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Mathematical modeling for selecting center locations for medical and health supplies reserve in Hainan Province

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ABSTRACT

Objective: To explore how to choose the center locations to build the medical and health supplies reserve among many island towns. **Methods:** The center locations were selected from 18 towns Hainan Province, it's maximum service range (distance) was required to reach the minimum, or to minimize. **Results:** Three scenarios were considered, the center locations included only one town, two towns, three towns. By the use of graph theory and MATLAB programming, a mathematical model was established to obtain the shortest distance and the shortest path between arbitrary two towns. **Conclusions:** We find out the center sites under certain conditions, and determine the specific service ranges of the center sites.

1. Introduction

With special geographical position and geological structure, Hainan province is regarded as an island area that the various natural disasters could occur frequently, such as typhoon, tsunami, earthquake, flood, fire *etc*. Hainan is located at the national border area and fortified with military base, currently facing Southeast Asia national complicated political, military and natural disaster environment. With the rapid development of Hainan Provincial economy, diversified culture in recent years, and the large chemical enterprises entering to Hainan island's western zone, we are also under the risk of non-natural disaster events, such as mass chemical poisoning, explosion, prevalence of the infectious disease, the sea and air transportation accidents, and the threat of terrorist attacks. Due to the establishment of Yangpu Economic Development Zone and Space city, it is imperative to build a relatively independent of disaster medical rescue system[1-7] in Hannan island. In addition, Hannan province is blessed with the geographical features of island, it is connected with surrounding regions by two kinds of transportations, either by air, or by sea, but once the earthquake, typhoon, tsunami occur, none of traffic ways are often passable and readily reachable, so self-help and island's internal rescue capacity is even more important and effective than external assistance from other provinces and areas in China. On December 31, 2009, the State Council of China issued a white paper of "Recommendations on promoting the construction development of Hainan international tourism island"[8]. In it, the constructing Hainan as an international tourism became one of the national strategies. Thus, the construction of Hainan to be an international tourism island officially is well on track. As the China major strategic plan, Hainan Island will be built to be the world's top-class leisure resort in 2020, it will be made to be an open island, and a green island, a civilization and harmonious island, so, it is strategically important and significant to set up a medical and health supplies reserve, in quickly responding to the natural and non-natural risk or disasters.

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2. Mathematical modeling and results

There were eighteen major towns in Hainan province. These towns were Lingao (1), Danzhou (2), Changjiang(3), Dongfang (4),Ledong (5), Sanya (6), Baoting (7), Lingshui (8), Wanning (9), Qionghai (10), Ding′an (11), Wenchang (12), Haikou (13), Chengmai (14), Tunchang (15),Baisha(16), Wuzhishan (17), Qiongzhong (18). For convenience of modeling, city′s names were denoted by a number with in the parentheses 1,2,3,..., 18, respectively, First of all, an adjacent matrix was established[9] between two towns, the resultant matrix was as below

$$W=\begin{bmatrix} 0 & w_{1,2} & w_{1.3} & \cdots & w_{1,18} \\ w_{2,1} & 0 & w_{2.3} & \cdots & w_{2,18} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ w_{17,1} & w_{17,2} & \cdots & 0 & w_{17,18} \\ w_{18,1} & w_{18,2} & \cdots & w_{18,17} & 0 \end{bmatrix} \quad (1)$$

Where $w_{i,j}=w_{j,i}, i,j=1,2,\ldots,18$, denotes the distance (km) between the town and the town . All the distance data of 18 Hainan towns[10] was shown in Table 1.

2.1. One center point (town) case

A center point (town) was selected from eighteen major towns in Hainan Province to build the medical and health supplies reserve. The maximum service range (distance) of the medical and health supplies was required to be the shortest distance to reach all towns of Hainan island[11-13]. First it was assumed that all towns have the required infrastructure and are eligible to be built such a reserve, and the roads connected arbitrary two towns are passable, and the length of path are known. By use of Floyd algorithm[14], the shortest distance matrix $D=(d_{ij}), i,j=1,1,\ldots,18$, and the shortest path index matrix R could be found between any two points(towns), where d_{ij} denoted the shortest distance between arbitrary two towns. If the center point was taken to be the town , then the maximum service distance(range) of v_i was as below:

$$d_i=\max_{1\leqslant j\leqslant 18}(d_{ij}), i=1,2,\ldots,18 \quad (2)$$

To search for an integer , such that:

$$d_k=\min_{1\leqslant j\leqslant 18}(d_i) \quad (3)$$

then the point v_k was the town to find. The maximum service distance (range) of v_k could reach the minimum. The specific process was as follow, by MATLAB programming[15], to obtain the maximum values of each line in the matrix $D=(d_{ij}), i,j=1,2,\ldots,18$, the minimum value was taken out from these maximum values. The point corresponding to the minimum value was the target town. Calculating results showed that the minimum value was 219.9 km, and $v_k=18$, or Qiongzhong was the center town (point). Further more, the shortest distance and the corresponding path to the rest of 17 towns from Qiongzhong could be determined and given as follows. The shortest distances from Qiongzhong(18) to Lingao (1), to Danzhou (2), to Ledong (5), to Sanya (6), to Baoting (7), to Lingshui (8), to Wanning (9), to Qionghai (10), Ding′an (11), to Haikou (13), to Chengmai (14), to Tunchang (15), to Baisha(16), to Wuzhishan (17) were 143.6 km, 86.2 km,101.3 km, 141.0 km, 108 km, 91.2 km, 82.3 km, 125.2 km, 125.9 km, 142.0 km, 105.2 km, 52.7 km, 70.9 km, 77.1 km, respectively. The corresponding path are direct (no middle point), but the shortest distance was 161.7 km from Qiongzhong (18) to Changjiang (3), the corresponding path was from Qiongzhong (18) to Danzhou (2) to Changjiang (3). The shortest distance was 219.9 km from Qiongzhong (18) to Dongfang (4), the corresponding path was Qiongzhong (18) to Danzhou (2) to Changjiang (3) to Dongfang (4). The shortest distance was 184 kilometers from Qiongzhong (18) to Wenchang (12). The corresponding path was Qiongzhong (18) to Qionghai (10) to Wenchang (12) (Figure 1).

Figure 1. One center point (town) case.

2.2. Two center points (towns) case

Two center points (towns) were selected as the medical and health supplies reserve from eighteen main towns in Hainan Province. The maximum service range (distance) of two center points was required to reach the minimum, or to minimize. The basic assumptions about the towns were the same as the previous case. It was assumed that two center points are located at the points v_i, v_j. Let d_{ij}^k denotes the shortest distance from the point v_k to two center points v_i, v_j.

$$d_{ij}^k=\min\{d_{ik},d_{jk}\}, k=1,2,\ldots,18 \quad (4)$$

$$d(i,j)=\max_{1\leqslant j\leqslant 18}\{d_{ij}^k\}, i,j=1,2,\ldots,18 \quad (5)$$

To search for two integers, such as that: