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Modeling Ground Access Traffic Based On Air Passenger Data In Juanda International Airport

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ABSTRACT : Airport attracts large scale of demand to travel in. Most air travelers use private cars or taxi to reach and leave the airport. This number leads to congestion and reducing the quality of air in and around airport. The effect of increasing number of air traveler to the quality of ground access demands the airport to re-evaluate the design of the available access mode. To evaluate the available design of access mode, this study requires data of air travelers as well as the airplane schedules in Juanda International Airport Surabaya. The data incorporate the economic growth results in prediction of future demand that will occupy the road access to airport. This research attempts to build a model to generate potential passengers in inducing traffic congestion. This model suggests the period of airport operational to develop alternative access modes to reduce the congestion level. The model shows that in 2020, every air traveler generates 3.6 vehicle trips of ground access traffic.

Keywords*: air passenger, ground access traffic, trip generation.*

1. INTRODUCTION

Saphiro (Philip Shapiro, 1994) said that access movement to the airport has discussed as widely problems of transportation in US since 1974. As air travel, urban congestion and environmental concerns have significantly increased over the last quarter century. The growth of air travelers' demand in the world caused the volume of ground access traffic to and from the airport increase. In any airport, the ground access travelers mostly use the private car. The private car usage causes congestion and raises pollution level in all of roads around the airport. Therefore, airports are re-evaluating their approach through the access mode choice and considering how to reduce the reliance on private cars (Budd, Ryley, Ison, 2014).

Humphreys and Ison (Humphreys, 2003) find that private cars dominate the majority of travel to and from airports. In big airports, the number of private cars usage is 65%. Even for small airports or secondary airports, the use of private cars can reach 99%. The increasing of the access volume influences the capacity of the access facilities on airport. In planning the access facilities, the estimation of ground access volume is very important.

Ideally, all of the access facilities in airports should accommodate the increasing of demand for the targeted time.

This paper attempted to determine the number of traffic generated by the increasing number of air traveler in Juanda International Airport. The research focuses on the estimation of vehicle trips for air traveler since the use of private car is dominant.

In 2013, the number of Juanda passengers is around 15 million passengers. This is a high traffic since the rate of increasing number of passengers is around 6% annually. Each passenger will generate trip to and from airport called ground access traffic. Mostly, air traveler uses private car to access the Juanda Airport. This access traffic needs the facilities. On the other hand, the usage of private car will potentially cause congestion, pollution and highly fuel consumption. Therefore, the number of ground access traffic generated by air passenger should be calculated accurately. Ground access traffic data can be used to determine the facilities needed and the environmental impacts such as congestion, pollution and energy consumption. To this extend, the estimation of ground access traffic is an important parameter to be considered.

2. LITERATURE REVIEW

2.1 Ground Access Model

Research in airport ground access become increasingly important due to the probability of the passengers' selection in how they choose their travel mode (Akar, Gulsah, 2013). The research related to behavior of traveler mode and departure time choice has been started since 1997 by developing analytical model (Satosi and Katsuhiko, 1997). They concluded that safety time margin for avoiding delayed arrival at the airport strongly depends upon the mean and standard deviation of total travel time from origin to airport.

Few studies performed that estimating the number of ground passenger trips made to an airport as a function of originating passengers (Philip Shapiro, 1994). Data compiled for The California Aviation System Plan, estimated that originating passengers and enplaning passengers were used to derive a relationship between originating passengers and daily vehicle trips to California Airport (Philip and Katzman, 1998). This analysis included 10 California Airports ranging in size from Fresno Airport, with under half million annual enplanements, to Los Angeles International Airport, with over 22 million annual enplanements. The analysis yielded the following equations, which had coefficient of determination (R^2) of nearly 1,0 :

$$\textit{Total Vehicle Trips} = \textit{(3,526} \times \textit{Originating passengers)} + \textit{(0,818} \times \textit{Connecting Passengers)} - \textit{497} \quad (1)$$

In this equation, the connecting passengers are defined as enplaning passengers minus originating passengers.

