Data Analysis Investigation: Papua is The Most Unsafe Province in Indonesia for Aviation: An Exploratory Data Analysis Study from KNKT-Database Accidents and Incidents (1988-2021)

by Rossi Passarella

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Data Analysis Investigation: Papua is The Most Unsafe Province in Indonesia for Aviation: An Exploratory Data Analysis Study from KNKT-Database Accidents and Incidents (1988-2021)

Rossi Passarella[1,2,*] and Siti Nurmaini[2]

[1]Doctoral Engineering Department, Faculty of Engineering, Universitas Sriwijaya, Indonesia
[2]Intelligent System Research Group, Faculty of Computer Science, Universitas Sriwijaya, Indonesia

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Abstract

Due to its high population and growing middle class, Indonesia is a locale for a promising expansion of commercial aviation businesses. Furthermore, being a large archipelago, mobility of people and goods via air travel appears to be the most convenient option available. Nevertheless, aviation safety has remained an issue of concern in Indonesia since 2007, after the EU banned Indonesian aircraft flights in the European airspace. This was done as a response to the multiple accidents that earned Indonesian aviation a global reputation for being unsafe. We conducted the investigation based on a reputable report produced by KNKT, known as the National Transportation Safety Board, to establish a more comprehensive context of this situation. Since 1988, all accident data reports have been gathered and archived in the KNKT database, which was then utilized to further investigate the issues confronting Indonesian airlines by evaluating the data using the EDA approach. According to the results, Papua Island is the least safe region for aviation, with 140 accidents (21.9 percent of the total accidents) in Indonesia over the past 33 years. Moreover, the noteworthy results reveal that 45.71 percent of the accidents or incidents occur during the landing phase. This finding informed us regarding the overall geography of Papua, which lacks transportation roads, prompting the government to open the airport for mobilization. Papua has 217 airports, accounting for 42.3 percent of all Indonesian airports, with 196 being small airports at an average altitude of 452.15 meters. Human factors account for 63 percent of accidents in Papua, while technological factors account for 19 percent. The government may use the study's findings to pressure operators to enhance safety in addition to revitalizing aviation safety supporting technologies.

Keywords: Aviation Safety, Commercial Aviation, EDA Method, KNKT database, Papua Island

1. Introduction

Indonesia is renowned as the world's biggest archipelagic country, with 17,504 islands distributed throughout an area of 5,193,250 km^2, divided as land (37 percent) and water (63 percent) areas - equivalent to 1,919,440 km^2 for land and 3,273,810 km^2 for sea, with a span of 6400,361 km (3,977 miles). Indonesia categorizes its area into 34 provinces, of which Papua is the largest, accounting for 319,036.05 km^2 or 17 percent of the total land area. The Riau Archipelago Province contains 2,408 islands, accounting for 13.75 percent of Indonesia's islands. Such a vast amount of land, with consideration for the landform, demands an efficient means for the mobilization of goods and people. Thus, air and sea transportation come to mind, out of which air transportation has the most efficient potential of the two modes as it can traverse great distances over shorter periods (time efficiency). However, each mode of transportation, including air travel, is not without its risks [1].

The rapid expansion of the population in Indonesia, particularly in metropolitan areas, has brought with it a boom in social, economic, and cultural activities, resulting in an urgent need for transportation. In light of these requirements, a liaison system is required, which would enable movement between regions and neighboring nations [2], [3]. According to [4], the industry of civil aviation in Indonesia began in the third decade of the 20^{th} century, marked by the establishment of KNILM (Koninklijke Nederlandsch Indische Luchtvaart Maatschappij) in 1928. KNILM is a Dutch East Indies commercial airline company with an initial flight route from Batavia (Jakarta) to Bandung with Fokker-type aircraft (F.VIIb and F.XII). Following independence, commercial flights in Indonesia were greatly influenced by the establishment of Garuda Indonesia Airways (GIA), resulting from the nationalization of some of KNILM's assets and diplomatic relationships with KLM (Koninklijk Luchvaart Maatschappij) in 1954.

