Optimization Hotel Staff in Uncertain Condition Using Integer Linear Programming

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Abstract

Nature and man-made disasters have a significant impact on the tourism sector, either immediately or in the long term, disrupting the sustainability of tourism. Even decent planning has been carried out on the basis of previous experience, there is still a new challenge to be met as an impact of reducing sales. One of the problems is the number of hotel workers who have to stay in the tourism crisis. The goal is to provide a defined planning so that hotel managers and staff can prepare for the fluctuation of hotel occupancy. Modelling the demand of hotel guests and the availability of hotel staff is based on the method of aggregate production planning with the optimization result of integer linear programming. The effect is the number of hotel workers for each time , taking into account no disappointment on the part of hotel guests and reducing the cost of recruitment and lay-off of hotel staff. Case study is taken from the hotel occupancy in Bali before and during the Covid-19 pandemic, to demonstrate how the model works to quantify the number of workers required.

Keywords: disaster tourism, sustainability tourism, integer linear programming, hotel staff, covid-19

I. INTRODUCTION

Sustainable tourism will continue to exist if tourism is able to meet the needs of the visitor sector, the tourism industry and the local community on an ongoing basis. This word would refer to good quality practice between natural resources and human resources. The four fundamental principles for sustainable tourism are integrated planning and decision-making, the conservation of habitats, the preservation of human and natural resources and the creation of a framework that can exist in the long term.

Indonesia is a country with abundant natural resources, a wealth of cultural arts, customs and historical heritage, so this is a potential that can be built in the tourism sector. Indonesia 's tourism potential, which has approximately 17,508 islands with a coastline of 81,000 km and an area of approximately 3.1 million km2, stores potential resources[1].

The growth of the tourism sector can be demonstrated by a number of indicators, namely foreign exchange earnings and the number of tourists arriving in Indonesia. Both are showing a growing pattern. In 2015, 10.23 million international tourists came to Indonesia, and by 2019 the number rose to 16.11 million. The Indonesian tourism sector was the fastest growing sector in 2018, namely the 9th in the world, the 3rd in Asia and the 1st in the South East Asia region, according to the Minister for Tourism [2]. In addition, the ranking of Indonesia 's tourism competitiveness index in the world rose from 42 in 2017 to 40 in 2019 from 140 countries, based on the Travel & Tourism Competitiveness Survey of the World Economic Forum in 2019. Indonesia's global tourism competitiveness index rose from 42 in 2017 to 40 in 2019 from 140 countries [3].

The advanced tourism sector must be supported by the availability of appropriate support facilities. Tourist service services include the provision of hotels , restaurants and accommodation. The accommodation company is a building or part of a building that is specially furnished, and anyone can stay, eat and get services and other facilities with payment. Hotels / inns are one form of tourism support for accommodation. In addition to the number of accommodations / rooms / beds, the hotel room occupancy rate is another metric that can be used to see the tourism performance in the region. The occupancy rate is a comparison of the number of room nights used and the number of room nights available. This indicator can offer an idea of how much tourists are interested in certain hotel accommodations in the region. In addition, the occupancy rate can be used as an initial indicator to determine the state of tourist accommodation in the region in order to increase tourist attractiveness.

However, behind Indonesia 's ability and attractiveness in the tourism field, Indonesia has risks and hazards that can be dangerous. According to Undang-undang Republik Indonesia No 24 (2007) on Disaster Management, the concept of a disaster is an occurrence or sequence that threatens and disrupts the life and livelihood of the society, either by natural or non-natural causes. The United Nations International Strategy for Disaster Mitigation (2002) describes the forms of natural disasters that include hydro-meteorological disasters such as hurricanes, typhoons, flash floods , droughts and landslides; geophysical disasters in the form of earthquakes , tsunamis and volcanic activity; and biological disasters are epidemics, plant and animal diseases. How to deal with the disaster has been developed by the government through crisis management. Coles [4] and Rittichai Kuwait, Nelson, and Rahmafitria[5] described the government's intervention to prevent the disaster risk on tourism. More detailed case studies include Kim and Marcouiller [6] on hurricane disasters in Honduras, Nuzura [7] on tsunamis in Aceh, or Pyke, De Lacy, Rule, and Jiang [8] on bushfires in Australia. Non-natural disasters are disasters that have resulted from events or a sequence of non-natural events, such as technological failure, failed modernisation, epidemics and infectious diseases. Malaria [9], SARS [10], avian influenza [11], swine flu [12], ebola [13], and beginning in 2019 is the corona epidemic that ruins the business field. Social catastrophe is a catastrophe triggered by events or a sequence of human events that include social tension between groups or societies and terror. In Indonesia, such disasters mostly range from a small impact to a major impact.

