Applied Research on Cruise Rescue Station Establishment of an Inland River Based on a Kind of Linear Programming Model

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Abstract Some key water areas in the prefecture of an inland river can be looked as some spots on a straight-line. On that basis, the anthor establishes a simple mathematics model about decision analysis of cruise rescue station establishment of an inland river by comparing the time spended on accomplishing the same rescue task starting from the pre-cruise station The best location can be found based on a linear programming theory and the schedule table of cruising in a day established by the manager. At last, instance is given to certify that the method is practical and feasible.
Key words Cruise rescue station establishment; Inland river; Linear programming; Applied research

1 Introduction

Now, the cruise rescue stations of inland river were established mainly by two approaches: one is to set the station by equidistance in a prefecture water area in order to meet the the requirement of rescue in time, the other is to set the station at the vicinity of the accident-prone waters, bridge district, Dam and other key waters based on the empirical data. These two methods both have its advantages and disadvantages in application, and by using these two methods a certain waste of resources were created in the course of the cruise work. The author applied the theory of linear programming to the cruise rescue station establishment of an inland river, by comparing the time spended on accomplishing the same rescue task starting from the pre-cruise station to find the best location. It can make the the cruise rescue station establishment of inland river more scientific and economic, and it has definite practical significance.

2 A Practical Problems

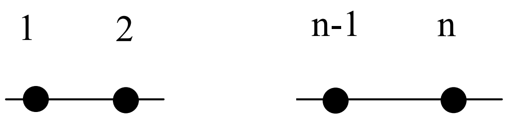

Figure 1 A Simple Mathematics Model of Some Key Water Areas in the Prefecture of An Inland River

As is shown in Figure 1, an inland prefecture has n key water areas, X_{ij} expresses the distance between key water area *i* and the key water area *j* , the average speed of the patrol craft is *v*, the *i* key water area need to cruise every t_i hours in a day, The average staying time in each station can be looked as t_0 hours, the question is where the most reasonable place is to set the cruise rescue station ?

3 Application of Linear Programming Model

3.1 Establish the schedule table of cruising in a day

Table 1 The Schedule Table of Cruising in a Day

Time division	The cruising situation of every key water area				
	1	2	……	n-1	n
T_1	a_{11}	a_{12}	……	$a_{1(n-1)}$	a_{1n}
T_2	a_{21}	a_{22}	……	$a_{2(n-1)}$	a_{2n}
……	……	……	……	……	……
T_m	a_{m1}	a_{m2}	……	$a_{m(n-1)}$	a_{mn}
The frequency of cruise task everyday	$24/t_1$	$24/t_2$	……	$24/t_{(n-1)}$	$24/t_n$

In the table 1, a_{ij} denotes the cruise situation of *j* key water area at *i* time, if the *j* key water area was cruised at *i* time, the value of the a_{ij} can be looked as 1, otherwise, the value of the a_{ij} can be looked as 0. In the following calculation we can bring out a matrix A,A can be showed as:

$$A_{m\times n}=\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1(n-1)} & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2(n-1)} & a_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{m1} & a_{m2} & \cdots & a_{m(n-1)} & a_{mn} \end{pmatrix}=\begin{pmatrix} A_1 \\ A_2 \\ \cdots \\ A_m \end{pmatrix} \tag{1}$$

In above matrix, $A_i=\begin{pmatrix} a_{i1} & a_{i2} & \cdots & a_{i(n-1)} & a_{in} \end{pmatrix}$

3.2 The programming component S_{ij} solving

S_{ij} expresses the require time starting from the *i* water area to accomplish the A_i rescue task if the cruise rescue station was established near the *i* water area. To the shipping water areas of inland river, a number of inland water areas of the same prefecture can be abstracted of a few points on a straight line. When the cruise rescue station was established near the *k* water area, the shortest time of completing the A_i task is the total time of a patrol craft cruising to and from the farthest distance waters of the both sides of the pre-cruise station added the total dwell time of each task cruising waters. Here we note that the water area was all day cruising if the cruise rescue station was established near a water area, and the spend time from the pre-cruise station to the water area is 0.

$$S_i=\sum_{j=1}^{n} S_{ij} \tag{2}$$

3.3 To obtain the optimal solution

Set $S=\min\begin{pmatrix} S_1 & S_2 & \cdots & S_{(n-1)} & S_n \end{pmatrix}$, suppose $S=S_k$ (3)

When the cruise rescue station was established at the vicinity of the key water area *k*, the required time of completing the cruise task should be the shortest, the resources consumed should be the least, and the key water area *k* should be the most reasonable place.

