum, Wasior, Bintuni, Kambuaya, Teminabuan, Inanwatan, Ayawasi, Kebar, Frans Kaisiepo, Wamena, Moppah, Nabire, Zugapa Bilorai, Tanah Merah, Ilaga, Enarotali, Oksibil, Sinak, Beoga, Mindiptanah, Bade, Dekai, Karubaga, Mulia, Bornakia, Ewer, Towe, Moanamani, Okaba, Kamur, Senggo, Kimaam, Nop Goliat Dekai
2	Sultan Thaha Syarifuddin, Raden Inten II, Depati Amir, Adi Sumarno, Abdul Rachman Saleh, Elitari, Juwata, Mutiara SIS Al Jufri, Pattimura, Mozes Kilangin
3	Sultan Syarif Kasim II, Husein Sastranegara, Achmad Yani, Lombok Baru, Syamsudin Noor, Sam Ratulangi, Sentani
4	Minangkabau, Sultan Mahmud Badaruddin II
5	Halim Perdanakusuma, Supadio
6	Hang Nadim, Adi Sucipto, Sepinggan
7	Kualanamu
8	Ngurah Rai, Hasanuddin
9	Juanda
10	Soekarno Hatta

To make clearer perspective, in the third clustering, we cluster the baggage-passenger ratio. This value is obtained by dividing the baggage weight with the number of passengers in every airport. This parameter is used to measure how heavy baggage that is carried by a passenger that departs from certain airport. The quantitative aspect is shown in Table 5. Meanwhile, the airports list is shown in Table 6.

Table 5 shows different trends. In Table 5, a passenger from 14 airports brings more or less 1 kg baggage. It means that passengers from these airports depart without any baggage or very light baggage. Meanwhile, a passenger in 141 airports brings more or less 7 kg baggage. This condition means that a passenger that departs from these airports bring baggage with normal weight. It is common tourist behavior who bring single suitcase bag. This condition is very different with condition in the 3rd-10th clusters. The average baggage weight in the 3rd cluster is 29 kg per passenger. Meanwhile, the average baggage weight in the 10th cluster is 182 kg per passenger. This condition shows that basically, passengers that depart from these airports are not tourist. It is very uncommon for tourist to bring more than 50 kg baggage.

Table 6 strengthens findings in Table 5. Many important airports in Indonesia are in the second cluster such as: Halim Perdanakusuma, Husein Sastranegara,

Achmad Yani, Adi Sucipto, Juanda, Ngurah Rai, Soekarno Hatta and Kuala Namu. Other common airports are also in the second cluster.

Airports that are in the first cluster are minor airport. Tuanku Tambusai Airport and Japura Rengat Airport are in Riau Province. Cakrabhuwana Airport is in Cirebon, West Java Province. Dewa Daru airport is in the Islands of Karimunjawa, Central Java Province. Namrole Airport and Wahai Airport are in Maluku. Wasior, Ayawasi, Kebar Airports are in West Papua Province. Meanwhile, Zugapa Bilorai, Illaga, Sinak, Beoga and Nop Goliat Dekai Airports are in Papua Province.

Meanwhile, location of airports that every passenger brings very heavy baggage is as follows. In the 4th cluster, Inanwatan Airport is in West Papua while Towe Airport is in Papua. In the 5th cluster, Gebe Airport is in North Maluku. In the 6th cluster, Terdamu Sabu Airport

Table 5: Quantitative aspect in baggage to passenger ratio clustering result

Cluster No.	No. of airports	Average baggage to passenger ratio (kg/person)
1	14	1
2	141	7
3	21	12
4	2	29
5	1	42
6	2	64
7	1	72
8	1	81
9	1	140
10	1	182

Table 6: Airports list of baggage to passenger ratio clustering result

Cluster No.	Airports list
1	Tuanku Tambusai, Japura Rengat, Cakrabhuwana Penggung, Dewa Daru, namrole, Wahai, Wasior, Ayawasi, Kebar, Zugapa Bilorai, Illaga, Sinak, Beoga, Nop Goliat Dekai,
2	Sultan Iskandar Muda, Cut Nyak Dhien, Alas Leuser, Kuala Batu Blang Pidie, Teuku Cut Ali Tapak, Blangkejeran, Maimun Saleh, Kualanamu, Silangit Siborong Borong, Binaka, Tobing Pinang Sori, Aek Gondang Sidempuan, Minangkabau, Sultan Syarif Kasim II, Pinang Kampai, Sultan Thaha Syarifuddin, Pasir Mayang-Muara Bungo, Depati Parbo, Sultan Mahmud Badaruddin II, Silampari, Fatmawati Soekarno, Mukomuko, Raden Inten II, Depati Amir, As Hanandjoeddin, Raja Haji Fisabilillah, Hang Nadim, Ranai, Dabo, Sei Bati Tanjung Balai Karimun, Matak, Letung, Raja Haji Abdullah, Halim Perdanakusuma, Husein Sastranegara, Nusawiru, Achmad Yani, Adi Sumarmo, Tunggal Wulung, Adi Sucipto, Juanda, Abdul Rachman Saleh, Rogojampi Blimbingsari, Jember, Bawean, Trunojoyo, Soekarno Hatta, Ngurah Rai, Lombok Baru, Sultan Kaharuddin Brang Biji, Muhammad Salahudin, Elitari, Komodo Labuhan Bajo, Hasan Aroeboesman, Fransiscus Xarevius Seda, Umbu Meheng Kunda, Torelelo Soa Bajawa, Tambolaka Waikabubak, Mali Kalabahi, Bere Tallo Haliwen Atambua, Gewayantana Lantaka, Wunopito Lewoleba, Frans Sales Lega Satar, David Constantijin Saudale Lekunik, Rahadi Oesman, Susilo, Pangsuma Putusibau, Nanga Pinoh, Iskandar Pangkalan Bun, Asan Sampit, Tjilik Riwut, Beringin Muara Teweh, Kuala Pembuang, Dirung Puruk Cahu, Kuala Kurun, Syamsudin Noor, Sjamsir Alam Stagen, Bersujud Batu Licin, Kalimantan, Temindung, Melak, Dajah Dawai, Nunukan, Tanjung Harapan, Sam Ratulangi, Melonguane, Naha Tahuna, Syukuran Aminuddin Amir, Kasiguncu, Pogogul, Tanjung Api Ampana, Aroepala, Bone Mappalo Ulaweng, Mali Bua, Pongtiku, Soroako, Sugimanuru, Wolter Monginsidi, Betoambari, Sangia Ni bandera, Matahora, Djalaluddin, Tampa Padang, Pattimura, Karel Sasuitubun Tual, Kufar, Rargwamar Dobo, John Becker Kisar, Larat Liwurbunga, Banda Naira, Matilda Batlayeri, Dumatubun, Saumlaki Olilit, Sultan Babullah, Kuabang Kao, Buli Maba, Pitu Morotai, Gamar Malano Galela, Oesman Sadik Labuha, Emalamo, Rendani, Jefman, Babo, Torea, Utarum, Bintuni, Kambuaya, Teminabuan, Frans Kaisiepo, Nabire, Tanah Merah, Mindiptanah, Bade, Dekai, Karubaga, Mulia, Bomakia, Okaba, Kamur, Senggo, Kimaam
3	Lasikin Sinabang, Malikul Shaleh, Rembele Takengon, Supadio, Sepinggan, Badak Bontang, Juwata, Seluwing, Yuvai Semaring, Mutiara SIS Al Jufri, Sultan Bantilan Lalos, Hasanuddin, Andi Jemna Masamba, Seko, Rampi, Mozes Kilangin, Sentani, Wamena, Moppah, Oksibil, Moanamani
4	Inanwatan, Towe
5	Gebe
6	Terdamu Sabu, Amahai
7	Ewer
8	Syekh Hamzah Fansuri
9	Enggano
10	Enarotali

is in East Nusa Tenggara while Amahai Airport is in Maluku. In the 7th cluster, Ewer Airport is in Papua. In the 8th cluster, Syekh Hamzah Fansuri Airport is in Aceh. In the 9th cluster, Enggano Airport is in Bengkulu. In the 10th cluster, Enarotali Airport is in Papua. This condition shows that passengers who bring heavy baggage depart not only from Papua Island.

