STUDY ON FACTORS INFLUENCING AIR CARGO OPERATION AT PARO INTERNATIONAL AIRPORT, BHUTAN BASED ON FUZZY AHP METHOD

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ABSTRACT

This study aims to establish and evaluate the factors that influence efficiency of the air cargo operation in Paro International Airport, Bhutan. Nine factors under three dimensions which are airport infrastructure, airport network and airport service quality were established and prioritized using the Fuzzy AHP method. The data were collected by using structured questionnaires from experts in various organizations including major airlines in Bhutan, Air transport department as well as experts directly involved with air cargo departments in the airport. The weight result of Fuzzy AHP ranked that airport infrastructure as the main factor that influence the air cargo operation in Paro International Airport. These results could be used for planning, designing and developing the airport infrastructure and service environment for air cargo operation.

Keywords: 1) Air Cargo Operation 2) Fuzzy AHP 3) Bhutan 4) Airport Operation

1. Introduction

Air cargo industry is a part of driving force in world trade that extensively increase the air cargo market since 1907 (Chang et al, 2007; Zhang et al, 2002). Air cargo market demand had increased 9.3% in 2017 and it is expected to increase year by year according to International Air Transport Association (2018). As the demand and market increases, the need for service quality and overall performance must be carried out to meet the customer satisfaction. Air cargo enables many countries to keep pace with global trade and helps to expand the economics of that particular county. Trading between one side of world to the other wouldn't be successful without the air transportation. In the world of e-commerce and digital technology, air cargo plays a vital role in providing the fastest delivery of goods and services. Air freight transportation is a part of ongoing integration of economics in Asian Pacific region (Grosso, et al., 2011).

Air transportation in Bhutan is a crucial and important part of the solution to economy, energy, and environmental challenges which could bring the better quality of lifestyles. Bhutan is located between China and India. According to National Statistics Bureau of Bhutan (2018), Bhutan's total population is 735,553 as of 30th May 2017 and a total land area of 38,394 km (Brooks, 2013). Gross National Happiness Commission (2011) stated that road transportation in Bhutan faces the certain challenges due to their vulnerability to landslides and adverse climatic conditions which resulted in weak and poor road condition. Asian Development Bank (2013) mentioned that Bhutan faced the unique development challenges and opportunities. It is difficult to achieve the economy of scale in term of service delivery due to the location and infrastructure. The trade volume is comparatively low due to the location of the county. The main cross trade border is in the

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south of Bhutan, which is purely for land transportation. The weak and poor road infrastructure connecting Bhutan to India resulted in high cost and low reliability. These factors comparatively affect the growth of trade in Bhutan. As the geographical location cannot to changed or improved, the study on air cargo operation might suggest and help the current situation of trade in Bhutan. The study focuses on establishment and prioritization of key factor in air cargo operation in Paro International Airport based on Fuzzy AHP method.

2. Literature Review

A cargo transportation provides the service of goods delivery from the place of origin to destination (Derigs et al.,2009) moving cargo through a shipper, a forwarder, a road transporter, an airline and a consignee (Feng et al., 2015). When shippers want to send the goods to some destination with low cost and better service, forwarders act as a bridge between airlines and shippers. Road transporters, also known as truck are used to carry the goods to airport through land. The cargo airline receives goods, store in warehouse and transfer the goods to the destination. Finally, the shipment is received and acknowledge by consignee (Kasilingam, 2003). The following factors that influences airlines cargo operators in Paro International Airport, Bhutan were selected based on literature review and present situation of air cargo operation in the airport. The three dimensions of factors; lack of Airport Infrastructure, limited airport network and airport service facilities were established to study on the factors influencing air cargo operation.

Table 1: Factors influencing air cargo operation at Paro International Airport

Criteria	Sub- criteria	References
Airport Infrastructure (AI)	• Airport capacity (AI1) • Cargo handling equipment (AI2) • Airport charges (AI3)	Struyf (2016). Adenigbo (2016) Zhang et al (2003)
Airport network (AN)	• Current flight route (AN1) • Flight frequency (AN2) • Air connectivity network (AN3)	Jing (2007). Gupta and Walton (2017) Jing (2007)
Airport service quality (AS)	• Cargo security (AS1) • Custom efficiency (AS2) • Cargo Processing Time (AS3)	Gupta and Walton (2017) Gardiner et al (2005 Jing (2007)

2.1 Airport Infrastructure

Forsyth (2007) stated that the demands on airport infrastructure around the world are both growing and changing. Airport infrastructure are considered as the strategic due to its importance and increases in air transport movement (Percoco, 2010). With changes in demand, the airport infrastructure needs to be upgrades and increase its facilities. At present, some of the factors that need to be studied under airport infrastructure are airport capacity, Cargo handling equipment and Airport charges for airline cargo operators (Adenigbo 2016) and (Struyf, 2016).