Since 1954, commercial airline companies have been rapidly flourishing. Significant market demand accompanied by economic improvements has made commercial aviation one of the favorites of the community. During this time, aviation regulations were under the control of the Ministry of Transportation. With Indonesia joining in ICAO (The International Civil Aviation Organization), a permanently independent institution was to be responsible for the investigation of safety deficiencies in transportation. To this end, the Indonesian government established the National Transportation Accident Committee (KNKT). One of these committees conducts Transportation Safety System Investigations as well as Accident and Incident Investigations [5], [6].

Based on their performance, the KNKT documented reports of commercial aircraft accident investigations from

*E-mail address: passarella.rossi@unsri.ac.id
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1988 to the present time. The data from the accident reports are saved and published on their website. Statistics from these reports offer greater context concerning aviation safety in Indonesia. For example, in early 2007, Indonesian planes were involved in a series of mishaps that drew international attention. The number of stories run by the Indonesian media addressing the challenges in aviation has debilitated the reputation of the country, reflecting poorly on the quality of Indonesian aviation. In 2007, aviation authorities from the United States downgraded flights in Indonesia, followed by the implementation of flying restrictions mandated by the EU. The latter action (which took place in July 2007) was informed by an ICAO-executed assessment from February 2007. Due to its difficulty in implementing ICAO regulations, Indonesia was deemed to have risky flying conditions, resulting in a poor image for the country's aviation facilities [7].

Despite the harshness of the ban and the global scrutiny that the country received, Indonesia reflected on its mistakes and continues to maintain a healthy and communicative relationship with the EU communication. Periodic updates on flight conditions have been provided by the country to the EU in efforts to maintain diplomacy. This has enabled the EU, in turn, to support the country in meeting international safety standards as soon as possible. Furthermore, Indonesia produced a special law for aviation as a legal basis, namely Law No. 1 of 2009 [8], [9]. Due to the given context and the corresponding ban, it is imperative that researchers probe into the causes of commercial aviation accidents from 1988 until 2021 to determine which provinces correspond to the highest accident data, in academic efforts to prevent similar circumstances.

Data analysis required the identification of correlations, data trends, and additional information that addresses the research questions raised in a study. It allows for the interpretation of a collection of facts and helps policymakers make informed decisions. The goal of collecting and analyzing historical accident aviation data is to draw accurate conclusions and offer good recommendations to concerned stakeholders.

2. Material and Methods

This section describes the material and method used in the investigation. With regards to the material, databases were retrieved from the website of KNKT on-site [10] and the site transportation department of the Republic of Indonesia [11]. Both sources of data were public, thus, it was permissible for anyone to retrieve them and utilize them for public interest. The investigation was conducted from August 2021 to January 2022 for the aviation accident report data between 1988 and 2021. However, the aviation accident data was separated and featured on two different websites with the duration of the years being truncated. The KNKT website published the accident report from 1997 until 2021, while the Department of transportation published data for the period between 1988 and 2021. Both sets of data were in the form of a KNKT report; thus, it was necessary to transform it into the CSV format (Fig. 1).

In the process of transforming data from reports into a database, the column headers or attributes were determined first based on the research question. Hence, the year was added to the header of the table, followed by Location, Provinces, Region, Type of aircraft, Operator, Roles, A/I (Accident /Incident), Phase of Accident (POA), Possible Cause of Accident (PCOA), and Remarks. The total observation data collected and restructured amounted to 639 observations, with 11 identified variables. At the same time, the feature consisted of 6 categorical and one numerical, with four meta-attributes. Data from the reports were simplified into a tabular format for the purpose of this study. The dataframe of the dataset is shown in Fig. 2.

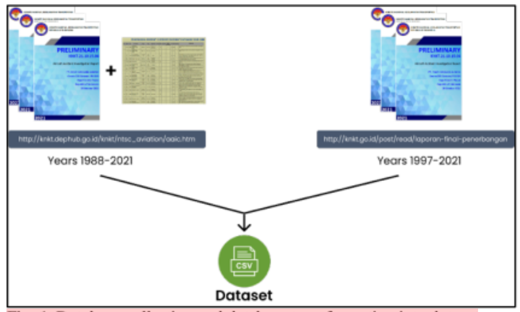


Fig. 1. Database collection and database transformation into dataset

	Years	Location	...	PCOA	Remarks
0	1988	Pabelokan island West Java	...	Human	On landing the main rotor struck another helic...
1	1988	Pabelokan island West Java	...	Human	On landing the skid struck another helicopters...
2	1988	Long Bawan Airport	...	Technical	An explosion occured during climbing; the prop...
3	1988	Kediri East Java	...	Human	The helicopter turned when the altitude was st...
4	1988	Djalaluddin Airport Gorontalo	...	Technical	The nose wheel tire blown out and then nose hi...
...	...	...	...	...	...
634	2021	Biloria Airport	...	Human	The PK-OTW made a go around from Runway 27 and...
635	2021	Matak Airport	...	Technical	At 1316 LT just prior to touchdown at Soehana...
636	2021	Ilaga Airport	...	Human	According to the witness that was on the Ilaga...
637	2001	Airspace Bali	...	Human	Engine 2 sustained an uncontained engine failu...
638	2001	Long Bawan Airport	...	Human	AC was unloading with 2 engine running to keep...

639 rows × 11 columns

Fig. 2. The dataframe of the dataset used

The method of analyzing aircraft accidents in this study employs several stages - clarifying research questions, preparing data, processing, analyzing, and presenting results.

3. Results and Discussion

According to ICAO's International Standards and recommended practices [12], an accident is generally associated with the operation of the aircraft, resulting in fatalities, casualties, or seriously injured persons on board the aircraft, who may have come into direct contact with any part of aircraft, or directly exposed to jet blast. This definition is also inclusive of structural failure of the aircraft and cases where the aircraft is missing or is completely inaccessible. In contrast, the incident is defined as related to the potential or recognized impact on the safety of the operation of the aircraft. The difference between an accident and an incident is in its consequences. Accidents and mishaps can happen anywhere, whether the aircraft is parked or in flight. The activity of the aircraft during flight is referred to as the flight phase. In commercial aviation, the flight phase is generally divided into several phases, including the taxi phase, take-off phase, climb phase, cruise phase, descent phase, and landing phase [13]–[15]. Information concerning the phase during which an accident occurs in the KNKT report is listed in the POA variable. This information is crucial for identifying the causes of the accident/incident in the investigation.

To elicit findings, a preliminary analysis is performed by examining the kind of each variable. The dataset comprises one quantitative data type, namely the variable ‘year’. The year variable, in general, classifies this dataset as time-series data. Consequently, the data visualization will relate to time. Furthermore, descriptive statistics (DS) are employed to examine missing data for the analysis and potential identification of significant characteristics in the given information. The DS findings demonstrate that the missing data from each dataset variable is given the value 0 (Fig. 3), indicating that the dataset is appropriate for the data analysis procedure.

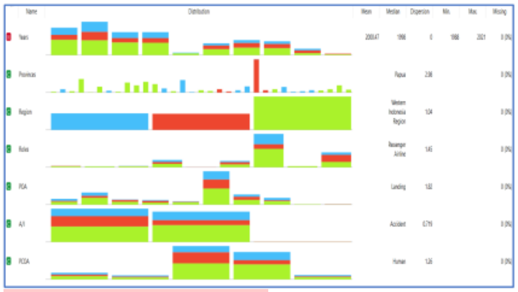
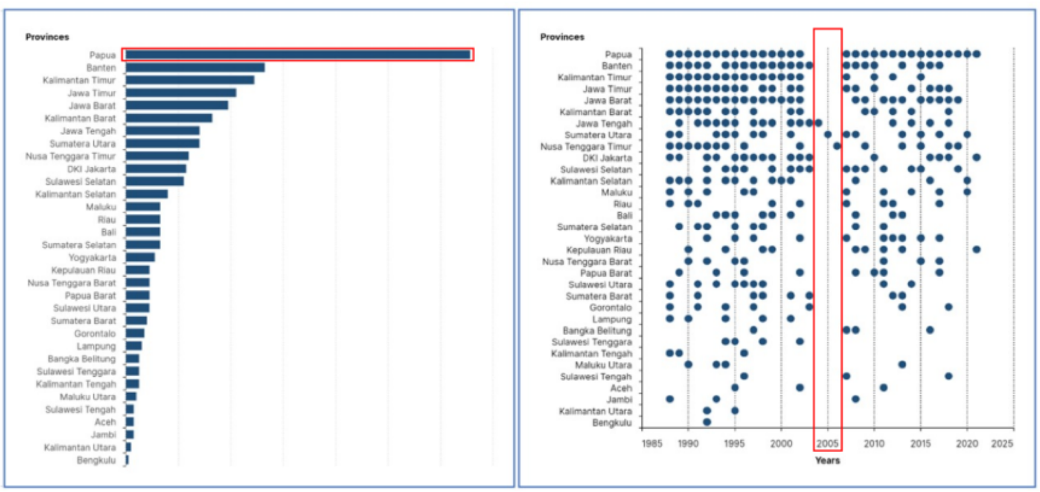


