A Fuzzy Analytic Hierarchy Process Approach to Identify the Relative Importance of Factors Influencing Air Cargo Operation: A Case Study with Paro International Airport in Bhutan

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Abstract

It is crucial for countries located in mountainous areas where the surface transportation system is extremely poor to have effective air freight capabilities. As a case study, the objectives of this research are to identify the principal factors required to enhance air cargo operations at Paro International Airport in Bhutan, and to prioritize the importance of each factor to determine solutions for the effective development of the airport. The study utilizes the fuzzy analytic hierarchy process (AHP) as its research methodology. According to the analysis of the data obtained via the AHP survey through air cargo management experts in Bhutan, cargo handling infrastructure is identified as the most important area needing improvement, followed by airport charges and cargo security service. This study finds three main conclusions. First, the airport authority should devise a financing plan, and this plan should utilize airline participation if the airport authority does not have a sufficient budget for airport infrastructure development. Second, the airport should look to utilize a small number of employees who can perform multiple duties. For instance, security functions and customs functions for cargo operations could be carried out via combined procedures by multi-functional staff members, which would reduce operational costs and cut back on airport charges related to cargo operations. Third, the airport should increase its supply of flight services by lobbying for economic deregulation in the aviation industry. This could, for example, pave the way for foreign airlines to start using the airport.

Keywords: air cargo operations, fuzzy AHP, Bhutan, airport operations

1. Introduction

The air cargo industry, which has increased extensively over the past few decades, is a driving force in world trade (Chang et al., 2007; Zhang et al., 2007). It is also expected to increase year by year in the future according to the International Air Transport Association (2018). Air cargo enables countries to keep pace with global trade and plays a vital role in providing the fast delivery of goods and services in a period of e-commerce and digital technology. It is particularly crucial for geographically rugged regions in which surface transportation systems are poor to develop effective air freight capabilities. Bhutan is a prime example given its location in a mountainous area between China and India.

Bhutan is a small country. According to National Statistics Bureau of Bhutan (2018), the population of Bhutan was 735,553 as of May 30th, 2017 and has a total land area of 38,394 km2 (Brooks, 2013). The Gross National Happiness Commission (2011) stated that road transportation in Bhutan faced certain challenges due to its vulnerability to landslides and adverse climatic conditions that resulted in poor road conditions. The Asian Development Bank (2013) also mentioned that Bhutan faced unique development challenges and opportunities. It is difficult for the country to achieve economies of scale in terms of service delivery due to its geographical location and substandard infrastructure. The main cross-border trade is in the south of Bhutan and depends entirely on road transportation. In terms of logistics systems, the poor road infrastructure connecting Bhutan to India results in high costs and low reliability, and this has retarded the growth of international trade in Bhutan.

As the geographical location cannot be changed or improved, studies on air cargo operations might help in finding solutions to incumbent obstacles in facilitating trade in Bhutan. As an initial study in this area, the objectives of this research are to identify the principal factors required to improve air cargo operations at Paro International Airport, and to prioritize the importance of each factor. These objectives are examined via an analysis of data collected using an opinion survey involving experts in the area of air cargo operations for the airport utilizing the fuzzy AHP methodology

1.1 Background Knowledge on Case Airport and Its Cargo Handling

Paro International Airport was opened in 1983 and is managed by the Bhutan Civil Aviation Authority under the Ministry of Information and Communication. It is located at an altitude of 2,243 meters (7300 feet) above sea level and is considered to be one of the most challenging airports in the world (Wangdra,et al ,2018).The airport only operates during the day and is constrained by meteorological conditions. The freight handling infrastructure of the airport, including the cargo terminal, warehouse, cargo security services and associated airport services and facilities, are very poor and are perceived as major defects in cargo operations according to the two home base airlines, Drukair and Bhutan Airlines. Actually, there is no cargo terminal, and a temporary storage facility is used as a cargo warehouse. In the peak seasons, summer and winter, this temporary warehouse is unable to accommodate the cargo demand as the capacity is insufficient. As a result, many of the commodities are kept outside and around the facility.