The spread of the pandemic to numerous countries around the world has had a significant impact on all aspects of the economy. The tourism industry is one of the industries that is heavily affected. This is because many countries have closed airports and tourist attractions to avoid the spread of the virus. With the existence of a government policy on physical distance (maintaining physical distance) and the advice to stay at home in an attempt to minimize the spread of the virus, the tourism sector has been sluggish and almost collapsed. The downturn in the tourism sector in Indonesia has already begun long before the first positive case was discovered in March 2020. Covid-19 has made it impossible for foreign tourists to visit Indonesia because a number of countries have locked themselves in and requested their people not to fly abroad. According to the World Tourism Organization (WTO) report , global travel in 2020 will be in the range of 58 to 78 percentage points [4]. In fact, the report notes that the losses incurred by the tourism sector could surpass US$ 1 trillion. In Indonesia, tourist arrivals also began to decline rapidly in February, when the first Covid-19 cases had not yet occurred. Even in April, the

fall in international tourist arrivals reached 87.44% year on year. In that month, also three major entrances, namely Ngurah Rai, Soekarno-Hatta and Batam, had decreased to more than 99 per cent year on year [15][16]. The Indonesian Employers' Association (Apindo) said that the domestic tourism industry had sustained a loss of at least US $1.5 billion from January to April 2020, equivalent to IDR 21 trillion [17]. In addition to the decrease in tourism visits, the spread of the pandemic is expected to endanger 13 million employees in the tourism sector and 32.5 million employees who are indirectly connected to tourism deposits. The existence of a government policy to enforce Large-Scale Social Restrictions (PSBB) has also had an effect on the closure of all Indonesian tourist destinations. In addition to having an impact on foreign exchange earnings, the spread of Covid-19 also forced thousands of hotels, hundreds of restaurants and travel agents to leave business during the pandemic. Assaf [18] clarified the impact of declining tourist arrivals on hotel operators in Asia Pacific, as well as Wang and Ritchie [19] on the housing industry in Australia.

The Association of Indonesian Hotels and Restaurants (PHRI) said that by April 2020, 1,674 hotels and 500 restaurants in Indonesia had ceased to operate. In fact, many hotels have begun offering leave to lay off staff in order to preserve the stability of their cash flow, in particular the cost of paying workers ' salaries. The Government, through the Ministry of Tourism and Creative Economy, has taken steps to mitigate the impact of Covid-19 on the crisis in the tourism sector.

The effect of the pandemic on corporate income varies depending on the size of the business (micro, small, medium and large). However, it is believed that the position of the company and the business sector also influences the extent of revenue shifts. In general, 8 out of 10 businesses are expected to experience reduced sales. Approximately 82.29 per cent of UMB and 84.20 per cent of UMK experienced a decline in profits. Food and beverage accommodation was the sector most affected at 92.47 per cent due to a decrease in demand of 87 per cent [20].

The decision to maintain, decrease or even raise the number of employees is a move that the organization must take to adapt to a pandemic situation that has an impact on the operations of the company. The food and beverage housing industry cuts its workers by 50.52% in the midst of a pandemic. Reduction of workers is comparatively more common in medium and large businesses.

76 out of every 100 businesses currently running as normal, the number of employees continues to be steady. There have been numerous efforts by businesses to maintain their employees even as the company's operations have been seriously

impacted by the pandemic. The decision to lay off is likely to be a final step in the direction of its workforce. Reducing working hours by 32.66 per cent is a move that businesses have taken comparatively more than they have chosen.

Others include being laid off (unpaid, partially paid, and fully paid) or laid off for a short period of time. The reduction in working hours was the strategy most sought by businesses currently functioning as normal, accounting for 24.59 per cent of the total number of respondents. The strategy that was often followed at the time was that staff should be laid off (not paid) and laid off by 14.04 per cent in a short period of time. Accommodation and food and drink are included in three sectors of the business which lay off staff in a short period of time, namely 17.63 per cent.

