Undesirable Facility Location under Uncertainty: Modeling and Algorithm

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Abstract: In undesirable facility location problem contrary to desirable location, facilities are located far from service receiver facilities as much as possible. The problem of locating such facilities is discussed in this study. This research is focused on the 'not in my backyard' (NIMBY) phrase which refers to the social phenomena in which residents are opposed to locate undesirable facilities around their houses. Examples of such facilities include electric transmission lines and recycling centers. Due to the opposition typically encountered in constructing an undesirable facility, the facility planner should understand the nature of the NIMBY phenomena and consider it as a key factor in determining facility location. Because of the adverse effects of these facilities, coupled with the uncertainty in the real world, it is estimated taking into account the potential uncertainty. This problem has been considered in the discrete space. The mathematical model is presented and methods to deal with uncertainty and stochastic programing problems modeling and methods used in the study are presented. According to the NP-hard problem, Simulated Annealing suggested for solving problems in large-scale. Numerical experiments to evaluate and validate the mathematical modeling and proposed algorithm are considered and operation of the proposed algorithm to solve various problems with genetic algorithms available in the literature about the problem is compared.

Keywords: Undesirable Facility Location, Uncertainty, Simulated Annealing, Genetic Algorithm

Introduction: From a general point of view, it is possible to investigate locational issues in two categories of optimal and undesirable facilities. There are many location models available for desirable facilities such as warehouses, service centers, police stations, and more. In such instances, customers are attracted to their facilities. Unlike desirable facilities in the location of undesirable facilities, it attempts to facilities as far away as possible from receiving areas. Undesirable facilities, while providing essential services for the people, at the same time, may have negative consequences for their neighborhoods. The proximity of undesirable facilities to residential areas due to their high pollution and hazardousness, will lead to lower quality of life in these areas and increase the health risk for residents of these areas. This type of problem is formulated in order to minimize the adverse effects of a new facility on existing facilities. Given that the degree of pollution from this facility in the real world is associated with uncertainty, in this paper, the mathematical model for the problem of locating undesirable facilities with uncertainty in degree of pollution parameters is presented. Also, the history of the problem of locating facilities in stochastic conditions and undesirable facilities has been presented. In the following, considering the mathematical model in a deterministic and stochastic manner, the proposed algorithm structure is described.

Materials and Methods: The problem of locating the undesirable facilities discussed in this paper is based on the article that focuses on the purpose of the term (not in my backyard). This refers to social phenomena in which residents oppose the placement of undesirable facilities around their homes. Considering the opposition to the creation of undesirable facilities, the facility planner must understand the nature of the NIMBY phenomenona and consider it as a key factor in determining the location of the facility. In this research, the NIMBY phenomenona is directly discussed through the structure of the objective function. The purpose function structure allows the residents to speak of the fact that the hosts hosting these facilities are those who are absorbing environmental costs, while other regions enjoy the benefits of this facility.

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1- First, uncertainty in the degree of pollution is considered and different scenarios are considered for it and the problem will be solved.

2- According to the mathematical model presented in stochastic mode, the problem is solved for each individual scenario and finally, three scenarios are compared and the objective hope of the target function is obtained for all scenarios. We considered the scenarios based on the degree of difference between these two parameters, which are as follows: The scenario (1): The degree of main contamination (a) 100 times the marginal contamination (b) Scenario (2): both change in close proximity. Scenario (3): The degree of main contamination (a) is 10 times the marginal contamination level (b)

3- Because of the NP-hardness of the nature of the problem studied, it is proposed to solve it in large dimensions for the large-scale simulation of Simulated annealing algorithm. A Heuristic method has been used to generate the initial answer to this question. The method of transfer from a solution to its neighboring solution is characterized by a known key factor called the neighborhood structure. Here, four operators for generating neighboring solutions are used in the Simulated annealing algorithm.

Results and Discussion: The problem in small and medium sizes in all experimental samples of the Metaheuristic-algorithm has been reached to the optimal solution of the problem Cplex solving software. Due to the fact that the Cplex software was unable to solve test samples for dimensions of 1000 node and larger than this dimension of the problem, the results of numerical tests of the problem were considered by considering 3 scenarios in each sample. Sixteen types of problem in large dimensions are solved with genetic and Simulated annealing meta-heuristic algorithms, and the stopping time of both algorithms is 1 hour. Finally, the results are compared. The genetic algorithm is written according to Sang et al. (Sang et al., 2013). Due to the fact that it was not able to produce feasible answers on large dimensions, the Heuristic method used in the Simulated annealing algorithm to generate the primary solution is also used in this algorithm. In all experimental samples, the Simulated annealing algorithm has the lowest value of the target function in comparison with the genetic algorithm.

Conclusion: In this paper, the problem of locating undesirable facilities with a focus on reducing the degree of pollution from these facilities was studied. Considering that in the past and also in the real world, the exact amount of this degree of pollution is uncertain, it was decided to investigate the degree of contamination resulting from this facility in the uncertainty mode. Then, by investigating the methods of dealing with uncertainty and modeling methods of random planning problems, the scenario method was used to consider the uncertainty in this problem and scenarios were designed to take into account the uncertainty in degree of pollution of the facility for the points around them. The problem was solved for various test examples in small to medium size scenarios with Cplex exact solver software and optimal solutions were obtained. Given the complex nature of this problem, a large-scale Simulated annealing algorithm was proposed to solve it in large dimensions and given that the space is large, it is used to generate an initial possible response instead of producing a random solution from an Heuristic method to produce an initial possible answer to this problem. The computational results of Optimal Optimization and Simulated annealing Algorithms in Small and Medium Dimensions were compared. Both methods achieved the optimal response and the difference was during solving these samples. For large dimensions, experimental samples were used using the Simulated annealing, and genetic algorithm available in the literature were compared and the efficiency of Simulated annealing algorithm in convergence to optimal solution and less time to solve in different samples and scenarios has been proved.

References

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