Fig. 3. Features statistic of the dataset

Once the dataset is prepared for analysis, the causes of accidents are explored. The PCOA variable in the dataset is attributed the cause of the accident and is divided into five categories in the KNKT report, namely Human, Technical, Environment, Facility, and Unknown. According to [16], who studied causes for accidents of commercial airplanes in Indonesia between 2002 to 2012, the highest-rated factor was the human factor – accidents caused by pilots and co-pilots, aviation security officials, and aircraft maintenance staff. The second-most rated component is the environment, which includes dense clouds, heavy rain, high winds, and topography. The third factor includes facilities such as runways and associated obstacles on the runway (animals or items). Finally, the fourth component is the technical element, which includes aircraft engines, procedural maintenance, and maintenance equipment. To investigate these causes, we used a spreadsheet tool for tabulating data, orange tool and a Scimago Graphica tool for visualization, collectively enabling better comprehension.

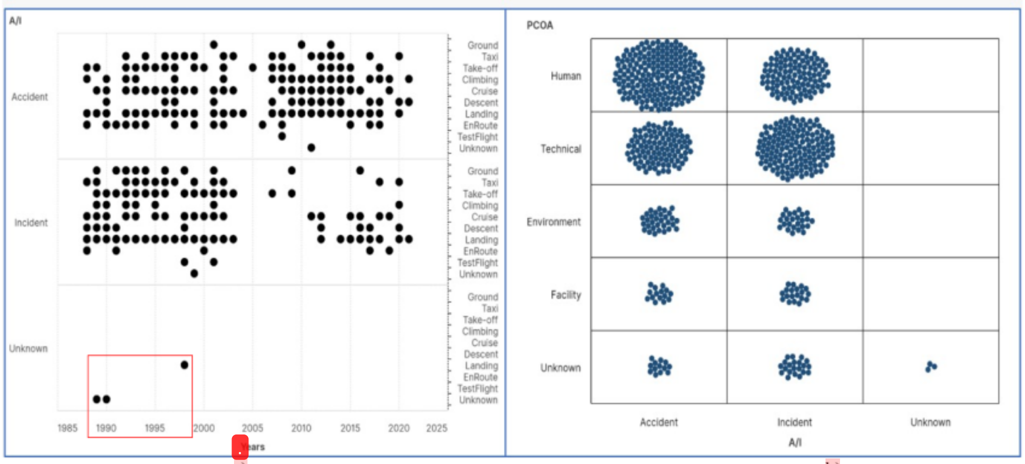
The data visualization is then used to show patterns, data insights, and existing problems. To this end, the frequency measurement of the total incidents reported and documented by the KNKT over 33 years (1988-2021) was employed. We found that the total number of provinces with accidents was 33 out of 34, as shown in Fig. 4(A). The province that does not have a record in the KNKT data is in the West Sulawesi province, with Mamuju as its capital city. Based on the government website, West Sulawesi Province has 2 airports, namely Sumarorong Airport (IATA: MSA / ICAO: WAFS) and Tampa Padang Airport (IATA: MJU / ICAO: WAFJ). Sumarorong airport is served by Susi Air and Aviastar Indonesia, both of which have registered their aircraft under Air Operator Certificate (AOC)135, while Tampa Padang airport is served by the airlines: Batik Air, Garuda Indonesia, Sriwijaya Air, and Wings Air (their aircraft registered under AOC 121).



a) b)

Fig. 4. Data visualization of the dataset using the frequency of accidents (A). The number of accident frequencies by provinces (B). Scatter plot of accident data by provinces