The same condition also occurred at Soekarno-Hatta Airport, Juanda Airport, and Hang Nadim Airport where foreign tourists' visits continued to decline by up to 50 percent month to month. The decline in foreign tourist arrivals to Indonesia is due to restrictions on travel by almost all countries in the world to prevent the spread of the Covid-19 pandemic. Impact of travel restrictions was even more pronounced when the Chinese government officially announced a policy to ban its citizens from traveling abroad at the end of January. This has greatly reduced the number of foreign tourists visiting Indonesia, considering that foreign tourists from China are one of the three countries with the highest number of foreign tourists visiting. It has been recorded that more than 10,000 trips from China to Indonesia have been canceled. The majority of the trip cancellations came from Wuhan where the first report and subsequent outbreak was from a cluster of novel human pneumonia cases in Wuhan City, China, since late December 2019 [25]. Moreover, in March, international tourists arriving at Ngurah Rai Airport had only reached 155.85 thousand or decreased by 56.50 per cent compared to the previous month.

The goal of this paper is to plan the emergency situation as part of staff scheduling crisis management. The confusion in the case of a catastrophe or a catastrophe must first be expected, which starts with the decision as to how many hotel workers who must stay in charge of all. The lack of staff will influence the satisfaction of the guest, while the overworked will increase the cost of the salary. In order to get successful planning, the forecast demand becomes the input of the optimization of workers scheduling. Aggregate planning is an approach for deciding the quantity and time required for the output of products by operating managers over a certain period of time. In the range of production planning, aggregate planning is medium-term capacity planning, typically having a two-to 12-month time horizon. Such preparation is useful for organisations with seasonal or fluctuating demand or capability. The goal of aggregate planning is to establish an

efficient production plan using organizational resources to meet the expected demand. The optimization approach that will be used in this paper is a whole linear programming model. This model is used because it is difficult to account for the validity of the management coefficient approach. The goal of the formulation of integer linear programming is to minimize the overall cost. This paper would take the hotel workers in Bali as a case study as part of the management decision that needs to be taken. This paper is a guideline on how to assess the number of workers on the basis of demand, not only for hotels, but also for all elements of the tourism industry that have often been affected by disasters. At the end of this article, future studies will be addressed in order to deal with more uncertain variables.

II. METHOD

All the data used here are from secondary data from Badan Pusat Statistik [8] with 34,559 respondents. Data was compiled from 10 to 26 July 2020. Respondents represent all areas of industry, bar government, employer household operations and foreign organizations. Data was obtained using Computer Aided Web, Self Interview (CASWI) and Survey Online. The approach is a sampling method with a probability sampling of 24,000 samples chosen from the 2020 Statistical Business Registry (SBR) framework, while non-probability sampling or voluntary sampling was achieved by submitting survey links to network associations and other types of business associations.

According to Heizer, Make, and Munson [26] the goal of aggregate forecasting is to satisfy the need for future projections and reduce costs over the planning phase. This strategy may include smoother work rates , lower inventory levels and better service levels for customers. Aggregate planning would create an average production level of demand with fluctuating potential demand. Forecasting is used in the manufacturing process to estimate the amount of customer orders for a commodity.

Approach the case study of tourism using aggregate planning:

1. Accessible capability (staff) can be represented in person equal to the need (demand).

2.The overall time horizon forecasting capability must be equal to the total prediction requirements, if not the same, the dummy would be used as far as the unit cost difference = 0 (zero).

3. All of the cost interactions are linear.

4. Calculate in advance the overall demand for all visitors who stay in the hotel over the planning period.

5. Optimize the production plan for each period within the planning horizon, starting with the early period of the last period.

Many aggregate preparation strategies specify a schedule that minimizes costs. Costs cover hiring costs, termination costs, overtime and undertime costs (less and more personnel needs), inventory and backorder costs, and subcontracting (personnel from other hotels). As there is no commodity in the tourism case study, the inventory and backorder will not be included and will be substituted by time and time costs. All data is taken from various sources as feedback for the entire linear programming model. The model itself should be used for any data that the consumer has for a more reliable and feasible outcome.