The fourth clustering work is clustering the airports based on their cargo weight. Air cargo represents perishable goods or goods that must be transported fast. In this process, the quantitative aspect result is shown in Table 7 while the airports list result is shown in Table 8.

Result in Table 7 shows similar result in passenger and baggage clustering work. The first cluster dominates the number of members. With 159 airports, the number of airports in the first cluster is about 85.9% of the number of all airports in Indonesia. There are 14 airports in the second cluster. If the number of airports in the first cluster is summed with the number of airports in the second cluster, totally, it is 93.5% of the number of all airports in Indonesia. Meanwhile, there is only one airport in a cluster from the sixth cluster to the 10th cluster.

Based on the average cargo weight, the 10th cluster is very dominant. In other word, disparity in cargo is wider than disparity in passenger or baggage. With more or less 223 million kg, it is far above the average cargo weight of all other cluster. The average cargo weight of the first

cluster is only 0.1% of the average cargo weight of the 10th cluster. This value is fewer than same ratio in passenger clustering and baggage clustering. The average cargo weight in the second cluster is still 2.3% of the average cargo weight in the 10th cluster. More over, the average cargo weight in the 9th cluster which is the nearest cluster to the 10th cluster is only 27.6% of the average cargo weight in the 10th cluster.

In total cargo weight, the 10th cluster is very dominant. The total cargo weight of the 10th cluster is approximately 37.1% of total cargo weight off all clusters. Besides, disparity among cluster is also wide. The total cargo weight of the first cluster is only 6%.

Table 8 shows that there is not any difference between airports list distribution in cargo clustering and in passenger clustering or baggage clustering. Soekarno Hatta Airport is very dominant as it is the only airport in the 10th cluster. Meanwhile, Sentani Airport which its

Table 7: Quantitative aspect in cargo clustering result

Cluster No.	No. of airports	Average cargo (kg)	Total cargo (kg)
1	159	228.129	36,272.460
2	14	5,066.176	70,926.462
3	2	11,116.695	22,233.390
4	2	15,186.428	30,372.856
5	3	18,448.737	55,346.211
6	1	21,672.605	21,672.605
7	1	35,113.676	35,113.676
8	1	45,470.827	45,470.827
9	1	61,925.992	61,925.992
10	1	223,817.315	223,817.315

