# Methodology Development For Land Evaluation

## Models Incorporating Aggregated Knowledge and Fuzzy Membership Construction

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**Abstract**

The most widely used methods in agricultural land evaluation are parametric methods. Unfortunately, none of them are pre-eminent. The reason for this is that parametric methods lack the ability to deal with: 1) inappropriate or incomplete data sets; 2) complex interactions between any of the factors and constraints which have not or cannot be related experimentally; 3) incorporating user information, which is generally expressed in natural language and often contains uncertainty, into models so that decisions can be made based upon both objective and subjective information. The purpose of this study was to investigate the application of fuzzy set theory along with conventional parametric methods as a possible means to overcome the above shortcomings.

Fuzzy sets theory helps to create a commonsense picture of an uncertain world. The way in which it is used in this study is by using fuzzy sets to: (1) describe the degree of membership of a variable to the system under investigation, and (2) to determine weightings to adjust for the interaction of the variables with respect to each other. The specific way the degrees of membership and weightings are derived is explained in the thesis. These were constructed into an interaction matrix. The solution of the matrix gives a numerical "comprehensive interaction index". This index can be used as a basis for: predicting rangeland production and crop yields; for measuring the comprehensive effects of all variables studied on the environment; or, for aiding a decision maker in selecting the most suitable crop for a given land unit. The index gives a measure of the interactive interplay of the variables.

The method accommodates knowledge derived from empirical experimentation and the human expert.

In this study, the use of an original multiplicative parametric method to estimate land capability for dry land agriculture and grazing in Fukang County, Xinjiang, China was studied. The results showed that the multiplicative parametric methods were reasonably successful in predicting plant production and hence land capability. However, it did indicate that a more interactive way of dealing with the operative variables would be of great advantage as the multiplicative parametric method treats each variable independently. In addition, it indicated that this method can be used only if the complete data sets are available.

A model was constructed which used fuzzy membership functions to construct an "aggregated interaction matrix" in which the summation of variables were scaled according to the way rainfall and soil variables affect water availability to plants, and hence, influence rangeland productivity. This model was used to predict rangeland production. The results indicated that this new model increased the predicability of rangeland production to 81% compared to the 61% and 67% from models using rainfall and a multiplicative parametric respectively. The results also showed that: (1) rainfall was most important in determining production at lower rainfalls (<350 mm); (2) soil texture and particularly slope were important throughout the rainfall range of 149mm to 700mm, and that (3) soil depth was only important at the higher (>350mm) rainfalls. This new method showed the potential ability to obtain knowledge from local pastoralists and experts when empirical knowledge is unavailable.

The method was also applied to predict the crop yield. The results indicated that the method, including the aggregated fuzzy knowledge, increased crop yield predicability. The accuracy was increased from 58% to 97% for field peas and from 60% to 95% for wheat compared to methods that used growing season rainfall alone. In wheat yield analysis, the results obtained using weightings derived from expert knowledge were compared with those from a least square analysis to check the reliability of this expert knowledge. The results showed that expert knowledge can be satisfactorily used to estimate local yields. This is considered important as it provides a means of estimating crop yields when data is limited, which is often the case in developing countries.

The methodology also demonstrated that these techniques can be extended into the use of comprehensive estimation for environmental impacts of agricultural land use, as well as a comprehensive evaluation for determining the selection of a preferred crop for a given set of conditions, including the biophysical, social-economic and environmental factors..

Aggregated knowledge models such as these provide a computational framework for dealing with:

( 1 ) complex interactions which have not or cannot be related experimentally;

( 2 ) data sets that will always remain incomplete, and;

( 3 ) the incorporation of expert/user knowledge.

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