Group Decision for Multi – Criteria Decision Analysis

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ABSTRACT

Multi-criteria Decision Analysis, a computerized powerful tool, allows decision making in various semi-structured activities to make decisions that are accurate, appropriate, and consistent with the state of the problem. One important factor in determining multiple criteria, the weight value, which is weighted by the several stakeholder. This particular paper like to present the weighting values of multi-criteria decision, to determine the suitability of the area for maize cultivation in Uttaradit province, Thailand. We collected the seven criteria from the interviewing with twenty-five regional agricultural promotion officers and local farmers: including to rainfall quantity, soil drainage quality, amount of organic matter in the soil, temperature of the environment, soil pH, slope of the area and the depth of the topsoil, to calculate that values. The Analytic Hierarchy Process calculate each individual weight values to look for the Consistency Ratios of the total weight of the criteria. Finally, we discover the respective higher-to-lower of values are the amount of organic matter, soil drainage quality, soil pH-value, depth of topsoil and slope of the area. This study can helps to identify the importance of each factor in finding suitable areas for maize cultivation, and can be used to find the appropriate area in the next order.

Keywords: MCD - Multi-Criteria decision, Group decision, and Weight value

INTRODUCTION

Multi – criteria decision analysis, is a mathematical method, involve decision making to choice some solutions or find the answer to the problem from a large number of criteria that are complex. This methodology is widely appreciated for spatial planning activities such as the transportation and communication infrastructures, governance management and administration, economic development proposal, and natural resources management. As Mokarram and Aminzadeh (2010) on land suitability assessment, they used several conditions on geographic information systems, and a hierarchical weighting was used to determine the appropriate land use. They found that conservation of agricultural land resources are a complex problem that needs to be considered by multi - conditions. This method is a decision mechanism for decision-makers because it can help them to find a lot of decision-making strategies or scenarios. It also facilitates the understanding of the selection of appropriate land use patterns for multiple decision analysis. A significant element of analysis is the weighting of various criteria, it will determine the spatial suitability in the next order. Weighting the importance of criteria set by stakeholders, such as community leaders, farmers, and academics to define the significance of those criteria and make its standardization and reality consistency. Therefore, the group decision making is considered to be the appropriate approach to use to weight of the interested criteria. Because it is bringing the opinions of people of different occupations viewpoint and different areas of skill

to analyze together. In order to achieve the correct weighting, it can be used for spatial planning. The objective of this project require to analyze the weight of group decision making to find the suitable maize growing area.

CONCEPTUAL FRAMEWORK

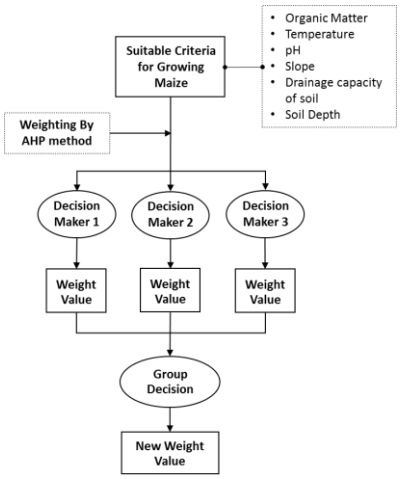

Figure 1. Conceptual Framework

Multi-Criteria Decision is a theoretical approach that helps in decision making. There are several considerations with multiple assessments to find a clear way to answer questions to help guide decisions. Decision making rule is an order of choice (Star and Zeleny, 1977; Chankong and Haimes, 1983) that make the best choice in order. It is the integration of information into alternatives. The decision maker can evaluate the options and decide whether they prefer the alternative. Decision rules determine the decision space by the meaning of the result as a one-to-one or one to many results relationship. This interpretive value shows a set of alternatives that are absolutely consistent with one-to-one or consistent with one-to-many relationships. So at the general level, multiple choice decision criteria is the process of grouping the results and identifying the results that will lead to the decision.