Table 8: Airports list of cargo clustering result

Cluster No.	Airports list
1	Sultan Iskandar Muda, Lasikin Sinabang, Cut Nyak Dhien, Malikul Shaleh, Alas Leuser, Kuala Batu Blang Pidie, Teuku Cut Ali Tapak, Blangkejeren, Renbele Takengon, Syekh Hamzah Fansuri, Maimun Saleh, Silangit Siborong Borong, Binaka, Tobing Pinang Sori, Aek Gondang Sidempuan, Pinang Kampai, Tuanku Tambusai, Japura Rengat, Pasir Mayang-Muara Bungo, Depati Parbo, Silampari, Fatmawati Soekarno, Mukomuko, Enggano, Raden Inten II, Depati Amir, As Hanandjoeddin, Raja Haji Fisabilillah, Ranai, Dabo, Sei Bati Tanjung Balai Karimun, Matak, Letung, Raja Haji Abdullah, Nusawiru, Cakrabhuwana Penggung, Tunggul Wulung, Dewa Daru, Abdul Rachman Saleh, Rogojampi Blimbingsari, Jember, Bawean, Trunojoyo, Sultan Kaharuddin Brang Biji, Muhammad Salahudin, Elitari, Komodo Labuhan Bajo, Hasan Aroeboesman, Fransiscus Xarevius Seda, Umbu Mehang Kunda, Torelelo Soa Bajawa, Tambolaka Waikabubak, Mali Kalabahi, Terdamu Sabu, Bere Tallo Haliwen Atambua, Gewayantana Lantaka, Wunopito Lewoleba, Frans Sales Lega Satar, David Constantijn Saudale Lekunik, Rahadi Oesman, Susilo, Pangsuma Putusibau, Nanga Pinoh, Iskandar Pangkalan Bun, Asan Sampit, Tjilik Riwut, Beringin Muara Teweh, Kuala Pembuang, Dirung Puruk Cahu, Kuala Kurun, Sjamsir Alam Stagen, Bersujud Batu Licin, Kalimantan, Temindung, Badak Bontang, Melak, Dajah Dawai, Juwata, Nunukan, Tanjung Harapan, Seluwing, Yuwai Semaring, Melonguane, Naha Tahuna, Syukuran Aminuddin Amir, Mutiara SIS Al Jufri, Kasiguncu, Sultan Bantilan Lalos, Pogogul, Tanjung Api Ampara, Aroepala, Bone Mappalo Ulaweng, Mali Bua, Pongtiku, Andi Jemna Masamba, Seko, Rampi, Soroako, Sugimanuru, Wolter Monginsidi, Betoambari, Sangia Ni bandera, Matahora, Djalaluddin, Tampa Padang, Karel Sasuitubun Tual, Kufar, Rargwamar Dobo, John Becker Kisar, namrole, Larat LiwurBunga, Amahai, Banda Naira, Wahi, Matilda Batlayeri, Dumatubun, Saumlaki Olilit, Sultan Babullah, Kuabang Kao, Buli Maba, Pitu Morotai, Gamar Malamo Galela, Oesman Sadik Labuha, Gebe, Emalamo, Rendani, Jefnan, Babo, Torea, Utarum, Wasior, Bintuni, Kambuaya, Teminabuan, Inanwatan, Ayawasi, Kebar, Frans Kaisiepo, Moppah, Nabire, Illaga, Enarotali, Oksibil, Sinak, Beoga, Mindiptanah, Bade, Dekai, Karubaga, Mulia, Bomakia, Ewer, Towe, Moanamani, Okaba, Kamur, Senggo, Kimaam, Nop Goliat Dekai
2	Minangkabau, Sultan Syarif Kasim II, Sultan Thaha Syarifuddin, Sultan Mahmud Badaruddin II, Achmad Yani, Adi Sumarmo, Lombok Baru, Supadio, Syamsudin Noor, Sam Ratulangi, Pattimura, Wamena, Zugapa Bilorai, Tanah Merah
3	Husein Sastranegara, Adi Sucipto
4	Ngurah Rai, Mozes Kilangin
5	Hang Nadim, Halim Perdanakusuma, Sepinggan
6	Kualanamu
7	Hasanuddin
8	Juanda
9	Sentani
10	Soekarno Hatta

location is in Jayapura city, Papua Province is the one in the 9th cluster. Besides Ngurah Rai Airport, Mozes Kilangin Airport is also, airport in the 4th cluster. Its cargo weight is bigger than cargo weight in Husein Sastranegara and Adi Sucipto Airport which their location is in Java Island.

The fifth clustering process is the mail clustering. It represents the document volume that is transported from the related airport. Different from cargo that brings many kinds of goods, goods that is sent is only document. The quantitative aspect of mail clustering result is shown in Table 9 while the airports list distribution is shown in Table 10.

Table 9 shows that the mail quantity is less than cargo quantity. The total air mail quantity in Indonesia is only 0.5% of total air cargo quantity in Indonesia. The average air mail of the 10th cluster is about 0.6% of the average air cargo of the 10th cluster. Meanwhile, the average air mail of the 1st cluster is about 0.2% of the average air cargo in the 1st cluster.