In order to view the data in greater depth, an examination of the distribution of data points from each province was performed to ensure that the data in Fig. 4(A) was not biased. The findings show that there are noteworthy data points in the visual data, such as the fact that in 2004, 2005, and 2006, KNKT documented just one accident per year. Finally, in 2007, the EU abruptly prohibited Indonesian-registered aircraft from flying in European airspace. In our opinion, the facts provided by data visualization in terms of the accident time demonstrate a correlation or link that prompts the government to intervene and restructure aviation safety standards, resulting in Law No. 9 of 2009. The serious attitude undertaken by the government may be illustrated by the distribution of data points in Fig. 4(B), revealing that the documentation of aviation accident reports has resumed.



a) b)

Fig. 5. Insightful data on aviation accidents in Indonesia from 1988-2021. (**A**). Matrix dataset by type of accident (A/I)-POA. (**B**). Data points of 639 accidents by type of accident (A/I) and PCOA.

Fig. 5(A) shows that data with the label Unknown exists for both the A/I and POA variables. Although this data emerges from the sources released by the KNKT, the validity, and concerns regarding what actually transpired arise. Therefore, the KNKT database was reopened to dig up these two-accident data. In 1989, the accident or incident at Deli Serdang Medan (North Sumatra), an Argicalutral aircraft (PA 25-235) was registered with PT. Perkebunan IX, with a note given by KNKT - "The data have not been sent by the Regional Office of the Ministry of Transportation of North Sumatra." Next, the second incident in 1990 took place in the Siriwo area of Papua as a Hughes-500 helicopter operated by the Mission Aviation Fellowship (MAF) was gone missing for reasons unknown. The third incident was in 1998 at Kiwi, Jayawijaya Regency, Papua, as a Twin Otter DHC 6-300 type utility aircraft operated by the Mission Aviation Fellowship (MAF) was corresponded with a disturbance in the landing flight phase, while there was neither any record of what truly happened not the listing of the type of Accident/Incident. However, the frequency of events based on PCOA and A/I for 33 years in all provinces is shown in Fig. 5(B). By visualizing the data points in the form of scatter points, it is found that human factors dominate the causes of accidents while technical factors dominate the causes of Incidents. Thus, the statistics show that aviation accidents in Indonesia have been caused by two major factors: human and technical.

Fig. 6. A visualization data point of 140 locations on the map of Papua

Furthermore, it was also found that Papua had the most significant number of accidents, with 140 out of 639 analyzed data (Fig. 6). In other words, this figure represents 21.9 percent of civil aircraft accidents during the past 33 years. According to the data [17], the Soekarno-Hatta (CGK) airport in the Banten province is the busiest in Indonesia, with 19,480,251 civil flights in 2019, as compared to Papua with only 1,980,662 in the same year. To identify the primary cause for such accidents, the kind of aircraft, type of airport, and geographical particularities of Papua must be identified, following which secondary data must be searched in terms of the number of airports in Papua, their form and condition, and geographical position. According to the website, OurAirports [18], Indonesia has 513 registered airports, with 217 (42.3 percent) situated on Papua island. These airports are classified into four types: major, medium, small, and closed airports. Each airport is located at a distinct height. Tab. 1, displays the Papua airport tabulation statistics.

Table 1. Secondary data for the airports in Papua Island

Facility types	Number of Airports	Average of elevation (Meter)
Large airport	1	20.12
Medium Airport	12	88.09
Small Airport	196	452.15
Closed Airport	8	902.74

While a closed airport refers to one that has undergone closure and is no longer in operation, a big airport is defined as a land airport with multiple airline services that carry millions of passengers each year, or a military base. A medium airport is a land airport with scheduled regional airline services, regular general aviation, or military traffic. Finally, a small airport refers to general aviation activity conducted at a land airport with little or no scheduled service. So, how does the topography of the island of Papua allow for varied types and heights of airports? Papua's typical temperature ranges from 19 to 28 degrees Celsius, with humidity ranging from 80 to 89 percent. The annual rainfall ranges from 1550mm to 7500mm. Moreover, the province has the highest mountains in the country, reaching up to 4888 meters (16,024 ft), and lesser mountains spanning from the north to west of the mid-range. Papua's topography has resulted in low and medium elevation rainforests, wetlands, savanna grasslands, and mangrove forests [19]. Furthermore, one must examine the reason for which there are 196 small airports on the island of Papua (Tab. 1).

