Study of the industrialization-ability of the production of mescal in Guerrero-Mexico

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Abstract

We considered the modeling of the evaluation of projects for industrializing the artisanal production of mescal. A Decision Support system is modeled for determining the priorities of the tasks. The ability for evaluating projects is considered. Data provided from a large research developed in Guerrero provided data for generating scenarios and evaluating behavior of the system.

Keywords: DSS, AHP, regression, Bayes, similarity measures, consensus

1. Introduction

Maguey (Agave cupreataTrel*et* Berger) appears as a silvestre plant in Mexico. Its cultivation has roots in Mesoamérica. Náhuatls cultivated it for *pulque*'s production. Maguey is used for producing mescal and the worldwide known tequila , mescal produced in the region Tequila (so as Cognac respect to brandies).

The evaluation of industrial production of mescal by small and medium enterprises, and its sustainability requires maintaining information, for deciding whether to harvest or not an available natural maguey area. Commonly the uncultivated areas are of difficult access and there is a serious lack of information on them.

In this paper we propose a decision support system for managing natural areas where agave growth. We develop the study using the proposal of Kangas et al. (1997).

Fig. 1: Plants of Agave cupreataTrelet Berger in non cultivated areas

The Agave cupreataTrelet Berger appears in non cultivated zones in Guerrero State. It is divided into 77 municipals clustered in 7 regions. An investigation took place and an inventory identified 7625 plants of maguey papalote which were inventoried. The referred results appears in the technical report "Desarrollo de un Sistema de Inventario y Monitoreo de Maguey Papalote (Agave cupreataTrel. &Berger)", (Madariaga, 2004). The area studied is described in table 1.1.

LOCATION	*NA*	*RCA*	*R.A*	*MA*	*EPP*
Axaxacualco	1358	0,37	0,34	0,76	0,44
El Aguacate	512	0,49	0,49	0,56	0,62
Mazatlán	265	0,23	0,93	0,54	0,62
Mirabal	110	0,35	0,96	0,76	0,43
Mochitlán	1665	0,26	0,44	0,53	0,65
Ojitos de Agua	1209	0,33	0,44	0,67	0,66
Palo Blanco	1199	0,20	0,31	0,83	0,52
Plan Guerrero	437	0,08	0,93	0,84	0,56
Salto Valadez	404	0,11	0,69	0,81	0,56
Tlanipatla	656	0,16	0,36	0,56	0,41
Xochipala	765	0,12	0,64	0,53	0,52
Xocomanatlán	146	0,28	0,41	0,81	0,55

Table 1.1: Population of plants in the State of Gue-rrero and means of the elicited variables generated by Simulation (*NA: number of areas, RCA: relative covered area, RA: Relative Abundance, MA: Mean Age, EPP: Expected Production Potentialities*)

The existent data have been used for generating information to be analyzed by experts, looking for a consensus on the conditions of the areas. The lack of information and the environment effects fix the need of using experts forecast under uncertainty.

The construction process of a Decision Support System is discussed. The effectiveness of the process is simulated using the existent data and the opinion of experts in forest exploitation with he same level of expertise. The use of the Analytical Hierarchy Process (AHP) proposed by Saaty, the Bayesian approach and the application of a regression method are considered. They are presented in Section 2. The section ends with an evaluation of their behavior using different simulated scenarios.

Section 3 is concerned with the evaluation of the consensus of the experts in establishing which areas support the immediate exploitation of the plants and which should be maintained as stock for the substituting the areas exploited at a first stage.

The methodology proposed in this paper includes the use of three methods for the evaluation of the decision making criteria and its use for comparing alternative. It is also analyzed the experts judgment coincidences. The methodology is extensible to other contexts, where is present the necessity of evaluating forest sources of non renewable recourses and of making decision on their exploitation strategies. In fact, there is a lack of studies of the assessment modeling for ecological research in Latin America.

2. Constructing a decision support system (DSS). Analysis of the priorities

For developing a decision support planning process in a forest Kangas et al. (2000) suggested to implement it as follows:

Procedure 1. DSS planning stages

1. Indentify and structure the decision problem (qualitative analysis of the planning problem).
2. Describe the objectives of the analysis (Fix the goals expected form the study).
3. Describe the forest (Fix the characteristics of the population to be studied.)
4. Determine treatments and schedules (Establish what is to be implemented and when).
5. Examine the possibilities of the policies (determine a set of decision to be considered and their feasibility).
6. Provide alternatives development plans (Discriminate among the policies using common sense).
7. Analyze objectives and preferences of the decision makers (Establish which plans are feasible using common sense).
8. Evaluate and compare the plans in terms of the outputs (Use mathematical based methods).
9. Determine the plan to be implanted (Decide which is the best policy).

These stages overlap and there are interactions among them.

An optimal combination of the schedulesi of the treatment, places the need of solving an optimization problem. We will consider the case of an additive utility function.

$$U = \sum_{i=1}^{I} a_i u_i(q_i)$$

where

I = number of objectives,

u_i = partial utility of objective I

q_i = quantity produced or consumed by the objective i

The i-th sub-priority function describes the relative utility produced by different amounts of a product or resource. It is estimated as follows:

- Fix the maximum and minimum value of the objective analyzing all the treatments schedules.
- Determine the range of variation and divide it into a certain number of intervals of equal width.
- Analyze the pairs of class boundaries with respect to the relative sub-priorities.

