Genetic Algorithm Approach to a Multiobjective Land Allocation Model: A Case Study

Gopi Annepu, Department of Technical Education, Government of Andhra Pradesh, India
K. Venkata Subbaiah, Andhra University, India
N. R. Kandukuri, Department of Technical Education, Government of Andhra Pradesh, India

ABSTRACT

Optimal land allocation plays a vital role for the development of agriculture sector. Development toward optimal utilization of land under cultivation and increasing the production of crops and profit with less fertilizer consumption must be taken into consideration in agriculture planning. In this paper, a weighted additive model is formulated with net profit, production of crops, and fertilizer consumption as objectives and availability of cultivable land, agriculture labour, agriculture machinery, and water as constraints for optimal land allocation. Weighted additive model takes care of relative priority of objectives laid by the agriculture planners. To illustrate the model, a case study of Visakhapatnam district, Andhra Pradesh, India is presented. The results of GA approach are compared with LINGO solver and observed that there is an improvement in the utilization of land.

Keywords: Agricultural Planning, Crops, Genetic Algorithm, Land Utilization, Weighted Additive Model

INTRODUCTION

In today’s globalized world every sector of the economy needs to reorient itself to meet the changing demand. This is very much required as the need patterns of the individuals are getting transformed by the intensity of the local and global forces. The rural sectors of the developing countries are not exceptions in this regard. The sudden boom in food retail sectors has also changed the orientation and status of farming from purely individualistic to group oriented activities in India. At this instance it is inevitable for a country like India to improve its agriculture production not only to meet the demand of food grains for the growing population but also to improve the economic conditions of the majority population who live in rural areas. As a result of losing land due to growing population and industrialization, the production of crop per unit area must be increased by proper

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utilization of resources. One way of increasing production of crops is by increasing the area under cultivation. Planning of crops is the most crucial factor of Agriculture Planning which depends on several resources like availability of land, water, labour, machinery and capital.

Several authors have attempted the agricultural planning problem using Linear Programming (LP) techniques (Ahmad et al., 1990; Hassan, Ahmad, Akhter, & Aslam, 2005). Most of the problems in agriculture sector are multi objective in nature and have to be solved by multi objective programming techniques. Several classical multiobjective approaches (Goal Programming, Lexicographic Programming, etc.) have been developed to deal with multi objective decision making problems (Ghosh, Pal, & Basu, 1995; Sharma, Gaur, & Ghosh, 2008).

The classical optimization approaches suggest converting the multiobjective problem to a single objective problem by emphasizing one pareto optimal solution at a time. The most widely used method for multiobjective optimization is weighted sum method (Kim & de Weck, 2006). This method transforms multiple objectives into an aggregated scalar objective function by multiplying each objective function by a weighting factor and summing up. Though this approach generates efficient solutions to the problem, many compromise solutions may be missed. To overcome this drawback evolutionary algorithms can be used. Since the multiobjective evolutionary algorithms find multiple pareto optimal solutions in a single run, they are being used for solving the problems with multiple and conflicting objectives.

As evolutionary algorithms offer relatively more flexible way to analyze and solve realistic engineering problems, their use in multi criteria decision making is increased. The best known algorithm in this class is Genetic Algorithm (GA). Genetic Algorithm imitates the natural Darwinian evolution process which was originally conceived by John Holland (1975) of the University of Michigan, Ann Arbor.

Two important methods of GA are Binary GA and Real parameter GA. The binary representation of decision variables used in genetic algorithms has some drawbacks when applied to multi-dimensional, high precision numerical problems. Real coded or floating point representation has a very good usage because of the empirical findings that real codlings have worked well in a number of practical applications. The real parameter GA has also the advantage of less required storage space than the binary GA because a single real parameter value represents the variable instead of m (bits) integers. Also real parameter GAs deal with real parameter values and bring the GA technique a step closer to the classical optimization algorithms (Deb, 2001).

In most of the constrained optimization problems, the fitness function is obtained by adding a penalty proportional to the constraint violations to the objective function value. The constraint handling methods can be classified into five categories (Michalewicz et al., 2000). They are the methods based on preserving feasibility of solutions, penalty function, feasible over infeasible solutions, decoders and hybrid methods. Among these methods the method feasible over infeasible solutions is found to have more efficient and more robust than the penalty based methods (Deb, 2000). This method sometimes called as Deb’s penalty parameter less approach and the same is used in the present work.

Agricultural planning problems generally involve multiple goals such as maximizing production, profit, ecological benefit and minimizing expenditure, fertilizer consumption, environmental pollution, etc. These goals are conflicting in nature and it is not possible to maximize or minimize all goals simultaneously. Certain goals may be achieved with the expense of others and some goals compromise among them. It is required to obtain a satisfactory compromise solution in the decision making process. Weighted additive approach provides a compromise solution in decision making perspective.

In this paper, a weighted additive model is developed. The weights used in that model are determined from pair-wise comparison of the
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