III. RESULTS

We used data from Kementerian Pariwisata and Ekonomi Kreatif Republik Indonesia for tourists arriving at Ngurah Rai International Airport in 2018 and 2019 to find the overall number of international tourists arriving each year[15][16]. Bali has top priorities for all provinces in Indonesia. There are numbers of hotels run in 2018 and 2019 to serve visitors, assuming they are for foreign tourists only. The number of hotels operated yearly is equal to the number of hotels operated on a monthly basis.

By subdividing total foreign visitors arriving per month with an average number of hotels served each month equal to the number of hotels served in the year (1), we have total guests staying in the hotel for a month (2). The total guest will not arrive at the same time, so we need to know how many tourists will stay at the same time (3). First of all, we need to figure out how long the visitor lives in the hotel. Table 1 displays the details for the total number of hotel guests staying.

$$\frac{\sum_{t=1}^{t} H_t}{n} = H_m \tag{1}$$

$$G_m = \frac{T_m}{H_m} \tag{2}$$

$$L = 365 \; days/\left[T_t/(B_t \times P_t)\right] \tag{3}$$

While:
Pt = percentage bed occupied

Bt = total beds available per year
Tt = total international tourist arrived per year
n = number of years
Tm = total international tourist arrived per month
Gm = total guest per hotel per month
Ht = total hotels available per year
Hm = total hotels available per month
L = time to stay in days

Table 1. Hotel Guest's Length of Stay

Year	International Tourist from Ngurah Rai Airport	Occupancy Rate	Total Beds	Capacity fulfilled	Total Hotels	Length of Stay
2018	6,025,760	64.72	78,801	51,000	551	3.08
2019	6,239,543	59.58	97,099	57,851	507	3.38
			Average	4,535.45	529	3.23

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$$F_m = 30 \ days/L \qquad (4)$$

$$G = G_m/F_m \qquad (5)$$

While:

Fm = frequent guest hotel stay in a month

Gm = total guest per hotel per month

G = total guest per hotel in the same time

We used integer linear programming to reduce overall costs. The total cost shall be collected from the multiplication of each cost element, such as the total cost of the salary, the total cost of the staff recruited, the total cost of the staff laid off and the total cost of the staff under time (1). Time is a condition in which the number of staff available is higher than the number of staff needed so that the salary is overpaid. The drawback is that the amount of workers available must be greater than and equal to 70% of the overall guest (7). There is a balance limitation for workers available this month with staff available in the previous month, staff hired and staff laid off this month (8). Another balance limitation is

that under time workers come from the gap between the staff required and the staff expected, which is 70 percent of the guest (9). Both decision variables are integer (10).

$$Min\ TC = \sum_{m=1}^{M} C_S S_m + C_R SR_m + C_L SL_m + C_U SU_m \qquad (6)$$

$$G \leq \frac{S_m}{0.7} \qquad (7)$$

$$S_m = S_{m-1} + SR_m - SL_m \qquad (8)$$

$$SU_m = S_m - (0.7G) \qquad (9)$$

$$S_m,\ SR_m,\ SL_m,\ SU_m \geq 0\ and\ integer \qquad (10)$$

While:

Sm = total staff used per hotel per month

SRm = total staff recruited per hotel per month

SLm = total staff layoff per hotel per month

SUm = total staff under time per hotel per month

CS = salary cost per staff per month

CR = recruitment cost per staff

CL = layoff cost per staff

CU = under time cost per staff

According to Keputusan Gubernur Bali 2019, based on details from the Head of the Badung Industry and Manpower Office, the pay of hotel workers in Bali with a 3-year operating cycle is 5 % higher than the Bali UMR[30]. UMP Bali is IDR 2,493,523.00, so the hotel workers pay is IDR 2,618,199.15. Recruitment costs per worker include the applicant workers database, the distribution of work openings records, the administrative collection of job vacancies, recruitment facilities and the selection method. The overall recruiting fee for each hire is IDR 2,292,000.00. For UU Tenaga Kerja UU Severance Pay No. 13 2003 consists of Severance Pay for more than 3 years of service, time of employment, medical and accommodation money, then Severance Pay (4 x 2 x IDR 2,618,199.15) + (2 x IDR 2,618,199.15.) + 15% (10 x IDR 2,618,199.15.) = IDR 30,109,289.65. In the meantime, the time-limited fee comes from the Bali UMP for a month multiplied by the excess amount of the staff, which is IDR 2,618,199.15.