Another crucial factor for the development of Bhutan's air cargo industry is the air transport network from the airport. Bhutan has limited links to other countries. Bhutanese airlines fly to Singapore, Thailand, India, Nepal and Bangladesh. Today, most cargo shipments and transportation are to and from Thailand and Singapore. According to the responsible managers at Bhutan Airlines, the unit cost of cargo operation is also high due to the poor internal cargo system of the airline because flights are mainly for passenger services and only utilize the belly space for cargo transportation. The efficiency of air cargo operations is also influenced by airport services associated to cargo operations, including cargo security and customs services

2. Literature Review

An air cargo transportation service provides the delivery of goods from a place of origin to a destination, moving consignments sequentially through a shipper, forwarder, road transporter, airline and a consignee (Derigs et al., 2009, Feng et al., 2015). When shippers try to send goods to destinations at a lower cost and with better service, forwarders act as a bridge between airlines and shippers. Road transporters, also known as truckers, are used to carry the goods to the airport from the cargo's origin. Airlines receive goods and store them in warehouses for some time. They then load them into aircraft and transport the goods to their destinations. Finally, shipments are received and acknowledged by consignees (Kasilingam, 2003).

The air cargo market in the world continues to grow year by year. This increasing market has encouraged many airports and airlines to strive for a high quality of service and focus on further improvements (Park & Ha, 2013). Many researchers' works thus far have focused on the service quality of air cargo systems. For instance, Gardiner, Ison and Humphreys (2005) identified and evaluated factors that influenced how airports would choose freighter airlines. From fifteen factors, nine were considered as important – night operation, local origin-destination demand, minimize overall cost, reputation of airport cargo customs clearance times, influence of freight forwarders, airport road access, financial incentive from the airport and transportation to main markets. Their findings showed that the night operation of airports and the minimized costs were the most important factors. Yoon and Park (2014) studied the importance and satisfaction of forwarders with respect to airline service providers. They identified the services that the forwarders expected from airlines in five different factor dimensions – price, agility, reliability, ease of use and sociality – with 24 service items. May et al. (2014) studied the prioritization of performance indicators in air cargo demand management based on insights from industry perception using intelligent fuzzy multi-criteria methods. The findings highlighted network optimization as the KPI representing the most satisfactory solution. Other outcome-based KPIs of critical importance were optimizing density, permanent bookings (PB)/free-sale mix and overbooking. Adenigbo (2016) examined factors influencing a cargo agent's choice of operations in Abuja airport, Nigeria, using a factor analysis and multiple linear regression. The results showed that airport capacity, airport charges and custom efficiency were the most significant factors for the cargo agent when determining cargo operations in that airport. Gupta and

Walton (2017) used the interpretive structural modeling method to explore the statistical factors that affected an air cargo airline, including the operations, management and financial viability of cargo airlines. Under operations, eight attributes were selected – security, capacity issues, labor issues, fuel efficiency, flight frequency, geographic location, maintenance issues and level of service. They found that all cargo operations were most affected by the geographic location that the airline served.

This study focuses on all sectors involved in air transportation when considering all of the procedures related to air cargo transportation. From the aforementioned literature, 27 relatively important factors were selected to cover the scope of this study. Subsequently, the study conducted an in-depth interview with two managers from two Bhutanese airlines to identify the factors that influenced their cargo operations as well as to understand the detailed challenges and current situation associated with air cargo operations at Paro International Airport. Finally, only nine factors were selected to use in this study. Those nine factors are structured as components of Level 2 in the hierarchy, subordinated under three essential area factors. The three area factors are airport infrastructure, flight route network, and airport services involved in cargo handling. The overall structure of the area factors and involved subordinate factors are shown in Table 1.