Another study that yields some insight into airport trip generation was performed at Eppley Airfield in Omaha, Nebraska, USA in 1995 (FAA, 1999). This study related traffic entering and exiting the terminal facility on different days and different times of the year to enplanements and deplanements on those days. The analysis yielded the following two

regression equations, one for daily vehicle trips entering the terminal airport area and one for vehicle trips exiting the terminal area:

$$\textit{Entering Vehicle Trips} = (1{,}5937 \times \textit{Enplaning passengers}) + 1199 \quad (2)$$

$$\textit{Exiting Vehicle Trips} = (1{,}5403 \times \textit{Enplaning passengers}) + 1501 \quad (3)$$

These equations yielded very acceptable coefficient of determination (R^2) of 0,815 and 0,705 respectively, but did not account for passengers who drove to a 3.700-space, off-airport parking facility and did not enter the airport. While the data used to develop these relationship is limited, it is encouraging that they consistently predict that approximately 3,5 daily vehicle trips are generated for each originating passenger. This would include vehicle trips by passengers, employees, visitors, cargo vehicles and others. The California equation indicates that approximately 0,8 vehicle trips are generated for each the connecting passenger.

To evaluate the ground access capacity the Transport Research Board (Transportation Research Board, 1987) released two types of index. There are Passenger Demand Index (PDI) and Passenger Capacity Index (PCI). The PDI is meant to approximate the number of trips per day made to the airport. And the PCI is an access supply index. Ratio PDI/PCI greater than 1,0 indicates that there is a potential access capacity problem. The PDI and PCI are calculated by applying these formulas:

$$PDI = \{1{,}5\times(\text{daily passenger minus interline transfer}) + 2{,}0\times(\text{no.of airport employees})\}/1000 \quad (4)$$

$$PCI = 3{,}1\{\text{effective lane capacity (vehicles/hr)}\}/1000 \quad (5)$$

Such indexes reflect the underlying principles for access capacity analysis. The multipliers used could be changed to suit conditions at an individual airport. However, such indexes can only be first approximations, useful for initial screening for problems.

Those models demonstrated the effort in developing the model of airport ground access. Airport Cooperative Research Program (ACRP) stated that this research has been the subject of ongoing research for more than 30 years (ACRP, 2008). This report stated that the probability of choosing a particular alternative could not be greater than one or less than zero, these results in an S-shaped relationship between the difference in utility between two alternatives and the probability of choosing the alternative with the greater utility for that decision maker.

3. METHODOLOGY

3.1 The Juanda International Airport Transportation System

Juanda International Airport (JIA) is located approximately 12 km (8 miles) from Surabaya, Indonesia. In 2010, the airport handled 11 million passengers, although the capacity was 6 million passengers and the ATC Radar System at peak hour should handle 40 to 45 aircraft movements per hour (landing and takeoff). In 2013 airport serves about 400 aircrafts per day.

Access to JIA is available through toll road and arterial road. Ground access modes served passenger movement to and from JIA are dominated by private car for nearly 60%, taxi around 10%, scheduled bus is only 2%, and the rest is by motorcycles (El Hafiza, 2015). Bus may not attractive since the service provided is limited. The quality of travel to airport is getting worst since the unreliability of travel time (Istighfaroh, 2016).

Some researchers attempted to simulate the quality of airport access by utilizing the new transportation network plan. Nastiti (2015) attempted to utilize three different airport access modes, i.e. shuttle bus, dedicated train and passenger car/taxi. She simulated the passengers' movement from 31 districts in Surabaya. The results vary depend on the location of bus station and train station. Since the location of train station is in the middle-eastern part of the city and the bus station is in the western part and close to the toll road, that airport access mode gives the best travel time and cost only for those who live around the stations area.

