# A hierarchical optimization model for land resource allocation based on genetic algorithm and game theory


## Abstract

Existing models of land resources allocation mostly optimize the spatial layout of land use on one level, which makes them difficult to effectively combine strategies for solving land competition. Even if solving land competition, the existing models lack participation of different stakeholders and the results of land coordination are difficult to put into practice. In order to overcome the ability deficiency of traditional land resources allocation models in solving land competition, a hierarchical optimization model for land resource allocation, combining genetic algorithm and game theory, is constructed. With the objectives of land suitability level and spatial compactness, the model utilizes GA to separately optimize the spatial layout of each land use and traditional GA is improved in order to apply it to spatial optimization. On that basis, the model combines knowledge of land use planning and game theory to solve land competition. The layered architecture enables the model to have great flexibility in solving it and the model selects appropriate strategies for different categories of land competition. The model roughly divides land competition into three categories: agricultural land competition, competition between agricultural land and construction land, and competition involving ecological land. The model pays more attention to the solution of the first two categories and the knowledge of land use planning is extensively applied. The agricultural land competition can be subdivided, but the model deals with all varieties in a uniform way. According to land use status quo, competition between agricultural land and construction land is subdivided into two types: Construction (status quo)-Agriculture competition and Agriculture (status quo)-Construction competition. Through game theory interest demand of multiple stakeholders is incorporated into solving Agriculture-Construction land competition. Competition involving ecological land is solved by some mandatory constrains in land use conversion. The model introduces the concept of competition zones and takes them as basic operational units to promote land coordination.

In order to verify the model's validity, it has been utilized to allocate land resources in Zhejiang Province, Gaoqiao Town. Experimental results clearly evince that GA has well accomplished the optimization of spatial layout of each land use and the effectiveness of optimization is better for farmland and construction land. After land coordination, the spatial layout of agricultural land and construction land is more compact, and sporadic construction land in agricultural land is decreased greatly. The knowledge of land use planning well ensures the rationality of the land coordination results. When solving competition between agricultural land and construction land, the model balanced the interests of peasants and the government and supported the decision-making for the government to expropriate agricultural land from

peasants. The model wisely allocated land resources in Gaoqiao Town and greatly promoted the development of land resources in a sustainable way.

The spatial land competition is a complicated problem involving interests of multiple stakeholders. In solving Agriculture-Construction land competition the model preliminarily simulates the process of game between peasants and the government. In further researches, more socioeconomic factors can be coupled into the simulation. Stakeholders can also be introduced into solving other categories of land competition and thus more interest factors can be incorporated into land coordination.

# References:


[1]. Chuvieco, E., Integration of linear programming and GIS for land-use modelling. International Journal of Geographical Information Science, 1993(1).

[2]. ARTHUR, J.L. and D.J. NALLE, Clarification on the use of linear programming and GIS for land-use modelling. International Journal of Geographical Information Science, 1997(4).

[3]. Shen, Q., et al., A system dynamics model for the sustainable land use planning and development. Habitat International, 2009. 33(1): p. 15-25.

[4]. VERBURG, P.H., et al., Modeling the Spatial Dynamics of Regional Land Use: The CLUE-S Model. Environmental Management, 2002. 30(3): p. 391.

[5]. Aerts, J.C.J.H., et al., Using Linear Integer Programming for Multi-Site Land-Use Allocation. Geographical Analysis, 2003. 35(2): p. 148-169.

[6]. Aerts, J.C.J.H. and G.B.M. Heuvelink, Using simulated annealing for resource allocation. International Journal of Geographical Information Science, 2002(6).

[7]. Balling, R.J., et al., Multiobjective urban planning using genetic algorithm. Journal of Urban Planning and Development, 1999. 125(2).

[8]. Stewart, T.J., R. Janssen and M. van Herwijnen, A genetic algorithm approach to multiobjective land use planning. Computers & Operations Research, 2004. 31(14): p. 2293-2313.

[9]. Loonen, W., et al., Application of a genetic algorithm to minimize agricultural nitrogen deposition in nature reserves. Agricultural Systems, 2006. 88(2–3): p. 360-375.

[10]. Cao, K., et al., Spatial multi-objective land use optimization: extensions to the non-dominated sorting genetic algorithm-II. International Journal of Geographical Information Science, 2011. 25(12): p. 1949-1969.

[11]. Fotakis, D. and E. Sidiropoulos, Combined land-use and water allocation planning. Annals of Operations Research, 2012: p. 1.

[12]. Fotakis, D.G., et al., Spatial genetic algorithm for multi-objective forest planning. Forest Policy and Economics, 2012. 21(0): p. 12-19.

[13]. Cao, K., et al., Sustainable land use optimization using Boundary-based Fast Genetic Algorithm. Computers, Environment and Urban Systems, 2012. 36(3): p. 257-269.

[14]. Hui, E.C.M. and H. Bao, The logic behind conflicts in land acquisitions in contemporary China: A framework based upon game theory. Land Use Policy, 2013. 30(1): p. 373-380.