Table 1. Factors Influencing Air Cargo Operations at Paro International Airport

Level 1 Area Factors	Definition	Level 2 Subordinate factors	References
Airport Infrastructure	Airport infrastructure including the facilities needed to operate air cargo at the airport.	1. Airport capacity 2. Cargo handling equipment 3. Airport charges	Struyf (2016) Traguetto et al. (2017) Adenigbo (2016)
Route Network	The flights operated at the airport and route that are linked to other airports.	1. Routes in flight service 2. Flight frequency 3. Air connectivity network	Jing (2007) Gupta and Walton (2017) Jing (2007)
Airport Service Quality	The ability of the airport to support and render their services to air cargo airlines at Paro International Airport.	1. Cargo security 2. Customs efficiency 3. Cargo processing time	Gupta and Walton (2017) Gardiner et al. (2005 Jing (2007)

As indicated, the study identified three ***area factors*** to subordinate nine factors finalized by the literature review and interviews with experts. The following subsections explain the ***area factor*** and associated ***subordinate factor*** while referring to relevant references and the situation at Paro International Airport.

2.1 Airport Infrastructure

Forsyth (2007) stated that the demands on airport infrastructure around the world were both growing and changing. Airport infrastructure is considered a strategic tool due to its importance and comprehensive influence in air transport movement (Percoco, 2010). With changes in demand, airport infrastructure needs to be upgraded, and the capacity of associated facilities need to be increased. The major factors included in airport infrastructure are airport capacity, cargo handling equipment and airport charges for airlines' cargo operators (Traguetto et al., 2017, and Struyf, 2016). As described in the previous section, airport infrastructure influences air cargo operations at Paro International Airport. The airport, which is state-owned, is small in terms of area and infrastructure. In addition, the airport lacks the required equipment as well as the standard operating procedures for ground handling operations.

2.2Route Network

The route network from an airport forms the backbone of any air transportation system. Consumers today expect fast delivery regardless of locational handicaps. Accordingly, it has been argued that the expansion of an airport's route network is representative of economic growth (Zhang et al., 2010) as well as support for economic development. Airline flight routes (Jing, 2007), flight frequency (Gupta & Walton, 2017) and the air network of the airport (Jing,

2007) are major factors that affect a cargo operator's performance at an airport. Currently, Paro International Airport and its flight network are modest. The state-owned airport allows only two Bhutanese airlines to operate flights to limited destinations. The current flight routes provide links to just five countries – India, Thailand, Bangladesh, Nepal and Singapore. Moreover, the number of flights per day is also limited due to government policies and weather conditions. For these reasons, aircraft need to park and spend the night at Suvarnabhumi airport, in Thailand, for their return flights.

2.3 Airport Service Quality

An international airport operator should provide standardized services to their customers and stakeholders. Although there are numerous studies on airport services with respect to passenger handling, there are also quite a few studies on airport service quality related to cargo handling. The three major service factors related to cargo handling at an airport are recognized as cargo security (Gupta & Walton,2017), customs efficiency (Gardiner et al., 2005) and cargo processing time (Jing, 2007). At Paro International Airport, ground handling, including cargo handling, is carried out by the airport operator, which is a government-run organization. One of the air cargo managers from Bhutan Airlines mentioned that the services provided by the airport were not sufficient as the employees were not specialized in ground handling processes.

3.Methodology for Data Analysis

Although Van Laarhoven and Pedrycz (1983) introduced the first fuzzy AHP to solve complex decision-making problems, the original application and approach have been revised and studied by many researchers for decision making purposes. As the initial (pre-fuzzy) AHP was flawed by certain limitations (e.g. an imbalance in the judgmental scale and a lack of uncertainty) (Sirisawat et al., 2017), Chang (1996) presented a new approach with the fuzzy AHP using a triangular number with a pairwise scale to handle and solve those problems.