The problem of location of the stations was reduced (Kartika and Ahyudanari, 2015). They utilized the new transportation network based on rail, i.e. tram and monorail. The new network plan of intra-city rail network is facilitated by park and ride in some stations along the route of tram and monorail. The tram serves north to south area, while the monorail serves west to east area of Surabaya. The results showed that the facility of park and rides are not always provide the same travel time due to processing in parking and walking in the park and ride station.

Assessment on the quality of travel of airport access was also conducted through examined the degree of saturation (DS) of the roads access to airport (Rahayu, Ahyudanari, Pratomoatmojo, 2015) The DS values of the access roads are evaluated by determine the relationship between changing land use along the road access and increasing DS values of the related roads. The results show that though the number of airport access roads is increasing but this is not followed by the reducing DS values.

Those conducted researches indicate that the reliability of travel time to JIA is low. This quality of travel will be getting worst if there is no plan to provide an alternative for airport access mode. Therefore, the estimation of traffic attracted to airport need to be determine due to the high rate increasing number of air travelers.

3.2 Data Collection

Ground access demand analysis based on passenger data. The following are statistics of passenger recorded by Kementerian Perhubungan in 2013 (Kementrian Perhbungan, 2013). The data are shown in Table 1 to Table 6.

Transportation Research e-Circular (Transportation Research Board, 2002) said that typically, a passenger's forecasting model based on regression analysis. This model specifies passenger origination (dependent variable) as a function of one or more independent variable representing the regional economy such as employment, income or Gross Domestic Product (GDP), a price variable such as average fare level or yield (airline revenue per passenger mile) and sometimes an air service variable. In this paper the growth of originating passenger in Juanda Airport is considered only influenced by Regional GDP of Jawa Timur Province. So, Regional GDP Data is required for supporting this analysis. The Regional GDP of Jawa Timur Province is written in Table 1 (Biro Pusat Statistik, 2014).

3.3 ESTIMATION OF GROUND ACCESS DEMAND

Estimation analysis method used in this paper is simple regression analysis. The relationship between a response variable Y and a predictor X is postulated as a linear model.

$$Y = \beta 0 + \beta 1X + \varepsilon \quad (6)$$

where β0 and β1 are constants called the model regression coefficients or parameters, and ε is a random disturbance or error. It is assumed that in the range of the observations model, the linear equation provides an acceptable approximation to the true relation between Y and X. In the other words, Y is approximately a linear function of X, and ε measures the discrepancy in that approximation.

Table 1. The GDP of Jawa Timur Province

Year	GDP (Billion)
2009	686,8
2010	778,6
2011	884,5
2012	1001,2
2013	1136,3

In particular, ε contents no systematic information for determining Y that is not already captured in X. The coefficient β1, called the slope, is interpreted as the change in Y for unit change in X. The coefficient β0, called the constant coefficient or intercept, is the predicted value of Y when X = 0.

a. GDP Estimation

Theoretically, growth of the airport passenger is social economic of the region. One of a social economic parameters is represented by Regional GDP. Therefore, the first forecasting is Regional GDP estimation. Regional GDP of Jawa Timur Province is as variable Y and the year is as variable X. Based on time series data of Jawa Timur GDP from 2009 up to 2013 can be resulted as equation model:

$$Y = 112{,}16X - 224656{,}28, \text{ with } R^2 = 0{,}99 \quad (7)$$

Then the equation model is used to predict Jatim GDP for the future. By inputting X from 2014 up to 2020 is obtained the regression result as Table 8 and Figure 2.

