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ENVIRONMENTAL QUALITY AND OPTIMAL INVESTMENT IN TOURISM INFRASTRUCTURES: SETTING AN ENVIRONMENTALLY FRIENDLY PORT LOCATION COMBINED TO TOURIST DESTINATIONS USING TSP MODEL

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Abstract

The rapid growth of cruise ships has encouraged the Indonesian government and Bali's local governments in particular, to compete in developing and upgrading their existing ports. It needs a holistic and integrated transportation system before a decision to locate a port can be made. In order to avoid unconstructive local exploitation to the whole system and given the fact that cruises' visits are usually only for a short period, requirement for a synergized system is fundamental, in order to measure the whole chain of factors and values involved in the decision making process. Travelling Salesman Problem (TSP) Model implemented in this study is expected to be able integrate tourist destinations and transportation system.

Findings derived from this research will be used as guidance in managing many tourist destinations, which include the organization of local traffic and accessibility by introducing alternative routes; managing demands for transportation infrastructures, facilities, and services; reducing traffic congestion; controlling speed limit; mitigating air pollution; and synchronising location of the port and tourist destination. The strategic Environmental Sustainable Transportation is urgently needed to implement in Bali as the major tourist destination in Indonesia in order to minimized CO2 emission

Keywords: Port tourism, Environmental Sustainable Transportation, destinations, TSP model

1. Introduction

The design of a cruise ship ussually atract people to take cruise for their journey. They will also get unforgetable experiences and memories when visiting a nice and good port or harbour during their trip. The satisfaction depends upon the quality of the destination's environment, infrastructure, and services that are provided for the tourist (B.Ashrama 2007).

The cruise ship will stop at one port or harbour to give opportunity for passangers to do shoping and visit some tourist attractions. The time provided ussually very limited, therefore they have to use their time wisely in order to get and experience as much as they can in short time.

Destination is areas or places that bounds each other which will become a product of tourism industry. A destination has one or number of objects, or some unique culture attarction which become typical tourist attaction to that place. A right strategy is needed to integrate tourist destination itenary and port or harbour's location, and also combine to transportation condition, in order to get an effective journey which give more opportunities to visit more destinations and attractions for less time. *A perpect port's location will contribute an effective tourist destination itenary which can reduce the carbon emission due to less travel time, and also will increase the number of tourist visit.*

Table 1. Most popular activities – all nationalities:

What do they do in port	(%)
Visit museums and attractions	72
Experience on their own	66
Go shopping	46
Visit restaurants or cafes	37
Go on pre-paid excursions	35
Stay on board	17

Source: (Finland Cruise Seminar November 4-2008)

This paper present a decision making process in selecting a proper location of tourist port in Bali related to the tourist destinations. There are five port's in five different places in Bali. A number of itenaries to a number of destinations that originated from five different port locations have been analised by implementing a model that known by Travelling Salesman Problem (TSP).

The Concept of Environmental Sustainable Transportation" (EST)

Sustainable transportation is a concept that has been developed since 50 years ago to anticipate failure on transportation policy, implementation, and performance. The concept itself can be defined as an effort to fulfill transportation mobility need of current generation without reducing the ability of future generations in meeting their mobility needs. The sustainable transportation definition itself has been rising since sustainable development has been issued in year 1987 (*World Commission on Environment and Development, United Nation*).

2. Travelling Tourist Problem

Trip distribution

Trip distribution (or destination choice or zonal interchange analysis), is the second component (after trip generation, but before mode choice and route assignment) in the traditional four-step transportation forecasting model. This step matches tripmakers' origin and destinations to develop a "trip table" a matrix that displays the number of trips going from each origin to each destination. Historically, this component has been the least developed component of the transportation planning model. Where: T_{ij} = trips from origin *i* to destination *j*. Note that the practical value of trips on the diagonal, e.g. from zone 1 to zone 1, is zero since no inter-zonal trip occur. Work trip distribution is the way that travel demand models understand how people take jobs. There are trip distribution models for other (tourism) activities, which follow the same structure.

Over the years, modelers have used several different formulation of trip distribution. The first was the Fratar or Growth model (which did not differentiate trips by purpose). This structure extrapolated a base year trip table to the future based on growth, but took no account of changing spatial accessibility due to increased supply or changes in travel patterns and congestion. (Simple Growth factor model, Furness Model and Detroit model are models develop at the same time period). The next models developed were the gravity model and the intervening opportunities model. The most widely used formulation is still the gravity model.

At this point in the transportation planning process, the information for zonal interchange analysis is organized in an origin-destination table. On the left is listed trips produced in each zone. Along the top are listed the zones, and for each zone we list its attraction. The table is *n x n*, where *n* = the number of zones.

The Travelling Salesman Problem (TSP) is a problem in *combinatorial optimization studied in operations research and theoretical computer science*. Given a list of cities and their pairwise distances, the task is to find a shortest possible tour that visits each city exactly once.