The outcome in Table 3 indicates that the decision factors are open to workers, to hire, to lay off, and to time row. Each month, the management must decide on the number of hotel staff who must be employed to ensure the satisfaction of the guest. Management must reduce the overall cost by changing the minimum capacity, such as training, and by

laying off hotel workers, since all such actions entail higher costs. That's why, in a month, hotel workers would be more than needed to accommodate the guest. For example, from January to August 2019 (except for July 2019) the hotel has more staff than it is needed by recruiting and not to lay off the staff. This hotel was struggling to hold 80 hotel employees, even though the guess was that it was fluctuating. But as of February 2020, as the pandemic spread further and there were many reminders not to fly around the world, the hotel had to make the workers leave the company. This situation deteriorated in March 2020 after the first case of Corona occurred in Bali this month, with the death of a UK tourist with a positive corona. It lets several countries publish their travel warnings to Bali. The hotel must have the other staff laid off.

Table 2. Total Hotel Guest to be served

Year	Month	Total Guest	Total Guest/Hotel	Total Guest/Hotel/Day
2019	1	451,078	853	85
	2	436,266	825	82
	3	441,707	835	83
	4	476,104	900	90
	5	483,928	915	91
	6	549,483	1,039	103
	7	604,310	1,142	114
	8	602,457	1,139	113
	9	589,984	1,115	111
	10	565,966	1,070	106
	11	492,904	932	93
	12	544,726	1,030	102
2020	1	526,823	996	99
	2	358,254	677	67
	3	155,851	295	29

However, this model makes the staff preparation easier to do and the hotel management will get the best result compared to overall expense. This model is looking for some likelihood of retaining the available workers, adding or reducing the number. All of the mix produces successful preparation that will give effect to further preparation. For example , the manager can determine how to implement the budget either to personnel compensation in financial planning, to upgrade services or to retain expenses each year.

IV. CONCLUSIONS

For Bali itself, some natural and non-natural disasters have forced the government to focus more on crisis management and disaster risk reduction[27][28][29][30][31]. This pandemic has become one of the challenges that the government needs to address. The situation is pandemic because the hotel must have plans to experience the difficulties. One of the difficulties is the number of staff that the hotel management must retain while demand is fluctuating. With the optimization process, we will find an optimal number of hotel workers to guarantee hotel guest satisfaction at a minimal rate. The decision recognizes the consistency of the number of employees in order to reduce increased expenses for training and removal of employees, but the implications are added costs for overpaid jobs when they work beyond their abilities.

For future studies, more comprehensive data are required to adjust demand if the variations are more frequent. It is safer if the cost is more reliable than if the exact data is used. Another factor is that this paradigm is acceptable where the administration is employed by non-permanent workers. It is more difficult for a hotel with permanent staff to implement because the layoff costs are usually very high. The model needs to improve in real conditions and constraints. However, this model can be applied in a broader region, e.g. to quantify how many hotel workers are needed to provide support services in Bali or in other regions, such as the calculation of fast food outlet staff.

Table 3. Measuring the number of hotel staff

Variables	2019							
	1	2	3	4	5	6	7	8
Hotel Guest	85	82	83	90	91	103	114	113
Staff available	60	79	79	79	79	79	80	80
Staff hired	60	19	0	0	0	0	1	0
Staff fired	0	0	0	0	0	0	0	0
Staff excess	(1)	(22)	(21)	(16)	(15)	(7)	(0)	(1)
Work force balanced	0	0	0	0	0	0	0	0
Staff cost/person	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199
Hiring cost/person	2.292.000	2.292.000	2.292.000	2.292.000	2.292.000	2.292.000	2.292.000	2.292.000
Firing cost/worker	30.109.290	30.109.290	30.109.290	30.109.290	30.109.290	30.109.290	30.109.290	30.109.290
Undertime cost/unit/week	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199
Total cost	295.921.049	306.938.834	261.558.095	248.728.919	246.896.180	224.903.307	212.271.572	211.812.311
	2019				2020			
Undertime cost/unit/week	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	2.618.199	Min. TC =
Total cost	215.477.790	224.641.487	248.467.099	231.972.445	237.470.663	1.116.923.738	839.656.452	5.123.639.942

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