Table 8. The Estimation of GDP of Jawa Timur Province

Year	GDP (Billion)	Year	GDP (Billion)
2009	686,8	2018	1682,6
2010	778,6	2019	1794,76
2011	884,5	2020	1906,92
2012	1001,2	2018	1682,6
2013	1136,3		
2014	1233,96		
2015	1346,12		
2016	1458,28		
2017	1570,44		

b. Air Passenger Estimation

The calculation of passenger estimation is done in two stage. First stage estimated the domestic passenger and the second stage forecasted the international passenger. Based on the GDP forecasting result, it is calculated the domestic passenger estimation. The calculation assumed that domestic air passenger is as variable Y and Regional GDP is as variable X. Data Y is based on the time series data of passenger from 2009 up to 2012. The regression analysis obtain a mathematical model as below:

$$Y = 14997X - 2000000, \text{ with } R^2 = 0,97 \quad (8)$$

Completely estimation result of domestic air passenger is provided in Table 9 and Figure 4

Table 9. The Forecasting of Domestic Passengers

Year	GDP (Billion)	No. of Pax
2009	686,8	8436847
2010	778,6	10284413
2011	884,5	11582823
2012	1001,2	14086241
2013	1136,3	15016284
2014	1233,96	16505698
2015	1346,12	18187762
2016	1458,28	19869825
2017	1570,44	21551889
2018	1682,6	23233952
2019	1794,76	24916016
2020	1906,92	26598079

International passenger estimation is determined based on the number of foreign tourist visited Jawa Timur Province. Number of international passenger is variable Y and the number of foreign tourist is variable X. Regression analysis result of those data is :

$$Y = 1X + 2007,8 \text{ with } R^2 = 1,0 \quad (9)$$

Estimation result of international passenger is in Table 10 and Figure 3.

Table 10. The Forecasting of International Passengers

Year	Foreign Tourists	No. of Pax	Year	Foreign Tourists	No. of Pax
2010	72706	74716	2019	548626	550633
2011	84160	86171	2020	685782	687789
2012	93560	95572			
2013	143819	145832			
2014	179774	181781			
2015	224717	226724			
2016	280896	282903			
2017	351121	353128			
2018	438901	440908			

So, the total of air passengers in Juanda international airport is the sum of the domestic passengers and international passengers, such as Table 11.

Following is provided the estimation of transit passenger. The calculation is used the trend line method from transit passenger data in 2008 – 2012. The result of this trend line analysis is equation below:

$$Y = 64368{,}2X - 128718232{,}4 \text{ with } R^2 = 0{,}63 \quad (10)$$

Forecasting result of transfer passengers is in Table 12 and Figure 5.

Table 12 The Estimation Result of Transit Passengers

Year	No. Pax
2008	569406
2009	584727
2010	578480
2011	786049
2012	818670
2013	854954
2014	919322
2015	983691
2016	1048059
2017	1112427
2018	1176795
2019	1241163
2020	1305532

c. Ground access traffic forecasting

Then, originating and transfer passenger datas obtained is used to estimate the ground access traffic by using Equation 1. The calculation obtained total vehicle trip of ground access. By assuming, the ground access movement is served by two access road from Terminal T1 and T2, which each capacity 1400 vehicle per lane per hour, the V/C ratio of access road can be determined. Standard of ground access road volume in TRB 2002 is 1000 – 1600 vehicles per lane per hour. All of those calculations can be shown in Table 13.

The V/C ratio more than 0,75 indicates that the access road is needed a treatment. In the table, the V/C ratio are greater than 0,75 since 2016. Therefore, it should be done the development efforts to solve the potential problems. There are two actions can be done. The first is demand management and the other policy is development the access road. One of the demand management is by reducing the dependence of private car. Government should encourage the use of high occupancy vehicle as ground access mode. Development of bus and train operating are the right policies. The efforts of development should be started since 2017. The development of access road can be done by increasing the capacity of existing roads or by developing a new access road. If it is calculated ratio between total vehicle trips with originating passengers, so it is obtained a average ratio of 3,6. It means every passenger generates 3,6 vehicle trips of ground access traffic.