Accessibility

Literally, the word **Accessibility (http:/en wikipedia.org 2010)** *"is used to describe the degree to which a product, device, service, or environment is accessible by as many people as possible. Accessibility can be viewed as the "ability to access" and possible benefit of some system or entity. Accessibility is often used to focus on people with disabilities and their right of access to entities, often through use of assistive technology*"

An instance of the traveling tourist problem consists of a schedule, along with a starting city, and a starting time. The goal is to find a tour of minimum duration which visits all of the cities. A schedule is a set of routes, where a route specifies a starting city, a destination city, a departure time, and a travel time. A bus travels on each route once a day, leaving at the same time each day.

A tour is a sequence of routes, with the source of route i+1 the same as the destination of route i. To solve the tourist problem, the tour is required to visit all of the cities, and start and end at a specified city. A tour is allowed to visit the same city multiple times. The duration of a tour is the sum of the travel times and the waiting times.

From transportation point of view, Accessability is ability to connect one zone to the others by means transportation facilities consist of terminal (port, station), roadway, and by means services consist of reasonable price, and good services. The connection on each zone will need to move from each zone to another. Movement always cause problem, in particular when people move to the same direction at the same time in a certain place. Traffic congestion, air and noise pollution, delays, are some problems caused by movement. Problems due to the movement can be avoided by understanding and knowing the pattern of the movement such as direction, time, and capacity.

A destination will benefit to the society if it easy to reach, means its has a good accessibility, and has transportation service system, then it will also benefit to the tourism industry and attract tourist to come regularly.

Model Travelling Salesman Problem (TSP)

Travelling tourist problem is similar to travelling salesman problem*(H.Eugene Stanley and Sergey V.Buldrev 2001).* Tourists want to visit as many places as they can in short time. TSP Model does optimization in order to get the shortest route but passing more places, and no place passed more than once on their return.

Travelling Salesman Problem (TSP) is known as a classic optimization which can be solved in conventional way. Algorithm has to be applied to find the possible solutions (Hahsler and Hornik 2009). Therefore, the time complexity will become an exponential to the input. If there is "n" destinations to visit, then there will be *n!/2n* route. The more destinations to visit, there will be more time to calculate. As an example, if there are 10 destinations, then will be 181.440 routes. It shows that it almost impossible to calculate in conventional way, therefore software is needed.

There are "n" places to visit in a tour then there will be (n-1/2$^{!}$) combination of itenaries produced. The number of itenaries will be increased significantly due to the factorial (!). If there are 3 places to visit, it may produce 1 itenary, and if 4 place to visit there will be 3 combination of itenaries, if 5 place there will be 12 possibilities, if n = 7 there will be 360 itenaries, if "n" increases to 8 or 2.520, etc. (Longley et.al.,2001). We are solving the equation:

$$W = \frac{n\,!}{\Pi_{i=1}^{n} n_i!}$$

The TSP problem can be solved by using Heuristik Algorithm which calculate the optimum value of part or section of the basic problem then go to fixing process in order get the best solution.

TSP can be mathematically defined as:

$$X_{ij} \begin{cases} 1, & \text{if destination } j \text{ is visited from the destination } i \\ 0, & \text{if not} \end{cases} \quad (1)$$

if d_{ij} is the distance from destination *i* to destination *j*, the mathematical TSP model are as follow:

$$\text{Minimize } Z = \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}X_{ij}, \qquad d_{ij} = \infty \text{ for all } i = j \quad (2)$$

$$\text{Subject to: } \sum_{j=1}^{n} X_{ij} = 1, \quad i = 1,2,3,\ldots\ldots n$$

$$\sum_{i=1}^{n} X_{ij} = 1, \quad j = 1,2,3,\ldots\ldots n$$

$$X_{ij} = (1,0)$$

The case of the problem in this study is a little bit different. The problem is to define the number of tourist destinations that can be visited from a certain port with time constrainted. The model of this study can be shown as the model below:

$$X_{ij} \begin{cases} 1, & \text{if destination } j \text{ is visited from the destination } i \\ 0, & \text{if not} \end{cases} \quad (3)$$

If t_{ij} = trips from origin i to destination *j* plus the duration of visit in the destination j, and CT is travel cost (e.g. distance, money, time) and in this mathematical TSP model is time visit are as follows:

$$\text{Minimize } Z = \sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij}X_{ij}, \qquad t_{ij} = \infty \text{ for all } i = j \quad (4)$$

$$\text{Subject to: } \sum_{j=1}^{n} X_{ij} = 1, \quad i = 1,2,3,\ldots\ldots n$$

$$\sum_{i=1}^{n} X_{ij} = 1, \quad j = 1,2,3,\ldots\ldots n$$

$$\sum_{i=1}^{n}\sum_{j=1}^{n} t_{ij}x_{ij} \le CT \quad (5)$$

$$X_{ij} = (1,0)$$

3. Methodology

The first step in the research was the boundary of the modul; the data of the harbor, number of tourist destination, the distance between harbor and tourist destinations and distance between destinations. The TSP procedure can be broken down into:

- Problem size module/habour sub-identification, number of distination and route; which is used to set up the probable number of visit and existing time constraint. If is the points of visit where *i* =1,2,3..n then *i* = 1 is the point of harbor, the first point of visit for each habour simulation and *i* = 2,3,4,…n are the points of tourist destination. Furthermore, given t_{ij}, is the length of journey between destination *i* and destination *j* plus the length of visit or stay in the tourist destination *j*, and $t_{ij} = \infty$ for all *i = j*.
- Then, time constraint of Ct, was identified, where CT is the total time constraint, available hours for making visit by cruise ships at harbour *i*. All routes identified by x_{ij} where the routes between destination i and j; *i*=1,2,3,..n and *j*=1,2,3…n.
- Initial route modul/sub-modul comprise of origin point/harbour location, end point harbour, initial route, other tourist destination status. The time constraint is the number of available hours for making visits to several destinations. Initial route is the origin of departure which is the harbour where the journey start and this is also the end point of the journey, x_{1j} and $t_{1j}x_{1j} + t_{i1}x_{i1} \le CT$ where 1 is the destination point habour and *i=j* is the shortest route between tourist destination and the determination of end point was identified by x_{i1} where 1 is harbour destination point.
- The tourist destination status is the setting of visit status of each tourist destination and when the heuristk TSP was initiated, chosen initial visit route is has been visited, that means x_{1j}=1, and the status of all other destinations is has not

been visited or x_{ij}=0 and $i \neq 1$, therefore the of iteration of each tourist destination in this TSP heuristic model has the same probability.

- Modul/sub-Hauristik is checking the shortest time to the next destination from the initial point of departure, length of journey and length of visit at the next tourist destination and the length of returned journey to the harbour are within the time constraint, which are identified with $t_{1j}x_{1j} + \sum_{i=2}^{n}\sum_{j=2}^{n} t_{ij}x_{ij} + t_{j1}x_{j1} \leq CT$, if this meet the time constraints requirement then the status of the tourist destination will be updated as "chosen" x_{ij}=1.
- The same procedure will be carried out for each tourist destination and every chosen route will be updated. The heuristic procedure will stop when the total length of visit exceed the time constraint and all tourist destinations has been simulated in the program. Modul/sub-modul present the results, which are the total time the routes. The steps in the TSP modeling of plan journey are presented in figure

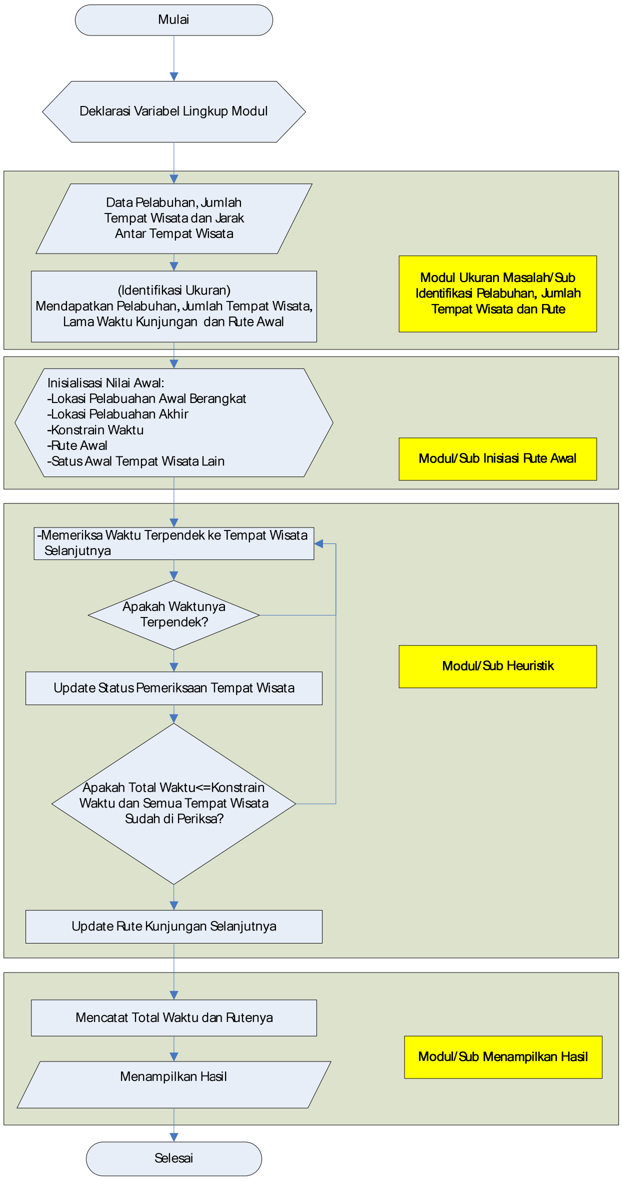

Figure 1. The procedure of journey distribution determination by using TSP model

4. Results and Discussions

Transportation Impact on Environment

In general, transportation impacts on environment due to following factors: transportation noise, air pollution, pedestrian facilities, traffic accidents, drivers stress, and public health. The main factors which affect environment are noise and air pollution. In common use, the word noise means any unwanted sound that has larger intensity or volume than normal level. Audio or sound can be categorized as noise when the level reaches 65 dB. At level 85 dB, the audio or sound is disturbing and it will harm human ears when the level touches 95 dB.