In air mail clustering, most of airports are in the first cluster. The number of airports in the first cluster is about 88.1% of total number of airports in Indonesia. Meanwhile, clusters from the 6th to the 10th contain only one airport. This condition is similar to condition in passenger, baggage and cargo clustering.

In average air mail weight, disparity among cluster is very wide. This disparity is even wider than disparity in

passenger, baggage or cargo clustering. The average air mail weight in the first cluster is only 0.02% of the average air mail weight of the 10th cluster. The average air mail weight of the 1st cluster is still only about 2.5% of the average air mail weight of the 2nd cluster. Meanwhile, the average air mail weight of the 9th cluster is about 44.3% of the average air mail weight of the 10th cluster. This ratio is better than the same ratio in the passenger, baggage and cargo clusterings.

Table 10 shows that there is dynamics in airports performance in air mail aspect. Soekarno Hatta Airport, which is usually sits in the 10th cluster, now sits in the 9th cluster. The 10th cluster is occupied by Kualanamu Airport that is in North Sumatera. Sam Ratulangi Airport which is usually in the 2nd or 3rd cluster and its location is in North Sulawesi is in the 8th cluster in air mail clustering. It means that its air mail production is high. In the other side, Juanda Airport which its passenger,

Table 9: Quantitative aspect in mail clustering result

Cluster No.	No. of airports	Average mail (kg)	Total mail (kg)
1	163	375.000	61.169
2	6	15.235	91.411
3	4	43.030	172.120
4	5	71.696	358.481
5	2	109.826	219.652
6	1	153.649	153.649
7	1	201.734	201.734
8	1	332.349	332.349
9	1	607.103	607.103
10	1	1,370.362	1,370.362

Table 10: Airports list of mail clustering result

Cluster No.	Airports list
1	Lasikin Sinabang, Cut Nyak Dhien, Malikul Shaleh, Alas Leuser, Kuala Batu Blang Pidie, Teuku Cut Ali Tapak, Blangkejeran, Rembele Takengon, Syekh Hamzah Fansuri, Maimun Saleh, Silangit Siborong Borong, Binaka, Tobing Pinang Sori, Aek Gondang Sidempuan, Minangkabau, Pinang Kampai, Tuanku Tambusai, Japura Rengat, Pasir Mayang-Muara Bungo, Depati Parbo, Silampari, Mukomuko, Enggano, Raden Inten II, As Hanandjoeddin, Raja Haji Fisabilillah, Hang Nadim, Ranai, Dabo, Sei Bati Tanjung Balai Karimun, Matak, Letung, Raja Haji Abdullah, Halim Perdanakusuma, Husein Sastranegara, Nusawiru, Cakrabhuwana Penggung, Tunggul Wulung, Dewa Daru, Adi Sucipto, Juanda, Abdul Rachman Saleh, Rogojampi Blimbingsari, Bawean, Trunojoyo, Ngurah Rai, Lombok Baru, Sultan Kaharuddin Brang Biji, Muhammad Salahudin, Elitari, Komodo Labuhan Bajo, Fransiscus Xarevius Seda, Umbu Mehang Kunda, Torelelo Soa Bajawa, Tambolaka Waikabubak, Mali Kalabahi, Terdamu Sabu, Bere Tallo Haliwen Atambua, Gewayantana Lantaka, Wunopito Lewoleba, Frans Sales Lega Satar, David Constantijn Saudale Lekunik, Susilo, Pangsuma Putusibau, Nanga Pinoh, Iskandar Pangkalan Bun, Asan Sampit, Tjilik Riwut, Beringin Muara Teweh, Kuala Pembuang, Dirung Puruk Cahu, Kuala Kurun, Syamsudin Noor, Sjamsir Alam Stagen, Bersujud Batu Licin, Sepinggan, Kalimantan, Temindung, Badak Bontang, Melak, Datar Dawai, Juwata, Nunukan, Tanjung Harapan, Seluwing, Yuvai Semarang, Melonguane, Naha Tahuna, Syukuran Aminuddin Amir, Kasiguncu, Sultan Bantilan Lalos, Pogogul, Tanjung Api Ampana, Aroepala, Bone Mappalo Uluweng, Mali Bua, Pongtiku, Andi Jemna Masamba, Seko, Rampi, Soroako, Sugimanuru, Betoambari, Sangia Ni bandera, Matahora, Tampa Padang, Pattimura, Karel Sasuitubun Tual, Kufar, Rargwamar Dobo, John Becker Kisar, namrole, Larat LiwurBunga, Amahai, Banda Naira, Wahai, Matilda Batlayeri, Dumatubun, Saumlaki Olilit, Sultan Babullah, Kuabang Kao, Buli Maba, Pitu Morotai, Gamar Malamo Galela, Oesman Sadik Labuha, Gebe, Emalamo, Rendani, Jefman, Babo, Torea, Utarum, Wasior, Bintuni, Kambuaya, Teminabuan, Inanwatan, Ayawasi, Kebar, Frans Kaisiepo, Wamena, Nabire, Zugapa Bilorai, Tanah Merah, Ilaga, Enarotali, Oksibil, Sinak, Beoga, Mindiptanah, Bade, Dekai, Karubaga, Mulia, Bomakia, Ewer, Towe, Moanamani, Okaba, Kamur, Senggo, Kimaam, Nop Goliat Dekai
2	Sultan Mahmud Badaruddin II, Adi Sumarmo, Hasan Aroeboesman, Rahadi Oesman, Mozes Kilangin, Moppah
3	Fatmawati Soekarno, Jember, Hasanuddin, Wolter Monginsidi
4	Sultan Iskandar Muda, Sultan Thaha Syarifuddin, Depati Amir, Mutiara SIS Al Jufri, Djalaluddin
5	Sultan Syarif Kasim II, Achmad Yani
6	Sentani
7	Supadio
8	Sam Ratulangi
9	Soekarno Hatta
10	Kualanamu