4. CONCLUSION

This analysis shows that the one of passenger movements to and from airport generates the 3,6 vehicle trips of ground access. The ratio is high because the number of passengers in Juanda airport are high too. Therefore, properly the ground access traffic can raise the potential problems of transportation. The problem is congestion probably occurs in the access road. It is needed anticipation efforts. There are two efforts to improve the condition. The one is demand management and the other is development of access infrastructures. Demand management can be done by reducing the use of private cars. Airport Authority should coordinate with Government and Operators of transportation to encourage the usage of high occupancy vehicle such as bus and train. Therefor Government has to invest for developing the infrastructures. Therefore, the demand management and the infrastructures development should be done simultaneously.

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Table 1. The number of Domestic Passengers

Year	Arrival	Departure	Total	Growth (%)
2008	3765862	3539582	7305444	
2009	4317785	4119062	8436847	15,49
2010	5239689	5044724	10284413	21,90
2011	5965890	5616933	11582823	12,63
2012	7355670	6730571	14086241	21,61
		Pertumbuhan rerata		17,91

Table 2. The number of International Passengers

Year	Arrival	Departure	Total	Growth (%)
2008	544725	459721	1004446	
2009	551904	510494	1062398	5,77
2010	614645	601334	1215979	14,46
2011	727332	682083	1409415	15,91
2012	794344	748657	1543001	9,48
		Average Growth		11,40

Table 3. The number of Domestic Aircraft Movements

Year	Arrival	Departure	Total	Growth (%)
2008	36238	36244	72482	
2009	36106	39052	75158	3,69
2010	44093	44146	88239	17,40
2011	50235	50279	100514	13,91
2012	60301	60385	120686	20,07
		Average Growth		13,77

Table 4. The number of International Aircraft Movements

Year	Arrival	Departure	Total	Growth (%)
2008	4521	4519	9040	
2009	4737	4741	9478	4,85
2010	4567	4521	9088	-4,11
2011	5091	5054	10145	11,63
2012	5385	5378	10763	6,09
		Average Growth		4,61

Table 5. The Domestic number of Cargos

Year	Arrival	Departure	Total	Growth (%)

2008	20124050	22757543	42881593	
2009	21417458	26015369	47432827	10,61
2010	24451862	34093603	58545465	23,43
2011	37906296	39348849	77255145	31,96
2012	34367439	51980373	86347812	11,77
Average Growth				19,44

Table 6. The Number of International Cargos

Year	Arrival	Departure	Total	Growth (%)
2008	6892512	7790519	14683031	
2009	8571373	7749905	16321278	11,16
2010	8196448	9031799	17228247	5,56
2011	9420406	8469992	17890398	3,84
2012	10214864	9452271	19667135	9,93
Average Growth				7,62

Table 11 The Forecasting Result of Air Passengers

Year	Domestic	International	Total
2010	10284413	74716	10359129
2011	11582823	86171	11668994
2012	14086241	95572	14181813
2013	15016284	145832	15162116
2014	16505698	181781	16687479
2015	18187762	226724	18414486
2016	19869825	282903	20152728
2017	21551889	353128	21905017
2018	23233952	440908	23674860
2019	24916016	550633	25466649
2020	26598079	687789	27285868

Table 13. Calculation of Ground Access Traffic and V/C Ratio

Year	TOTAL PAX	TRANSIT PAX	ORIGINATING PAX	TVT per Year	TVT per Day	TVT per Hour	V/C RATIO
2010	10284413	578480	9705933	34695819	95057	5003	0,39
2011	11582823	786049	10796774	38711916	106060	5582	0,44
2012	14086241	818670	13267571	47450630	130002	6842	0,53
2013	15016284	854954	14161330	50631704	138717	7301	0,57
2014	16505698	919322	15586376	55709069	152628	8033	0,63
2015	18187762	983691	17204071	61465718	168399	8863	0,69
2016	19869825	1048059	18821766	67222363	184171	9693	0,76
2017	21551889	1112427	20439462	72979011	199942	10523	0,82
2018	23233952	1176795	22057157	78735656	215714	11353	0,89
2019	24916016	1241163	23674853	84492305	231486	12183	0,95
2020	26598079	1305532	25292547	90248950	247257	13014	1,02