On the other hand, air pollution is a compound of gases and particles and at certain proportion can be dangerous to humans. Normally air contains nitrogen (78%), oxygen (21%), argon (0,93%), and CO^2 (0,032%). Additionally, air contains other compounds in limited quantities such as Neon, Helium, Methane, Krypton, Hydrogen, N2O, CO, O3, SO2, and NO2.

Combustion fuel gas from vehicles typically produces several gases and particles' compounds which dangerous to humans' health. Gas compounds due to pollution can be categorized as compound of sulfur, nitrogen, carbon, oxide carbon, and hydrogen. Furthermore, gas compounds from gas combustion of vehicles can be in the form of *carbon monoxide* (CO), *nitrogen oxide* (Nox), hydro-carbon (HC); and particulates and lead.

Air pollution endangers human health. Long term effects decrease of reflex response and visual capabilities Short term effects are respiratory problems and headaches. Respiratory problems because of the pollution can be specified as difficulty breathing, coughing, asthma, lung malfunction, chronic respiratory diseases and irritation of eyes. Dangerous levels depend on level of exposure and concentration of pollutants that are functions of volume, composition, heavy level of traffic, and weather.

Embodiment of Environmentally Friendly Transportation

Environmentally friendly transportation can be implemented by not doing unnecessary traveling or unnecessary mobility. Therefore reducing number of unnecessary traveling or unnecessary mobility is done with implementing TDM (*Transport Demand*

Management). The management application is quite cheap to increase quality of service of transportation network. Hence TDM implementation is expected to produce better environment, improved public health and society prosperity. An example of TDM implementation is itinerary plan.

The Use of TSP Model in the Travel Plan (Itinerary)

This study employsTSP model to determine the Travel Plan based on the rank obtained from the computation using Fuzzy AHP and TOPSIS of 47 destinations with several alternative horbours as the origin of journey (Budiartha R.M 2010).Tourists choose the destination based on four variables, which are the typical characteristic of destination (destination rank), length of journey, length of stay at destinations,andoverall available time for the travel (duration).

Tabel 2 Weight and rankof Bali's tourist motivation

Goal	Faktors	Criteria	Global	Sub-criteria	(Local)	Global	Rank
Choice of Destination	Internal (0.503)	Psychological (0.373)	0.187	Escape	(0.500)	0.094	2
				Self-actualization	(0.500)	0.094	2
		Physical (0.239)	0.120	Rest and relaxation	(0.497)	0.060	4
				Medical treatment	(0.295)	0.035	10
				Health and fitness	(0.208)	0.025	14
		Social interaction (0.239)	0.120	Visiting friends/relatives	(0.500)	0.060	4
				Meeting new people	(0.500)	0.060	4
		Seeking/exploration (0.149)	0.075	Novelty seeking	(0.411)	0.031	11
				Culture exploration	(0.332)	0.025	13
				Adventure seeking	(0.257)	0.019	16
				Enjoying night life	(0.000)	0.000	17
	External (0.488)	Tangible (0.700)	0.348	Transportation facilities	(0.136)	0.047	7
				Friendliness of people	(0.139)	0.048	6
				Quality and variety of food	(0.104)	0.036	9
				Accommodation facilities	(0.106)	0.037	8
				Personal safety	(0.186)	0.065	3
				Price	(0.056)	0.019	15
				Culture and historical resources	(0.090)	0.031	11
				Good shopping	(0.077)	0.027	12
				Environmental safety and quality	(0.069)	0.024	15
		Intangible (0.300)	0.149	Destination image	(0.668)	0.099	1
				Benefits expectations	(0.332)	0.049	5

Source : (Budiartha R.M 2010)

The alternative locationsof harbor was determined based on the aspiration of the community, district government and existing harbor such as Benoa Harbour,The Dutch colonial Buleleng, Celukan Bawang Harbour and Pengambengan Harbour as shown in Figure 2.

The main requirement for harbour was determined based on sufficient depth of the water. Other requirements include the difference between high and low tides, the projected hight of waves, impact on surrounding environment, governmental policies, reject communities, and construction cost, all of which will influence the type of port facilities and transportation network to tourist destinations (Budiartha R.M and Arnatha 2000)

The next step is the design of journeyplan based on the available time as follows: The plan of journeyof the cruise tourists with 2 hours stop in Bali, average 35 km/hour drive velocity, and average length of stay at destination 0.5 hours, result in that Harbours of Amed, Celukan bawang and Menjangan did not meet the criteria as the tourist will have not enough time to visit any tourist destination, even the nearest ones. Only two harbours meet the criteria, which are Benoa Harbourand Tanah Ampo Harbour with only one possible destination to visit as shown by Figure 4.