According to [20], no infrastructural road connects cities as 70 percent remains forested with some mountainous areas. These geographical circumstances require light aircraft transportation or pioneering flying. Thus, it is natural that the number of plane accidents occurs frequently, with data evidencing the highest event rate for incidents, accidents, and finally, unknowns. The event rate measures how often a statistical occurrence, accident, or incident occurs within a dataset - and the findings are 67 percent, 31 percent, and 1 percent, respectively. This is comparable with an expected frequency of 94, 44, and 2 out of 140. The findings of the event rate computation and the relative risk of the accident dataset are shown in Tab. 2.

Table 2. Framing the data analysis from dataset accident report in Papua Island

Method	Accident	Incident	Unknown
Event rate	67 percent	31 percent	1 percent
Expected frequency	94 out of 140	44 out of 140	2 out of 140
Odds	94/46	44/96	2/138

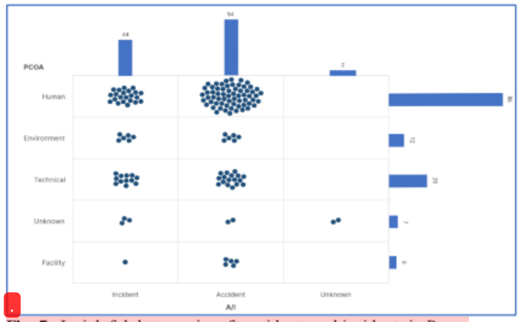


Fig. 7. Insightful data on aircraft accidents and incidents in Papua province based on PCOA and A/I observations (1988-2021)

Fig. 8. Distribution of accidents and incidents in the province of Papua (1988-2021) based on (A/I).

A retracing of the dataset is required to determine what factors lead to the high percentage of event rate for accidents or incidents. Therefore, we employed PCOA and AI variables from the dataset to better identify the causes. These two variables have been displayed as illustrated in Fig. 7. Human and technical factors were found to be the most common causes, with human factors accounting for 63 percent and technical factors accounting for 19 percent. In Papua, these two elements play a significant role in the occurrence of accidents and incidents. However, accidents and incidents continue to occur; what is the trend? To demonstrate this, we exhibit data on the year of incidence, kind of accident, and occurrences. Fig. 8(A) depicts the visible results achieved. According to the data plot, the number of accidents reduces every year, as does the frequency in the years after 2009. This data indicates that the impact of the Aviation Law's enactment has yielded positive consequences.

Furthermore, human and technical factors, which produce event rates of 67 percent and 31 percent, are vital to determine which flight period is the most dangerous. Consequently, data visualization between POA and A/I variables, as well as PCOA variables from the dataset, was performed. The findings revealed that the dominance of data distribution in the accident was observed in the landing phase, followed by humans being the primary causative factor (Fig. 8(B)). In the case of incidents as well, the same issues have been reflected.

The Orange tool is used to delve further into the records obtained for each accident and incident, as shown in Fig. 8(B). According to Fig. 9, during the landing phase in Papua, most incidents corresponded with exploded plane tires; thus, excessive brakes were identified as the most common cause. The majority of the aircraft involved in incidents were light aircraft such as the Cessna 185 Skywagon, DHC 6, and medium aircraft such as the Fokker F27. As per the recorded data in terms of landing accidents, most aircraft appear to have run out of runway, broken their left landing gear, or encountered hard landing. According to the data, the aircraft types that had the most accidents include the Cessna 185 Skywagon, the Boeing B737-300, the DHC 6, and the Cessna 208.