baggage and cargo productions are very high, now sits in the first cluster. It means that its air mail production is very low.

Based on clustering result that has been explained in the previous section in this section, we will discuss and resume the result. The purpose of this discussion is to produce findings, so that, they can become novelties in this research. To make broader analysis, the clustering result is also related with the economic, geographic and demographic aspect.

Generally, disparity among airports in Indonesia is very wide. Besides that, most of Indonesian Airports are small airport and sit on remote area. In the other side, the Indonesian main airports dominate the overall productivity while pioneer airports dominate in quantity.

Generally, Soekarno Hatta and Juanda Airports become the most important Airport in Indonesia. Soekarno Hatta Airport becomes the most significant airport in passenger, baggage and air cargo aspects. Meanwhile, Juanda Airport sits on the second position in passenger and baggage aspects and on the third position in air cargo aspect. This condition occurs because in economic aspect, both cities are the the biggest cities in Indonesia. Both cities are also surrounded by industrial area. Besides Soekarno Hatta Airport, Jakarta is also covered by Halim Perdanakusuma Airport as secondary airport. Basically, Halim Perdanakusuma is a military airbase that is operated by Indonesian air force. That is why Halim Perdanakusuma becomes important airport too for Indonesia, although, its capacity is limited. Condition in Halim Perdanakusuma Airport is also similar to condition in Adisucipto (Yogyakarta) and Husein Sastranegara (Bandung). That is why government of Indonesia has built and operates new airports: Kertajati Airport in Majalengka and Yogyakarta International Airport in Kulonprogo. This condition strengthens argumentation that air transportation plays significant role in economic development (Button and Taylor, 2000; Baltaci *et al.*, 2015).