From Tanah Ampo Harbor, only one tourist destination can be visited, which is Candi Dasa and this destination has the lowest rank among the others, which is 0 (the least demanded by tourists). Benoa Harbour is luckier, from where tourists still can visit Kuta in two hours stop in Bali. It is because of Kuta is at the rank-1 of tourist destinations in Bali.

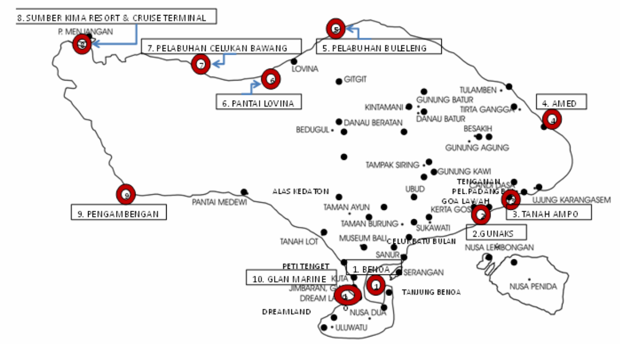

Figure 2. Alternative port location

Figure 3. Five alternative port location

Figure 5 shows almost similar condition to the above one. With 4 hours of stay, only two harbours meet the criteria stated above. These are Benoa Harbour and Tanah Ampo Harbour. Figure 6, Figure 7 and Figure 8 show the itineraries with duration of stay of 6 hours, 8 hours and 10 hours respectively.

Figure 6 shows that with 6 hours duration of stay, only Menjangan Harbour cannot serve as the docking harbor as no destination, even the nearest, can be reached in such a short time. From Benoa Harbour, tourist can visit sixdestination, which are Kuta (1), Nusa Dua (4), Uluwatu (7), GWK (8), Jimbaran (9), Dreamland (11). Whereas, from Tanah Ampo Harbour, tourist can visit three destinations; Besakih (14), Goalawah (15), Candidasa (0).

Table 3. Final Ranksoftourist destinations/hinterland of tourism harbor

Destination	Rank	Similarity to ideal solution
Kuta	1	0.800
Sanur	2	0.671
Ubud	3	0.646
Nusa Dua	4	0.561
Tanah Lot	5	0.531
Gunung Kawi	6	0.469
Uluwatu	7	0.452
GWK	8	0.444
Jimbaran	9	0.431
Bedugul	10	0.430
Dream Land	11	0.429
Kintamani	12	0.425
Danau Batur	13	0.404
Besakih	14	0.357
Goa Lawah	15	0.292
Serangan	16	0.290
Batubulan	17	0.256
Sukawati	18	0.256
Tanjung Benoa	19	0.248
Peti Tenget	20	0.241
Amed	21	0.239
Lovina	22	0.226
Gunung Agung	23	0.222
Goa Gajah	24	0.206
Taman Burung	25	0.205
Gunung Batur	26	0.197
Tampaksiring	27	0.188
Padang Bai	28	0.182
Sangeh	29	0.122
Pantai Medewi	30	0.112
Nusa Penida	31	0.109
Pulau Menjangan	32	0.095
Celuk	33	0.090
Danau Beratan	34	0.082
Tenganan	35	0.056
Alas Kedaton	36	0.048
Gitgit	37	0.048
Taman Ayun	38	0.047
Museum Bali	39	0.045
Jatiluwih	40	0.031
Penglipuran	41	0.027
Kerta Gosa	42	0.024
Nusa Lembongan	43	0.000
Ujung Karangasem	44	0.000
Tirta Gangga	45	0.000
Candi Dasa	46	0.000
Tulamben	47	0.000

Sourse: (Budiartha R.M 2010)