2.2 Airport network

An airport network forms the backbone of any air transportation system. The movement of people through air transportation has increases every year. The expansion of airport network brings not only people from different country but also the goods and products. Consumers today expects fast and quick delivery in spite of any location. The expansion and airport network show the growth of economic (Zhang et al., 2010) as well as support the development of economic. Airline flight route (Jing, 2007); flight frequency

(Gupta and Walton, 2017) and air network of airport (Jing, 2007) are some factors that affect the cargo operators in Paro International Airport.

2.3 Airport service quality

Airport provide the sufficient service to their customers and stakeholders. With rapidly changes in nature of the airport industry, many researchers emphasized and studied on airport service in term of passenger's perspective. The choice of airline to operate air cargo also depends on the airport service level and quality. The three service factors which are cargo security (Gupta and Walton,2017); custom efficiency (Gardiner et al,2005); and cargo processing time (Jing,2007) are considers as sub factors under airport service.

3. Methodology

Although Van Laarhoven and Pedrycz (1983) introduced the first fuzzy AHP to solve complex decision-making problems, the application and approach was revised and studied by many researchers for decision making purposes. As the AHP showed some limitations which are unbalance of the judgmental scale and lack of uncertainty (Sirisawat et al., 2017), Chang (1996) presented a new approach, fuzzy AHP, using triangular number with pairwise scale to handle and to solve those problems.

Definition of fuzzy AHP

The membership function of Ã fuzzy set is shown by μÃ(x) (Çebi, et al., 2017). The membership of triangular fuzzy numbers Ã on R shown in Figure1 where R→ [0, 1] denoted as (l, m, u) can be defined as; (Sun, 2010);

$$\mu\tilde{A}(x) = \begin{cases} \dfrac{(x-l)}{(m-l)}, & x \in [l, m], \\ \dfrac{(x-u)}{(m-u)}, & x \in [m, u], \\ 0 & \text{Otherwise} \end{cases} \qquad (1)$$

From Equation (1);

"l" is the smallest probable value
'm' is the most probable number
'u' is the largest probable value for Ã.

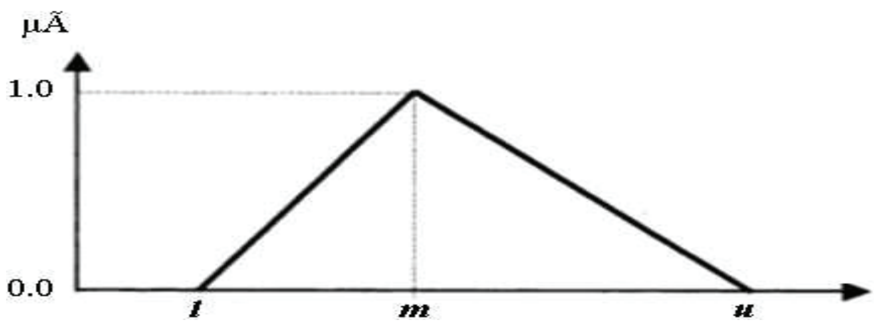

Figure:1 The illustration of membership functions of TFN

According to, Sun (2010), Prakash and Barua (2015), Zyoud (2016), and Sirisawat, et al. (2017), the operational laws of two triangular fuzzy number $\tilde{A}= (a_1, a_2, a_3)$ and $\tilde{B}= (b_1, b_2, b_3)$ can be written into the following Equations 2-6

$$\tilde{A} + \tilde{B} = (a_1, a_2, a_3) + (b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \tag{2}$$

$$\tilde{A} - \tilde{B} = (a_1, a_2, a_3) - (b1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \tag{3}$$

$$\tilde{A} \times \tilde{B} = (a_1, a_2, a_3) \times (b1, b_2, b_3) = (a_1 b_1, a_2 b_2, a_3 b_3) \tag{4}$$

$$\tilde{A} \div \tilde{B} = (a_1, a_2, a_3) / (b1, b_2, b_3) = (a_1/b_1, a_2/b_2, a_3/b_3) \tag{5}$$

$$\tilde{A}^{-1} = (a_1, a_2, a_3)^{-1} = (l/a_3, l/a_2, 1/a_1) \tag{6}$$

Sirisawat et al (2017) used the equation (7) as the method of extend analysis

$$M^1_{g_i}, M^2_{g_i}, M^3_{g_i}, \ldots, M^m_{g_i}, \quad i = 1, 2, 3, n, \tag{7}$$

Where all the M^j_{gi} (j =1, 2, 3, m) are TFN.