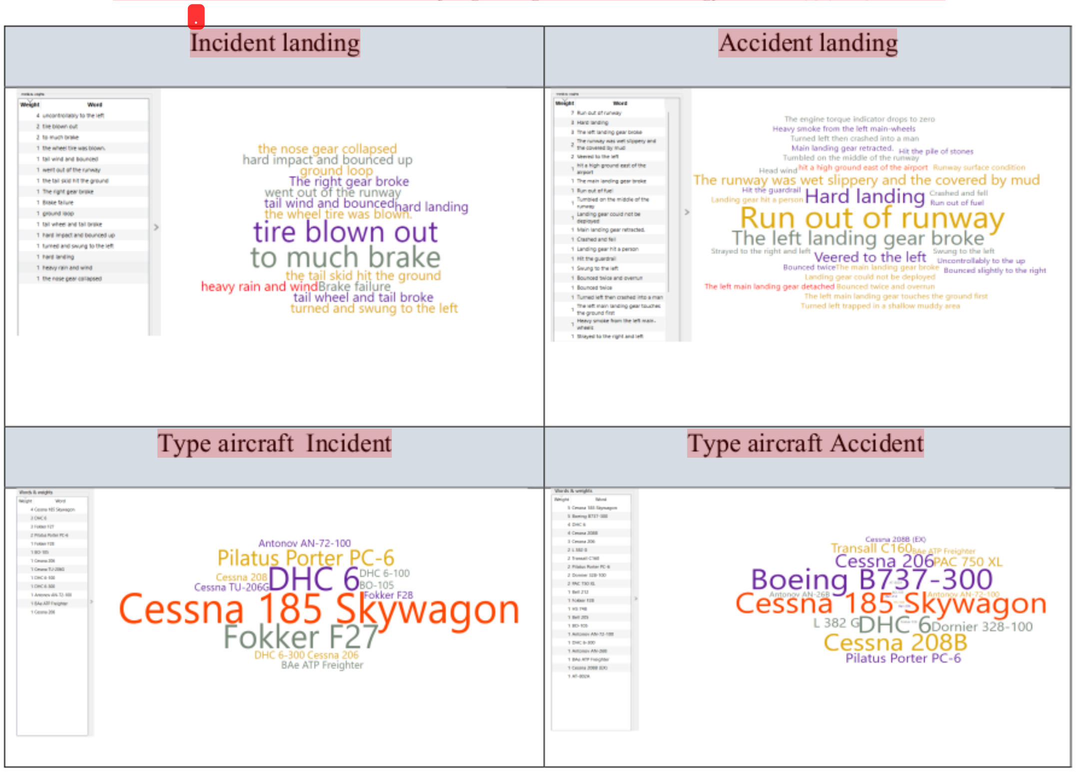


Fig. 9. The measurement of frequency from variable remarks dataset shows the majority of causes and the aircraft type in Accident and Incident aircraft during landing phase in Papua.

In cases where plans experienced a problem during the landing phase, around 48 percent of the incidents were discovered as being caused by human factors, whereas technical reasons caused 29 percent. For the accident data, 60 percent and 24 percent rates were shown for both components. In general, accidents and incidents in Papua during the landing phase accounted for 67 percent and 33 percent of the total 63 observation data, respectively.

4. Conclusion

From the analysis and visualization data findings, much information has been outlined regarding plane disasters on the island of Papua. 21.9 percent of accidents and incidents were found to have occurred in the past 33 years, which is the highest data compared to other provinces in Indonesia. There was considerable data regarding the flight phase (correspondent with the time of disaster), with around 45.71 percent out of the total accidents and incidents. Out of the 45.71 percent, 67 percent corresponded with accidents while 33 percent corresponded with incidents. The 67 percent value represents the accident rate as a result of failure to control the plane during landing. Following a thorough investigation, we discovered that human factors (pilot and co-pilot) caused 60 percent of the accidents, while technical factors caused 24 percent, with three leading causes for the latter: ran out of runway, left landing gear broke, and hard landing. While in the data of 33 percent who experienced incidents, we found that 48 percent were caused by human factors (pilot and co-pilot) and 29 percent by technical factors (aircraft maintenance). Furthermore, the two leading causes for the latter were tire blowout and additional pressure on the brakes.

The types of aircraft that experienced many accidents and incidents during the landing phase were mostly light aircraft or those used for pioneer flights such as the Cessna 185 Skywagon. This is because, out of the 217 airports in Papua, 196 airports are small airports with an average elevation of 452.15 meters above sea level. These small airports are mostly composed of grass and dirt (the natural surface of the runway). Therefore, to prevent similar accidents or incidents from occurring in the future, both the operator and the government as the regulator must strengthen pilot and co-pilot training and oversight.

Our analysis allowed for a detailed interpretation of the public data, which has thoroughly informed us of the reasons for which Papua is considered unsafe for aircraft in Indonesia.

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