Group decision making is a process that brings together the ideas, knowledge, and abilities of the various groups to provide an innovative approach to collaborative management that is standardized and accepted. There are four methods of weighting, including to ranking, rating, pairwise comparison, and trade-off. Each of these methods are a difference in the basis of theory, accuracy, difficulty in applying, and understanding the decision maker. However, each method of weight estimation can be used to analyze multiple-choice decisions using geographic information systems. An AHP, analytic hierarchy process developed by Saaty (1980), is weighted by one-way comparison. Now it has been used extensively. AHP weighting is a pairwise comparison to form a pairwise correlation matrix. The imported data is a comparison between the criteria and the results. To make the relationship of the weight of the criterion.

SAMPLE AREA

Changwat Uttaradit situate in the lower northern Thailand, covers 7,838 square kilometers. The terrain is divided into 3 types: the river basin, mountainous valleys and

rolling plain. and mountains and high places. The mountainous area are about half of the province that located in the north and east of the province. There are 1,451.32 mm of average annual rainfall, 28.34 ° C of average annual temperature, and 69.48 percent of average relative humidity (based on Uttaradit climate statistics, 1995-2007).

The main production source of Changwat Uttaradit is agricultural sector, followed by the fishery and commercial sector. The major crops are rice, sugarcane, Maize, garlic, beans, banana and tobacco. There are also many fruits grown in this area, including lansium, durian, rambutan, mangosteen, pineapple and chopped longan.

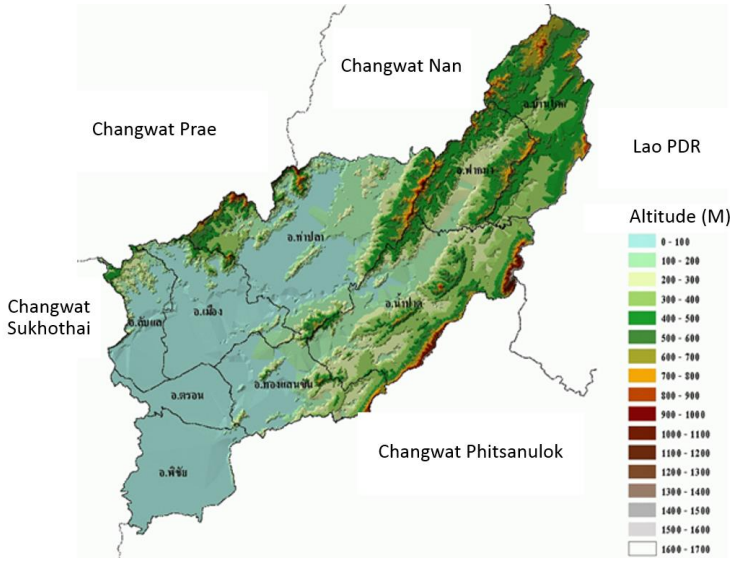

Figure 2. Map of Changwat Uttaradit, Thailand, Sample Area

METHODOLOGY

1. Selecting some criteria that are suitable for planting Maize

This research has selected the seven criteria that are significance for maize growth to determine the spatial suitability, consist of organic matter, temperature, pH, Slope, Drainage capacity of soil, water requirement or rainfall and topsoil dept. All of these criteria will be used in the analysis of multiple choice decisions. To find the spatial suitability of maize planting. Through weighting, to determine the importance of each criterion with the Analytic Hierarchy Process.

2. Data collection by questionnaire

The research was conducted by a questionnaire from 25 agricultural scientists and Maize farmers in Changwat Uttaradit to assess the significance of criteria that are important for maize growth.

3. Weight of individual criteria and find the Consistency ratios of the total weight of the criterion.

A well known consistency indicator that used to compile the vector of person's priority is consistency ratio, that $CR = CI/RI$ where $CI = (\lambda\text{-}n)/(n\text{-}1)$ and RI is a random index adjusted from the matrix, nxn. And the CR should be less than 0.1 so that it is possible to

conclude that there is a consistent relationship between the comparison pairs in the matrix.

Calculate ramda (λ) and consistency index (*CI*), where the value of λ is the mean of the vector.

$$\lambda = \frac{A+B+C}{n}$$

where *A, B* and *C* are sum of the multiplication between the weight values of the *i-th* order criterion and the *j-weighted order*. And n is the total number of criteria. Random index: *RI* is an index of consistency that gets from consistency table. The values are based on the number of criteria that are compared at the beginning. If *CR <0.10* shows that the comparison pair of criteria is consistent and reasonable. If $CR \geq 0.10$ indicates that the comparator is not consistent.