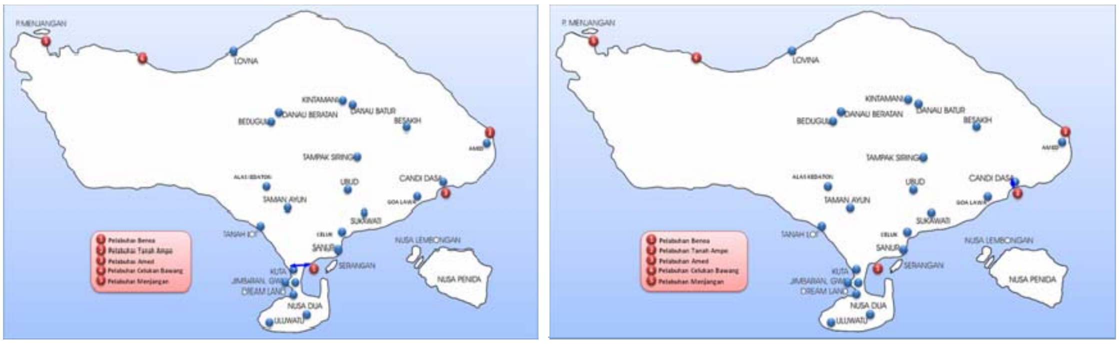

Figure 4. Itineraries with 2 hours duration of stay

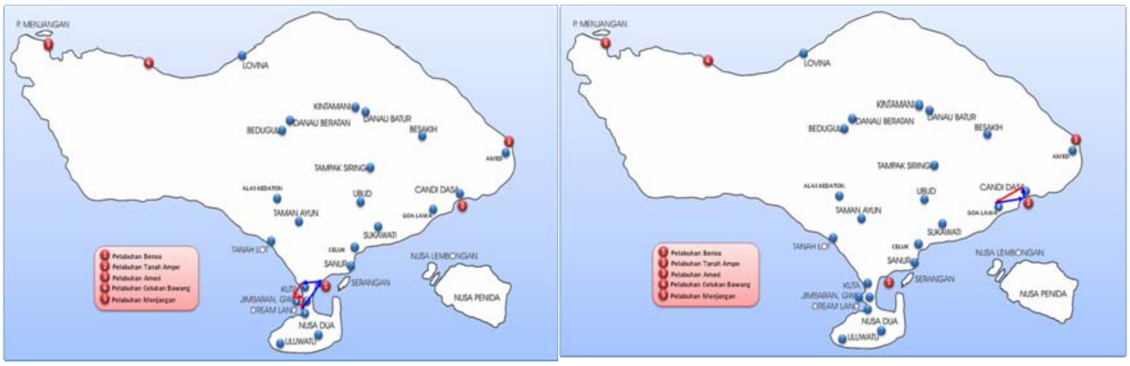

Figure 5. Itineraries with 4 hours duration of stay

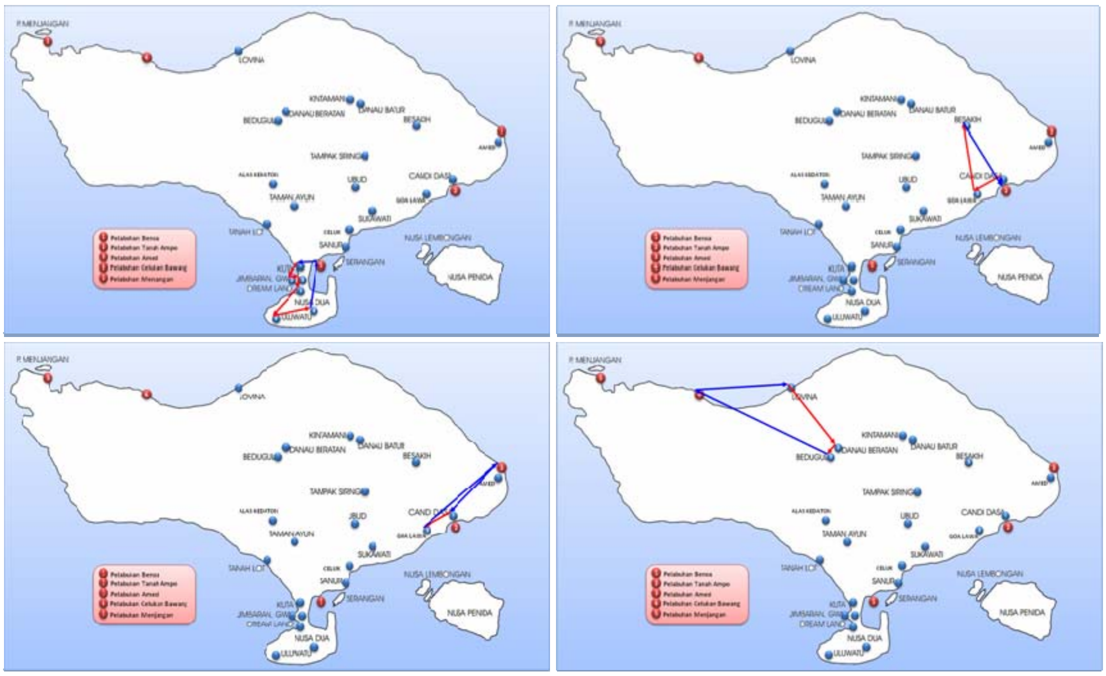

Figure 6. Itineraries with 6 hours duration of stay

Figure 7 shows that the most destinations can be reached from Benoa Harbour in 8 hours and these include top rank destinations; Kuta(1), Sanur(2), Nusa Dua(4), Uluwatu(7), Jimbaran(9), GWK(8), Dreamland(11), andCeluk(33). Whereas from Tanah Ampo Harbour, the most expected location by Karang Asem District Government, with 8 hours of stay, only five destinations can be reached; Kintamani (12), Danau Batur(13), Besakih(14), Goa Lawah(15), andCandi Dasa(0), and this does not include the highest rank destination. From Amed Harbour, and Celukan Bawang Harbour, only three destinations can be visited within 8 hours and these are seldom chosen by tourist, whereas from Menjangan Harbour, only one destination can be visited.