Note: TVT (Total Vehicle Trips of Ground Access)

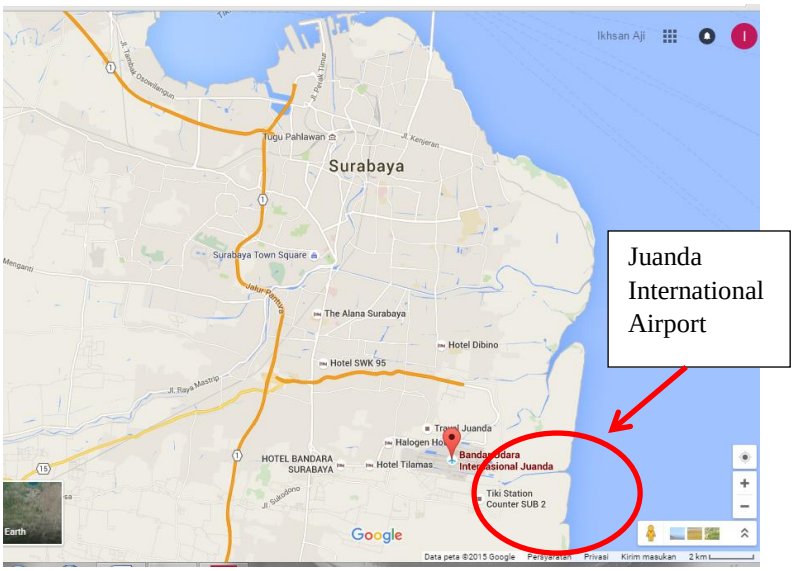

Figure 1. Map of Juanda International Airport

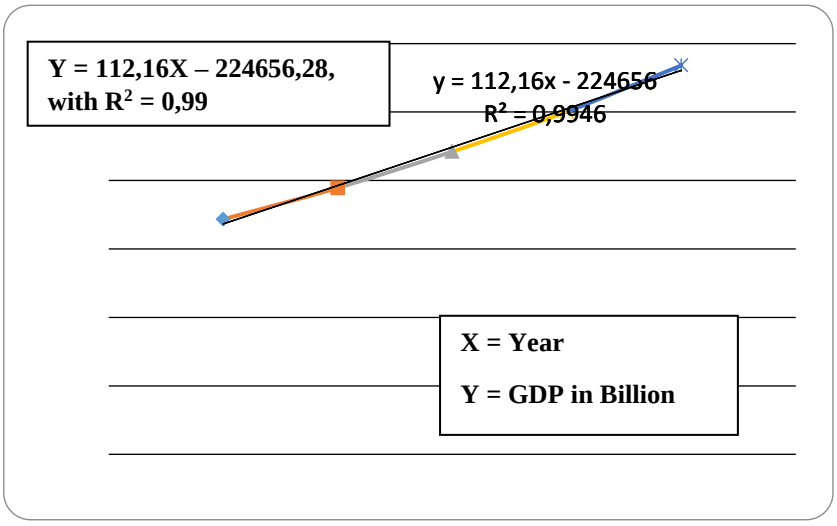

Figure 2. Estimation of GDP of Jawa Timur Province.