4. Calculate the weighted values of a group criterion.

AHP will be used for individual decision makers. Finally, it will bring together the vectors of priority of all the decision makers to prioritize the criteria of Maize growing land suitability. This decision is made in two ways: firstly, to assume the significance of the criteria given by the decision maker, it is correlated with the consistency ratio. And secondly, to suppose the importance of the decision maker, it correlates with the broader coverage ratio of each decision maker.

When the consistency ratio value was calculated, by this ratio of the individual criterion was less than 0.01. The next step is to apply the weight of the individual criterion to the weight of the group criterion.

Saaty (2001) suggested that if there are reasonable requirements. Calculating geometric mean is the most effective way to calculate the total weight of a judgment in a group. Therefore, the sum of the priority vectors from each decision maker is taken to the final step to find geometric mean. Following the equation below:

$$Z_i^G = \prod_{k=1}^{k} [Z_i(k)]^{\alpha_k}$$

where k represents number of decision makers, $Z_i(k)$ is the priority of the *i-th* alternative for the *k-th* of the decision maker, α_k for the weight of *k-th* of decision maker, and Z_i^G is the sum of group priority value.

An analytical process of the group decision criterion weighting values, as the following:

1) Calculate the *CR* values in all comparative matrices of each decision maker
2) The *CR* values of all matrices is combined. Separated by each decision maker.
3) The sum obtained from step 2, it is calculated for each decision maker.
4) Normalizing values of results by taking the sum obtained in the step 3 to divide
5) The average of *CR* values obtained in step 4, will be used as the final weight of the decision maker.

RESULTS

The twenty-five farmers and agricultural extension officers assessed the multiple criteria significance of maize growing land suitability. Of these the nine decision makers had the value of consistency ratio less than 0.01. Each decision maker determined the significance of the criteria show in Table 1.

Table 1. The criterion weighting values of maize growing land suitability from each decision maker

Criteria	Consistency ratio	Priority	Consistency ratio	Priority	Consistency ratio	Priority
	The 1st Decision Maker		**The 2nd Decision Maker**		**The 3rd Decision Maker**	
Organic Matter	0.082	6	0.167	3	0.195	3
Temperature	0.129	3	0.118	5	0.100	5
pH	0.117	4	0.088	6	0.200	2
Slope	0.052	7	0.052	7	0.051	7
Drainage capacity of soil	0.238	2	0.168	2	0.123	4
Rainfall	0.289	1	0.255	1	0.251	1
Soil Dept	0.093	5	0.152	4	0.080	6
	The 4th Decision Maker		**The 5th Decision Maker**		**The 6th Decision Maker**	
Organic Matter	0.125	4	0.232	1	0.104	3
Temperature	0.370	1	0.095	6	0.070	5
pH	0.122	5	0.167	2	0.082	4
Slope	0.053	6	0.094	7	0.064	6
Drainage capacity of soil	0.145	2	0.134	4	0.327	1
Rainfall	0.139	3	0.161	3	0.289	2
Soil Dept	0.046	7	0.117	5	0.064	7
	The 7th Decision Maker		**The 8th Decision Maker**		**The 9th Decision Maker**	
Organic Matter	0.337	1	0.260	2	0.220	1
Temperature	0.179	2	0.080	5	0.162	4
pH	0.150	3	0.108	3	0.108	5
Slope	0.081	6	0.031	6	0.064	7
Drainage capacity of soil	0.084	5	0.107	4	0.175	3
Rainfall	0.091	4	0.385	1	0.175	2
Soil Depth	0.078	7	0.029	7	0.096	6

Table 2. Frequency of Ranking from Decision Makers

Criteria	Ranking from Decision Makers (number of DMs)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Organic Matter	3	1	3	1	-	1	-
Temperature	1	1	1	1	4	1	-
pH	-	2	2	2	2	1	-
Slope	-	-	-	-	-	4	5
Drainage capacity of soil	1	3	1	3	1	-	-
Rainfall	4	2	2	1	-	-	-
Soil Depth	-	-	-	1	2	2	4

Based on the weighted individualized results in Table 2. It was found that the three of decision makers rated rainfall as the first priority. The other four decision makers focus on soil fertility. And another one decision maker, the temperature and drainage of the soil, are the most important factors. There are five decision makers saw the slope as important as the 7th, or the least significant of all criteria. And the four of decision makers gave the soil drainage to be the least important criterion.