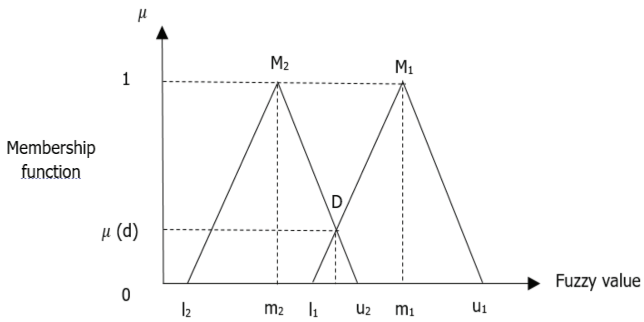

Figure 2: The illustration of intersection between two triangular fuzzy numbers.

After the aggregation of criteria matrix, three steps are applied to get the final weight of each criteria. The three steps according to (Sirisawat et al, 2017) are as followings; **In the first step,** Fuzzy synthetic extent's value with respect to i-th criterion can be shown as:

$$S_i = \sum_{j=1}^{m} M^j_{g_i} \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M^j_{g_i}\right] \tag{8}$$

$$\sum_{j=1}^{m} M^j_{g_i} = \left(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}\right)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M^j_{g_i}\right] = \left(\frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} u_{ij}}, \frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} m_{ij}}, \frac{1}{\sum_{n}^{i=1}\sum_{m}^{j=1} l_{ij}}\right)$$

In the second Step, the degree of possibility of criteria are compared as follows; If $M_1 = (l_1, m_1, u1)$ and $M_2 = (l_2, m_2, u_2)$ and are two fuzzy synthetic extent values, the degree of possibility of $M2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ can be illustrated as:
$V (M_2 \geq M_1) = hgt (M_2 \cap M_1) = \mu(d)$

$$= \begin{cases} = 1 & \text{if } m_2 \geq m_1 \\ = 0 \text{ if } l_2 \geq u_2 & \\ = \dfrac{l_1 - u_2}{(m_2 - u_2)\ (m_1 - l_1)} & \text{otherwise} \end{cases} \tag{9}$$

where μd is the ordinate highest intersection between two fuzzy numbers as shown in Figure 2

The degree of possibility for convex fuzzy numbers greater than *k* convex fuzzy M_i (i=1,2, 3…, k) can be defined by the following equations:

$$\begin{aligned} &V (M \geq M_1, M_2,, M_k) \\ &= V[(M \geq M_1), (M \geq M_2) \text{ and… and } (M \geq M_k) \\ &= \min V (M \geq M_i),\ i = 1,2,3,4,5, ... ,k \end{aligned} \tag{10}$$

By assuming that $d' (A_i) = \min V (S_i \geq S_k)$ For k = 1,2,3,4,5, … ,n (k≠i), then the weight vector is given by

$$W' = (d' (C_1), d' (C_2),…, d' (C_n))^T, \tag{11}$$
where C_i (i=1,2,3,4,5,…,n) are the weight of each criteria.

In the final step, via normalization, the normalized weight vectors of each criteria can be defined as:

$$W = (d (C_1), d (C_2),, d (C_n))^T, \tag{12}$$
where W is a non-fuzzy number.

Table 2: Linguistic variables and triangular fuzzy numbers for criteria and sub-criteria ratings

Fuzzy number	Linguistic variables	Triangular fuzzy numbers
$\tilde{9}$	Extreme Importance	(8,9,10)
$\tilde{8}$	Very strong to extreme importance	(7,8,9)
$\tilde{7}$	Very strong importance	(6,7,8)
$\tilde{6}$	Strong to very strong importance	(5,6,7)
$\tilde{5}$	Strong importance	(4,5,6)
$\tilde{4}$	Moderate to strong importance	(3,4,5)
$\tilde{3}$	Moderate importance	(2,3,4)
$\tilde{2}$	Equal to moderate importance	(1,2,3)
$\tilde{1}$	Equal importance	(1,1,1)

Source: Sirisawat, et al., (2017)

4. Result

Table 3: Aggregated decision matric of the main three dimensions

	Airport Infrastructure	Airport network	Airport service quality	Weight	Rank
Airport Infrastructure	(1.00,1.00,1.00)	(1.00,4.17,9.00)	(1.00,1.67,6.00)	0.39	1
Airport network	(0.11,0.38,1.00)	(1.00,1.00,1.00)	(0.11,0.60,1.00)	0.29	3
Airport service quality	(0.17,0.87,1.00)	(1.00,3.33,9.00)	(1.00,1.00,1.00)	0.32	2

Table 4: Aggregated decision matric of sub criteria (Airport Infrastructure)

	Airport capacity	Cargo handling equipment	Airport charges	Weight	Rank
Airport capacity	(1.00,1.00,1.00)	(0.20,1.88,5.00)	(1.00,3.00,8.00)	0.37	1
Cargo handling equipment	(0.20,1.25,5.00)	(1.00,1.00,1.00)	(1.00,3.17,8.00)	0.30	3
Airport charges	(0.03,0.61,1.00)	(0.13,0.60,1.00)	(1.00,1.00,1.00)	0.33	2