4 An Instance

4.1 A practical problem

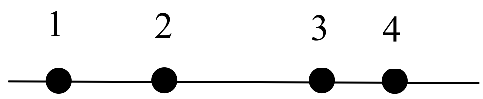

Figure 2 The Simple Mathematics Model of Station Establishment

From the figure 2, we can see that there are 4 key water areas in some inland river Prefecture, $X_{12}=10Km$, $X_{23}=15Km$, $X_{34}=5Km$. The average speed of the patrol craft is $v=30Km/h$ .The water area 1 and the water area 4 are required to cruise every 8 hours a day, the water area 2 is required to cruise every 12 hours a day, and the water area 3 is required to cruise every 24 hours a day. The average dwell time should be 0.5 hours in one cruising task. The question is which water area we should set the cruise rescue station in, the water area 1, the water area 2, the water area 3 or the water area 4?

4.2 To establish the schedule table of cruising in a day

Table 2 The Schedule Table of Cruising in a Day

Time Division	The Cruising Situation of Every Key Water Area			
	1	2	3	4
0：00-4：00	1	1	1	1
4：00-8：00	0	0	0	0
8：00-12：00	1	0	0	1
12：00-16：00	0	1	0	0
16：00-20：00	1	0	0	1
20：00-24：00	0	0	0	0
The Frequency of Cruise Task Evreyday	3	2	1	3

make matrix A,

$$A = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

4.3 To establish the programming component S_{ij}

4.3.1When the cruise rescue station is set at the key water area 1

$$S_{11} = 3.5, S_{12} = 0, S_{13} = 2.5, S_{14} = 1.2, S_{15} = 2.5, S_{16} = 0, S_1 = \sum_{j=1}^{6} S_{1j} = 9.7$$

4.3.2When the cruise rescue station is set at the key water area 2

$$S_{21} = 3.5, S_{22} = 0, S_{23} = 3, S_{24} = 0, S_{25} = 3, S_{16} = 0, S_2 = \sum_{j=1}^{6} S_{2j} = 9.5$$

4.3.3When the cruise rescue station is set at the key water area 3

$$S_{31} = 3.5, S_{32} = 0, S_{33} = 3, S_{34} = 1.5, S_{35} = 3, S_{36} = 0, S_3 = \sum_{j=1}^{6} S_{3j} = 11$$

4.3.4When the cruise rescue station is set at the key water area 4,

$$S_{41} = 3.5, S_{42} = 0, S_{43} = 2.5, S_{44} = 1.8, S_{45} = 2.5, S_{46} = 0, S_4 = \sum_{j=1}^{6} S_{4j} = 10.3$$

4.4To obtain the optimal solution

From the above analysis, we can conclude that $\boldsymbol{S} = \boldsymbol{min}(\boldsymbol{S_1} \quad \boldsymbol{S_2} \quad \boldsymbol{S_3} \quad \boldsymbol{S_4}) = \boldsymbol{S_2}$,it means that when the cruise rescue station is established at the key water area 2，the total time that we spended to complete the cruise task would be the shortest, and the resource consumed would be the least.

5 Conclusion

With the development of the inland river navigation, the ship traffic and the quantity of the passengers ferry are growing up, the types of ship are more abundantly. All these lead the merchant shipping management to more complex. Applying the decision analysis theory to the merchant shipping management and applying the linear programming model to the cruise rescue station establish problem would improve the timeliness, the effectiveness and the economy of the cruise rescue work. It has strong scientific and practical significance.

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