The criterion weighting values of maize growing land suitability from group decision maker can be ranking from higher to lower: rainfall (wgv = 0.212), organic matter (wgv = 0.195), drainage capacity of soil (wgv = 0.160), temperature (wgv = 0.152), pH (wgv = 0.133), soil dept (wgv = 0.086) and slope (wgv = 0.062)

Table 3. The criterion weighting values of maize growing land suitability from group decision

Decision	DM1	DM2	DM3	DM4	DM5	DM6	DM7	DM8	DM9			
Cr (Consistency ratios)	0.060	0.056	0.033	0.042	0.045	0.066	0.046	0.078	0.0320			
1/CR	16.667	17.857	30.303	23.810	22.222	15.152	21.739	12.821	31.250	sum	191.8	
norm CR	0.087	0.093	0.158	0.124	0.116	0.079	0.113	0.067	0.163			
Weights Value												
Organic Matter	0.082	0.167	0.195	0.125	0.232	0.104	0.337	0.26	0.22			
Temperature	0.129	0.118	0.1	0.37	0.095	0.07	0.179	0.08	0.162			
pH	0.117	0.088	0.2	0.122	0.167	0.082	0.15	0.108	0.108			
Slope	0.052	0.052	0.051	0.053	0.094	0.064	0.081	0.031	0.064			
Drainage capacity of soil	0.238	0.168	0.123	0.145	0.134	0.327	0.084	0.107	0.175			
Rainfall	0.289	0.255	0.251	0.139	0.161	0.289	0.091	0.385	0.175			
Soil Depth	0.093	0.152	0.08	0.046	0.117	0.064	0.078	0.029	0.096			
Group Decision										Weight Group		Rank
Organic Matter	0.007	0.015	0.031	0.016	0.027	0.008	0.038	0.017	0.036	sum	0.195	2
Temperature	0.011	0.011	0.016	0.046	0.011	0.005	0.020	0.005	0.026		0.152	4
pH	0.010	0.008	0.032	0.015	0.019	0.006	0.017	0.007	0.018		0.133	5
Slope	0.005	0.0054	0.008	0.007	0.011	0.005	0.009	0.002	0.010		0.062	7
Drainage capacity of soil	0.021	0.016	0.019	0.018	0.015	0.026	0.010	0.007	0.029		0.160	3
Rainfall	0.025	0.024	0.040	0.017	0.019	0.023	0.010	0.026	0.029		0.212	1
Soil Depth	0.008	0.014	0.013	0.006	0.013	0.005	0.009	0.002	0.016		0.086	6

CONCLUSION

The weight of Table 3 can be summarized as follows. Group decision is a tool that manages the values of individual weighting criteria of many decision makers who have different performances and characteristics, both the space difference experiences, academic intellectuals, and personal attitudes. Group decision make possible for those decision makers unify, diminish diversity and is acceptable. We can apply the weight values of the criteria and methods to find the spatial suitability of maize planting or apply to other decision makings such as an engineering, land use planning, and transportation etc.

REFERENCES

Chankong, Vira. and Haimes, Yacov Y. 1983. *Multiobjective Decision Making: Theory and Methodology*. New York: North-Holland Pub. Co.

Malczewski, Jack. 1999. *GIS and Multicriteria Decision Analysis*. New York: John Wiley & Sons.

Mokarram, M. and Aminzadeh, F. 2010. "GIS-Based Multicriteria Land Suitability Evaluation Using Ordered Weight Averageing with Fuzzy Quantifier: A Case Study in Shavur Plain, Iran". *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. 38, Part II: pp.508-512.

Saaty, T. 2001. *Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World*. Pittsburgh: University of Pittsburgh, RWS Publications.

Starr, Martin K. and Zeleny, Milan. 1977. *Multiple Criteria Decision Making*. New York: North-Holland Pub. Co.

Yan-Sui, LIU; Jie-Yong, WANG; and Li-Ying, GUO. 2006. "GIS–Based Assessment of Land Suitability for Optimal Allocation in the Qinling Mountain, China". *Pedosphere*. Volume 16, Issue 5, October: pp.579-586.