Table 5: Aggregated decision matric of sub criteria (Airport Network)

	Current flight route	Flight frequency	Air connectivity network	Weight	Rank
Current flight route	(1.00,1.00,1.00)	(0.14,1.62,6.00)	(0.17,1.32,6.00)	0.29	3
Flight frequency	(0.17,2.59,7.00)	(1.00,1.00,1.00)	(0.14,2.40,7.00)	0.41	1
Air connectivity network	(0.17,2.37,6.00)	(0.14,1.96,7.00)	(1.00,1.00,1.00)	0.30	2

Table 6: Aggregated decision matric of sub criteria (Airport Service Quality)

	Cargo security	Custom efficiency	Cargo processing time	Weight	Rank
Cargo security	(1.00,1.00,1.00)	(0.17,1.37,5.00)	(0.17,2.53,8.00)	0.39	1
Custom efficiency	(0.20,1.51,6.00)	(1.00,1.00,1.00)	(1.00,1.67,6.00)	0.30	3
Cargo processing time	(0.13,1.39,6.00)	(0.17,0.87,1.00)	(1.00,1.00,1.00)	0.31	2

Table 7: Value of Fuzzy Synthetic extent criteria

Airport Infrastructure	(3.00,6.83,16.00) x (1/30.00,1/14.01,1/6.39) = (0.10, 0.49, 2.50)
Airport network	(1.22, 1.98, 3.00) x (1/30.00,1/14.01,1/6.39) = (0.04, 0.14, 0.47)
Airport service quality	(2.17, 5.20, 11.00) x (1/30.00,1/14.01,1/6.39) = (0.07, 0.37, 1.72)

Table 8: Degree of possibility of criteria (V-Value)

	Airport Infrastructure	Airport network	Airport service quality
Airport Infrastructure	-	1.00	1.00
Airport network	0.74	-	0.91
Airport service quality	0.81	1.00	-

The Aggregated decision matric of the main three dimensions are shown in table 3 based on formula (2). Table 4-6 showed the aggregated decision matric for sub-criteria /factors. The calculation of Value of Fuzzy Synthetic extent criteria is shown in table (7). Table (8) is the calculation of degree of possibility of criteria (V-value) obtained using the equation (9). After applying equation 10, the following value are obtained;

d'(Airport infrastructure) =min V $(S_i = S_k)$ =min(1.00,1.00) = 1
d'(Airport network) =min V $(S_i = S_k)$ =min(0.74,0.91) = 0.74
d'(Airport network) =min V $(S_i = S_k)$ =min(0.81, 1.00) = 0.81
The weight vector for each criterion can be written as;
$W' = (1.00, 0.74, 0.81)^T$
Via normalization, the final weight for each criterion are obtained as
W= (0.39, 0.29,0.32). The final ranking is shown in table (9).

Table 9: Final Ranking of factors influencing air cargo operation at Paro International Airport

Criteria	Weight	sub-criteria	weight	Finalized weight	Global Rank
Airport Infrastructure	0.390	AI1	0.373	0.14541	1
		AI2	0.296	0.11557	5
		AI3	0.331	0.12902	2
Airport network	0.290	AN1	0.291	0.08435	9
		AN2	0.408	0.11838	4
		AN3	0.301	0.08727	8
Airport service quality	0.320	AS1	0.389	0.12434	3
		AS2	0.299	0.09577	7
		AS3	0.312	0.09989	6

5. Discuss and Conclusion

This study established and prioritized the factors that influence the efficiency of air cargo operation in Paro International Airport based on Fuzzy AHP method. The data were collected by using structured questionnaires from experts in various organizations including major airlines in Bhutan, Air transport department as well as experts directly involved with air cargo departments in the airport. The weightage result of fuzzy AHP showed that airport infrastructure is the most importance factors which are considered by two airlines in Bhutan while operating the air cargo operation. From the three main criteria, Airport service quality ranked second and airport network in the third.

For the sub- criteria under airport infrastructure, the ranking values are, airport capacity > Airport charges > Cargo handling equipment which means that airport capacity is the highest weighted factors whereas cargo handling equipment is lowest weighted factor. Similarly, under airport network, Flight frequency > Air connectivity network > Current flight route as presented in table 5. And finally, under the airport service quality, Cargo security > Cargo processing time > Custom efficiency respectively, which showed that cargo security is the most important factor and custom efficiency as the least important factor. The Fuzzy AHP method is very applicable for decision makers. The proposed result from this study presented the current situation of air cargo operation in landlocked country and gives information and guidelines to airport and its stakeholders for planning, policy making and implementing the development of airport in Bhutan.

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