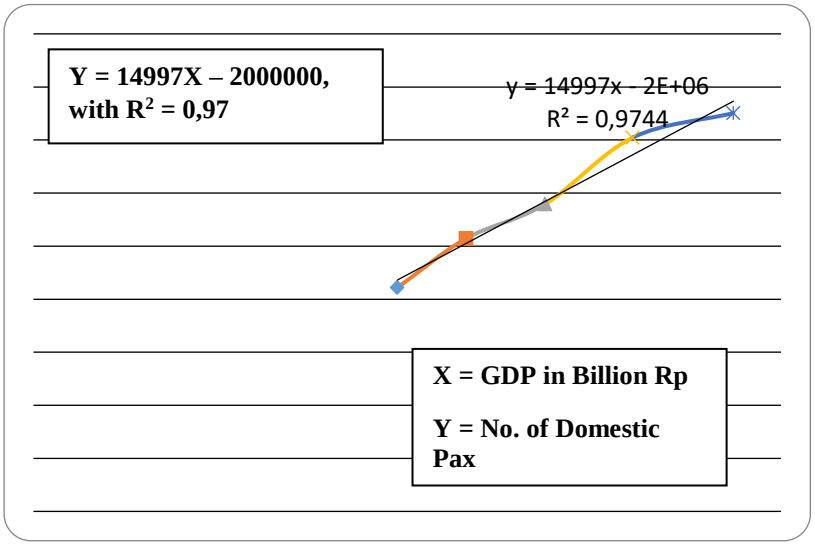

Figure 3. Interrelation Chart of GDP Vs No. of Domestic Pax

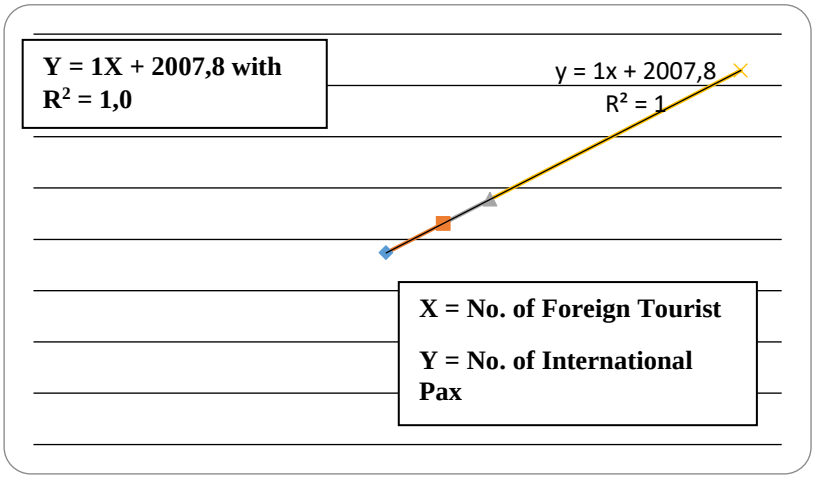

Figure 4 Interrelation Chart of No. Foreign Tourist Vs No. of International Pax

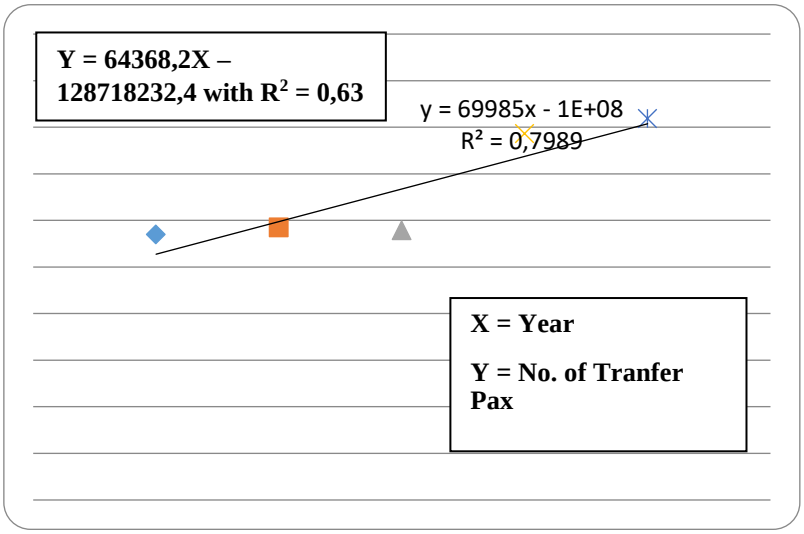

Figure 5. Forecasting of Transfer Passengers