The membership function of fuzzy set Ã can be represented by μ Ã(x) (Sirisawat et al., 2017), and the membership of triangular fuzzy numbers Ã on R is derived as R→ [0, 1]. This is denoted with (l, m, u) and can be represented as the following Equation. (1) (Sun, 2010)

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

In Equation (1), l is the smallest probable value, m is the most probable number, and u is the largest probable value for Ã.

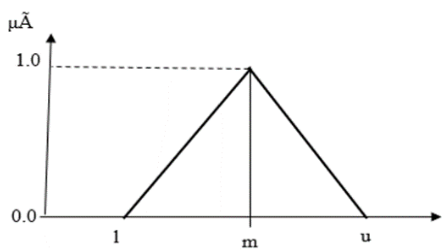

Figure 1 Concept of Membership Functions of Triangular Fuzzy Numbers

The operational laws of two triangular fuzzy numbers, Ã= (a_1, a_2, a_3) and $\tilde{B}$= (b_1, b_2, b_3), are shown in Equations 2-6, (Sun, 2010; Prakash and Barua, 2015; Zyoud et al., 2016; Sirisawat et al., 2017).

$$\tilde{A} + \tilde{B} = (x_1, x_2, x_3) + (y_1, y_2, y_3) = (x_1+ y_1, x_2+ y_2, x_3+ y_3) \tag{2}$$

$$\tilde{A} - \tilde{B} = (x_1, x_2, x_3) - (y_1, y_2, y_3) \tag{3}$$

$= (x_1 - y_1, x_2 - y_2, x_3 - y_3)$

$\tilde{A} \times \tilde{B} = (x_1, x_2, x_3) \times (y_1, y_2, y_3)$ (4)

$= (x_1y_1, x_2y_2, x_3y_3)$

$\tilde{A} \div \tilde{B} = (x_1, x_2, x_3) / (y_1, y_2, y_3)$ (5)

$= (x_1/y_1, x_2/y_2, x_3/y_3)$

$\tilde{A}^{-1} = (x_1, x_2, x_3)^{-1}$ (6)

$= (1/x_3, 1/x_2, 1/x_1)$

The method of extent analysis (Sirisawat et al., 2017) can be displayed as follows;

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

Where all the M^j_{gi} (j =1, 2, 3, m) are Triangular Fuzzy Numbers as shown in table 2.

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

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

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

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

In the second step, the degree of possibility of criteria are compared as follows.

If $M_1 = (l_1, m_1, u1)$ and $M_2 = (l_2, m_2, u_2)$ 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

$V(M_2 \geq M_1) = hgt(M_2 \cap M_1) = \mu(d)$

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

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

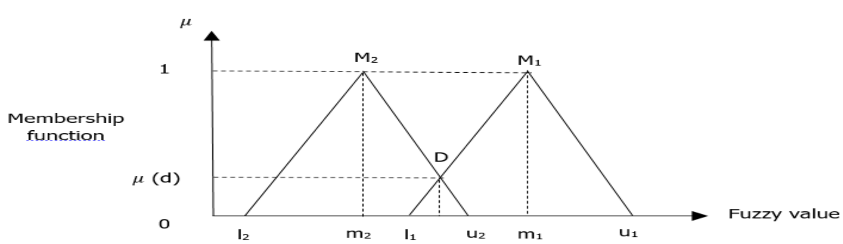

Figure 2 Illustration of Intersection between Two Triangular Fuzzy Numbers

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.

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

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.Data Collection Procedure

The data required for the fuzzy AHP analysis was collected via the survey of experts involved in the area. There is a very limited number of air cargo experts in Bhutan. Using non-probabilistic and purposive sampling, fifteen experts from involved organizations, including the two major airlines in Bhutan, the government's Air Transport Department and experts directly involved with air cargo departments at the airport, were identified. The structured questionnaires were distributed to the experts. The questionnaire was designed to work with our AHP analysis by prioritizing factors in the decision structure. The research survey was conducted from the 20th June 2019 to the 20th July 2019 for the period of one month. Because this research and survey were supported by the Ministry of Information and Communication, Government of Bhutan, all of the experts submitted fully-filled questionnaires, and all fifteen collected responses were confirmed as valid for a the fuzzy AHP analysis of this study.