This study discovered that ten hours is the most ideal duration of stay at port of call to visit the most preferred destinations. Benoa Harbouris the best port of call according to the number of destinations can be visited which is 10 destinations, followed by Tanah Ampo Harbor with 7 destinations, Amed Ahrbour with 5 destinations, Celukan Bawang Harbour with 5 destinations and Menjangan Harbour with 3 destinations. These is shoen in Figure 8 and Table 4.

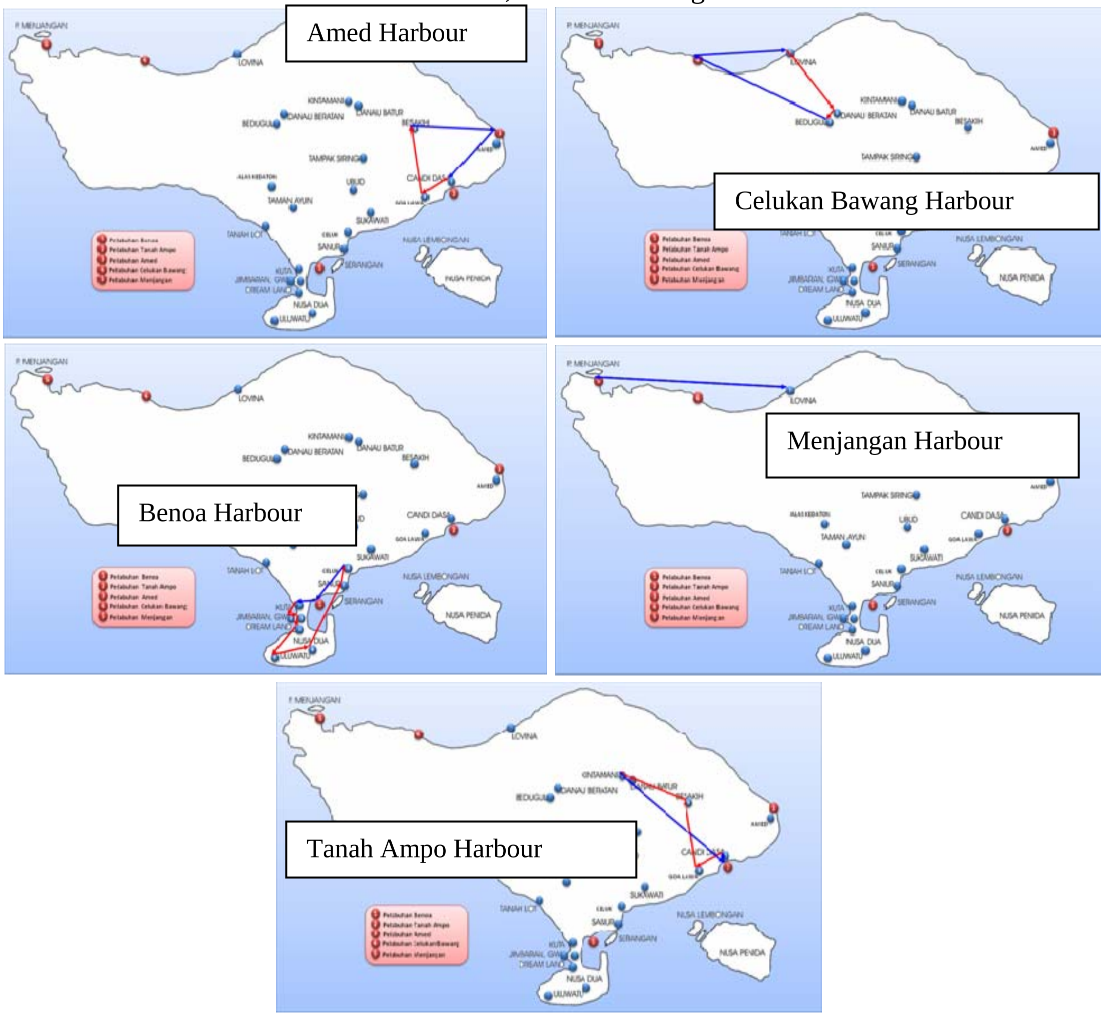

Figure 7. Itineraries with 8 hours duration of stay

Table 4.Destinations which can be visited in 10 hours duration of stay

Benoa		Tanah Ampo		Amed		Pel.Celukan B		Menjangan	
Destination	Rank	Destination	Rank	Destination	Rank	Destination	Rank	Destination	Rank
Kuta	1	Candi dasa	0	Candi Dasa	0	Lovina	22	Lovina	22
Jimbaran	9	Goa Lawah	15	Goa Lawah	15	Danau Beratan	34	Danau Beratan	34
GWK	8	Besakih	14	Besakih	14	Bedugul	10	Bedugul	10
Dreamland	11	Danau Batur	13	Danau Batur	13	Taman Ayun	38		
Uluwatu	4	Kintamani	12	Kintamani	12	Alas Kedaton	36		
Nusadua	2	Tampak siring	27						
Sanur	33	Ubud	3						
Celuk	18								
Sukawati	3								
Ubud									