Significant role of Ngurah Rai Airport strengthens argumentation that there is positive relation between airline industry and tourism (Spasojevic *et al.*, 2018; Duval, 2013; Chung and Whang, 2011). Bali is the most famous tourist destination in Indonesia. Meanwhile, Ngurah Rai Airport is the only airport in Bali. That is why Ngurah Rai Airport sits in the 8th cluster or in the third position after Soekarno Hatta Airport and Juanda Airport in passenger and baggage aspects. Disparity between Juanda Airport and Ngurah Rai Airport is also narrow. Unfortunately because it depends on tourism, productivity in air cargo and air mail is not significant. It

can be shown that in air cargo performance, it sits in the fourth cluster. Meanwhile it sits in the first cluster for air mail category. So, it can be said that tourism productivity has positive relation in passenger and baggage productivity but do not has any correlation in air cargo and air mail. This condition also occurs in Adisucipto Airport in Yogyakarta. The economic of this province is powered by tourism industry.

In Papua Island, basically the number of passengers is low. It is because population in Papua is also low. Based on population survei that was held by central bureau of statistics of Indonesia in 2017, the population of West Papua is only 915,361 persons while population of Papua is only 3,265,202 persons. In the other side, Papua Islands is a very big island with mountainous terrain. This condition makes aeroplane becomes the only transportation mode to connect area in Papua Islands. The fact in clustering result shows that. In passenger and baggage clustering result, Airports in Papua Islands sit on the lower clusters. Meanwhile, in baggage-passenger ratio clustering result, many airports in Papua sit in the higher cluster. It means that, although, the number of passenger is low, each passenger tends to bring heavy baggage. Result in cargo clustering strengthens this argument. Sentani Airport performs the second most productive airport. Sentai Airport plays significant role to connect Papua Islands to other island in Indonesia such as: Jakarta, Makassar and Surabaya. Sentani Airport also plays as a hub for other pioneer Airports in Papua.

The existence of Freeport mining area in Grasberg produces demand for air transportation, especially, air cargo. Mozes Kilangin Airport plays significant role in serving Freeport needs on air cargo. The fact shows the contribution of Freeport makes the air cargo production of Mozes Kilangin Airport is equal to Ngurah Rai Airport which it is more populous and busier.

The existence of pioneer airport is important as transportation hub that connects many areas in Indonesia as an archipelagic country. The pioneer airport makes the connectivity in remote area becomes possible (Gunadi and Martono, 2016). The characteristic of this area is small population, poor land or road infrastructure, in small islands and cannot be landed by big aeroplane. The characteristic of this airport is low number of passengers, low number of baggage, high baggage-passenger ratio and high air cargo productivity.

Besides Ngurah Rai, Kualanamu and Hasanuddin Airport are the most significant airports outside the Java Islands. Kualanamu Airport is the most significant airport in the west of Indonesia. Meanwhile, Hasanuddin Airport is the most significant airport in the east of Indonesia. Compared between these two airports, Kualanamu

Airport is more productive in air mail category while Hasanuddin Airport is more productive in air cargo category.

Sepinggan and Supadio Airports are the most important Airports in Kalimantan Island. They are also productive in passenger and baggage categories although their productivity is lower than Kualanamu and Hasanuddin Airports. Economically, Kalimantan Island economical powerhouse is oil, gas and coal mining. So, it can be said that extractive economy also has significant influence in area development.

CONCLUSION

In this research, we have clustered and analyzed the condition of the 185 airports in Indonesia, especially, in passenger, baggage, baggage-passenger, air cargo and air mail categories. In this research, we find that there is positive relation between air transportation and economy, especially, industrial and tourism activities where the relation characteristics is reciprocal. The characteristic of main Airports in Indonesia is high productivity in passenger, baggage and air cargo categories and low productivity in baggage-passenger category. In the other side, pioneer airports plays significant role to establish connectivity between remote area and the main area. The characteristics of pioneer airports are low productivity in passenger, baggage and air mail and high productivity in baggage-passenger ratio and air cargo.

Studies in transportation analysis such as this research and our previous research in strategic sea port analysis are important in part of development studies in Indonesia. These researches are also small part of analyzing the transportation in Indonesia and connecting the transportation condition with the economic and non economic development in Indonesia. To make these works complete, analysis in land transportation becomes interesting and important future research potential.

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