5. Results and Discussion

Initially, the fuzzy AHP analysis is able to indicate the relative importance of each component factor in the same level of the hierarchy. Table 3 shows the results of the analysis for the Level 1 component in the hierarchy of this study, which shows the importance weightage for each ***area factor*** involved in air cargo operations in the land-locked country.

Table 3 Aggregated Decision Matrix of the Main Area Factors (Level 1)

	Airport infrastructure	Route network	Airport service facilities	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
Route 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

After the aggregation of each value under each ***area factor***, 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) Sirisawat et al. (2017) is applied to obtain the value for each dimension.

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

Airport infrastructure = (1+1+1, 1+4.17+1.67, 1+9+6) = (3.00,6.83,16.00)
Route network = (0.11+1+0.11, 0.38+1+0.60, 1+1+1 0) = (1.22, 1.98, 3.00)
Airport service facilities = (0.17+1+1, 0.87+3.33+1, 1+9+1) = (2.17, 5.20, 11.00)

In the next process, the value of the fuzzy synthesis extent is calculated. Using Equation (8), as shown below, the sum of each fuzzy is calculated. The resulting value of the fuzzy synthesis extent for each criterion is shown in Table 4.

Table 4 Value of Fuzzy Synthetic Extent Criteria

Criteria	Calculation
Airport infrastructure	(3.00,6.83,16.00) x (1/30.00,1/14.01,1/6.39) = (0.10, 0.49, 2.50)
Route 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)

The value of each fuzzy synthetic extent for the criteria are subsequently compared, and the degree of possibility of criteria (V-value) is calculated using Equation (9), as shown in table 5.
d'(Airport infrastructure) = min V (S_i = S_k) = min(1.00,1.00) = 1
d'(Route network) = min V (S_i = S_k) = min(0.74,0.91) = 0.74
d'(Airport service quality) = min V (S_i = S_k) = min(0.81, 1.00) = 0.81

Table 5 Degree of Possibility of Criteria (V-Value)

	Airport infrastructure	**Route network**	**Airport service quality**
Airport infrastructure	-	1.00	1.00
Route network	0.74	-	0.91
Airport service quality	0.81	1.00	-

Finally, via normalization, the normalized weight vectors of each criteria are calculated using Equation (10). 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 is obtained as
W= (0.39, 0.29,0.32)

The final ranking of the main dimensions of the ***area factor*** is shown in Table 3. It is found that the three main criteria have obtained different weighted value. After comparing, the highest weighted value is 0.39 (Airport infrastructure) which is considered or read as the most important factors based on the ranking. The weighted value 0.29 is the least important factor as other weighted values are nearer to 1.

The same method is applied to all sub-factors under each dimension. Level 2, under Airport Infrastructure, the Airport capacity (0.37) was perceived as the most important factor followed by airport charges and cargo handling equipment as shown in table 6.

Table 6 Aggregated Decision Matrix of Subordinate Factors (Level 2, under 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 7 Aggregated Decision Matrix of Subordinate Factors (Level 2, under Route 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 8 Aggregated Decision Matrix of Subordinate Factors (level 2, under 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

Similarly, the same method was applied to calculate the aggregated decision matrix of subordinate factors (Level 2, under Route Network) as shown in table 7. The result demonstrated that flight frequency (0.41) is the most influencing factors followed by Air connectivity network and Current flight route. Whereas under level 2, airport service quality, Cargo security (0.39) is the most influencing factors. The final result is shown in table 8. Finally, the combined weight of each ***area factor*** (Level 1) and each of the associated ***subordinate factor levels*** (Level 2) was calculated. The combined weight and global ranking for subordinate factors are shown in Table 9. After the global ranking, it was found that the top three most importance factors are airport capacity (0.14541) followed by airport charges (0.12902) and cargo security (0.12434). The detail ranking is shown in table 9.