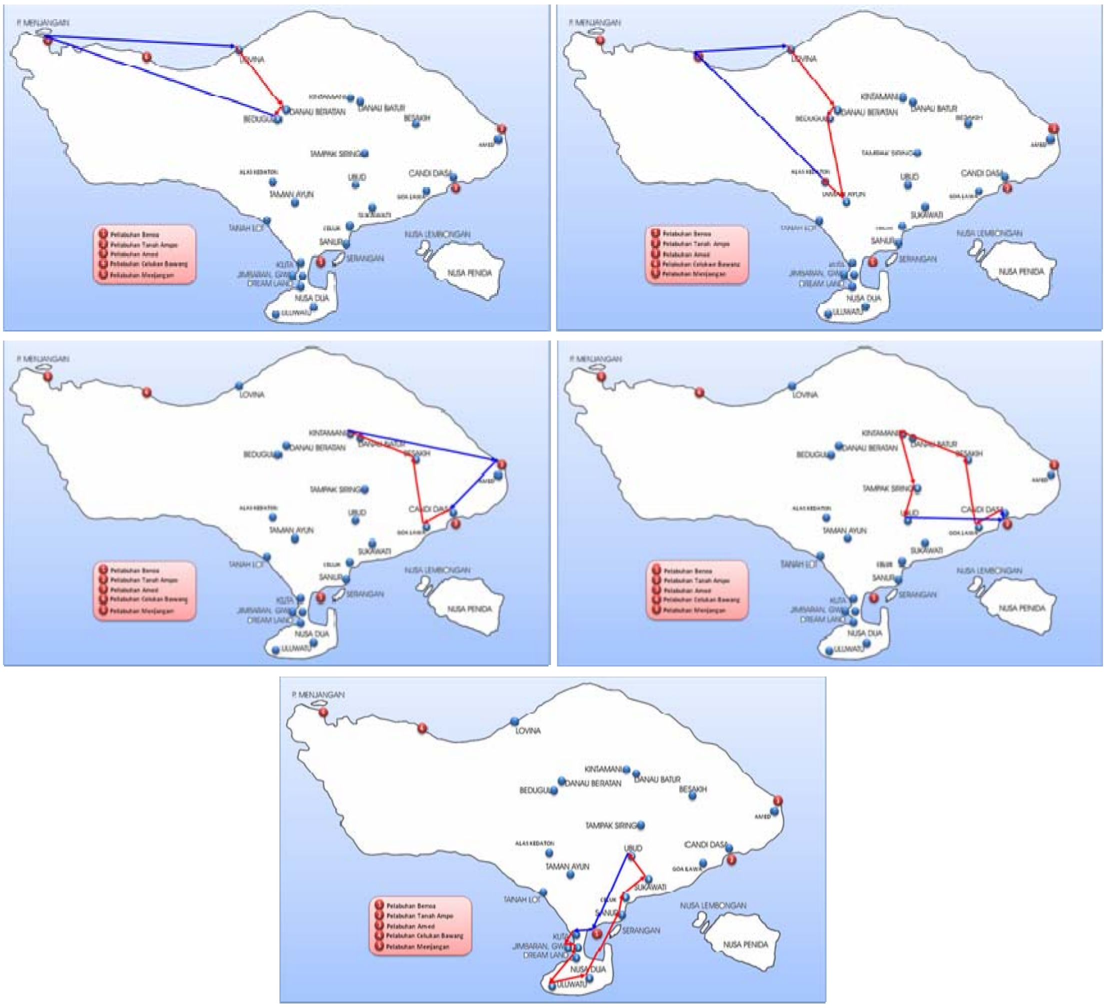

Figure 8. Itineraries with 10 hours duration of stay

5. Conclusion

The results of computation using TSP model revealed that Benoa Harbour is the best place to dock for cruise ship based on the number and rank of tourist preference of destinations can be visited. Hence, Benoa Harbour is the ideal tourism harbor as long as the requirement for a good harbor can be met; such as the acces channel and the water depth. Furthermore, this harbor is managed by Pelindo II with indoubtedly good management.

Tanah Ampo Harbour, which construction is being finalized and the second alternatice as docking harbor for cruise ship, will be the first alternative if the above requirement can not be met by Benoa Harbour. By improving the infrastructure such as direct connection by Bypass Jalan Prof. Mantra will make Tanah Ampo Harbour as the most ideal harbor.

If transportation activities do not managed well, then negative impact of the transportation to environment can be directly or indirectly experienced by community. As a result, green transport is suggested to reduce mobility needs by developing integrated area close to mass or public transportation route. In addition, TDM is another example to employ green transport. In summary, mobility of humans and goods can be done fast, safely, comfortably without causing negative impact to environment.

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