Table 9 Combined Weight and Global Ranking for Every Subordinate Factor

Criterion	Weight	Sub-criteria	Weight	Combined weight	Global Rank
Airport Infrastructure	0.390	1. Airport capacity	0.373	0.14541	1
		2. Cargo handling equipment	0.296	0.11557	5
		3. Airport charges	0.331	0.12902	2
Route Network	0.290	4. Current flight route	0.291	0.08435	9
		5. Flight frequency	0.408	0.11838	4
		6. Air connectivity network	0.301	0.08727	8
Airport Service Facilities	0.320	7. Cargo security	0.389	0.12434	3
		8. Custom efficiency	0.299	0.09577	7
		9. Cargo processing time	0.312	0.09989	6

6. Discussion of Analysis Results

The weight results of the fuzzy AHP demonstrate that airport infrastructure is the most important ***area factor*** among the Level 1 components. Among the subordinate factors under airport infrastructure, airport capacity is recognized as being the first priority in terms of the need to improve the efficiency of air cargo handling at Paro International Airport. With consideration given to the airport's current situation, a cargo terminal (with a cargo handling building) needs to be built. If the government authority or airport authority does not have the sufficient budget to construct such a facility, the authors recommend that the airport authority ask the two airlines to build the facility for their own purposes. They could utilize a project financing strategy such as build-operate-transfer (BOT) or build-own-operate-transfer (BOOT).

The second priority is to address airport charges, and the third is to look at cargo security, as shown in Table 9. It is necessary for the airport to reduce the costs of cargo handling to cut down on airport service charges, and the airport should also improve cargo security services, eliciting better on-time and effective screening. These two issues could be solved simultaneously by allowing airlines to conduct cargo security tasks rather than having government employees do the job. If airline employees are able to implement cargo security procedures, time management will improve, and the airport can save labor costs related to security activities. This will ultimately enable the airport to reduce its airport charges. This also addresses cargo processing times because airlines staff members are usually more sensitive to time management than airport employees.

Regarding airline-managed security procedures, it is necessary for the government to supervise cargo security activities to ensure that the level of security meets the security needs of the nation. The authors recommend that the Bhutanese government partially combine customs and security procedures. As mentioned, cargo security activities can be implemented by airline employees, and the supervision of these activities can be overseen by multi-function staff tasked with both security and customs responsibilities. Security checks and customs checks have different purposes, but their respective procedures are very similar in terms of conducting screening to detect prohibited items and substances. Accordingly, an overlap of procedures is possible if carried out in the same location. In this way, the government or the airport authority can reduce staff costs.

With respect to route networks for cargo operation, the respondents selected flight frequency as a leading factor. The authors recommend that more flights be added by allowing foreign airlines to provide flight services to Paro International Airport. Although this study was not initiated to address Bhutan's national air transport policies, it would be desirable to assess and compare the benefits obtainable from increased services that would accompany foreign airlines with the gains that come from protecting national carriers. It is also noteworthy that experts in the national airlines also pointed to the low flight frequency as a problem.

7. Conclusions

As a land locked country, Bhutan's air transportation has become crucial in finding solutions to promote economic development. First, sufficient hardware infrastructure must be developed for the gateway airport. To facilitate this, it may be useful to devise financing strategies with user participation (e.g. with national airlines). Second, airport services need to be provided at reasonable costs and with acceptable quality. Because there are not many skilled workers and only a modest level of demand in Bhutan's aviation industry, it would be prudent to cultivate a small team of staff members that can perform multiple duties. For example, within the scope of cargo operations, duties related to security and customs could be handled by the same employees. Third, it would be advantageous to increase the supply of flight services via the economic deregulation of Bhutan's aviation industry. This would allow foreign airlines to open routes to the gateway airport of the country.

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