A goal of our study is fixing exploitation strategies of the areas, i.e. to determine which areas will be harvest and which ones should stay in stock for being exploited in the future. Three criteria has been considered important for evaluating the areas: relative abundance of agave plants, the age of the plants population in them and the expected production of mescal obtainable from them.

2.1. Analytic Hierarchy Process (AHP)

Expert knowledge and subjective preferences are used in the determination of an Analytic Hierarchy Process (AHP). Saaty (1977, 1980) introduced this method. The AHP allows the derivation of a ratio scale of priorities for the set of criteria under analysis. The elicitations of pairwise comparison judgments, allowing expressing them verbally sustain the popularity of the method. The judgments can be expressed either directly by a real number in the interval [1, 10[or by choosing a verbal expression. Each verbal pairwise comparison elicited is automatically converted into a number w_{ij} (weight).

Many applications of AHP have been reported. A lot of research has been devoted to the critical analysis of AHP from various perspectives, some recent ones are Saaty, (2000); Forman and Gass, (2001), Golden and Wasil, (2003).

We propose the use of AHP method for fixing the weight of each criteria in the comparison of the areas. The scale of relative importance for pair wise comparison of the three criteria has been fixed as developed by Saaty 1977 (Table 2.1).

priority of dominant element "i" over element "j"
1 – same importance
2– slightly more important
3 – weekly more important
4 – weekly to moderately more important
5– moderately more important
6 – moderately to strongly more important
7– strongly more important
8 – greatly more important
9– absolutely more important

Table 2.1: Scale of relative importance for pairwise comparison

Each expert is asked about the pair wise comparison of the criteria and the comparison matrix is constructed. From the largest eigenvalue, the consistence index and the ratio of consistence is calculated for determining if is consistent. If it is the case, the eigenvector associated to expresses the importance of the criteria In other case, the process is repeated to improve it.

2.2. Regression model for pairwise comparisons

Pairwise comparisons of data can be also implemented through the use of regression analysis (RA). It is a challenging option to Saaty`s eigenvalue method because of the set of statistical tools supporting it. See a discussion in Crawford-Williams (1985) and Alho et al (1996).

Take

r_{ij} :value of attribute *i* when it is compared with attribute j

$TV(i)$ true value of attribute $i,\ i=1,..,l$

$\alpha_i = \log(TV(i))$

ε_{ij} uncorrelated error

$V(\varepsilon_{ij}) = \sigma^2 \quad E(\varepsilon_{ij}) = 0$

Crawford-Williams- model establishes that

$$y_{ij} = \log(r_{ij}) = \alpha_i - \alpha_j + \varepsilon_{ij}$$

and the usual methods for fitting the equation (estimating the regression parameters) can be used (least squares, least absolute deviation etc). The ability to identify is fixed by establishing that $\alpha_i = 0$. In multilevel decision hierarchy the model is used repeatedly. The response $\log(r_{ij})$ reflects the criterion of the judge. The regression generated allows establishing posterior of the priorities. It describes the inconsistency and the variance of the pairwise comparisons for given judge.

Alho et al (1996) considered the case of multiple judges and their model was

$$y_{ijk} = \log(r_{ijk}) = \alpha_i - \alpha_j + \varepsilon_{ijk} \quad E(\varepsilon_{ijk}) = 0$$

Hence taking the pairwise evaluation of judges we get a regression model for estimating α_i. The estimate of the relative value of the attribute i is computed by estimating

$$\frac{\exp(\alpha_i)}{\sum_{i=1}^{I} \exp(\alpha_i)} \quad i = 1,...I$$

The error structure is given by

$$\varepsilon_{ijk} = \eta_{ik} - \eta_{jk} + \xi_{ij} + \delta_{ijk}$$

δ_{ijk} = residual lack of consistency

$V(\delta_{ijk}) = \sigma_1^2$: Intra-individual inconsistency

ξ_{ij} : inconsistency shared by attributes *i* and *j*

$V(\xi_{ij}) = \sigma_2^2$ shared inconsistency

η_{ik} random effect mdeling how the criteria of judge *k* on the attribute *i* differ from the population.

$V(\eta_{ik}) = \sigma_3^2$ Interpersonal inconsistency

Hence the overall uncertainty measure is:

$$V(\varepsilon_{ijk}) = \sigma_1^2 + \sigma_2^2 + 2\sigma_3^2$$

It is worth noting that the analysis of the variance components permits to evaluate the uncertainty of the judges.

2.3. Bayes

$$R(\theta) = \int_\theta L(d,\theta)\, p(\theta)\, d\theta$$

A consequent behavior is to select $d^* \in D$ such that $R(\theta)$ is minimum. That is a Bayes decision rule. Bayes rule and the law of total probability is used for solving the problem. The DM must deal with determining $p(\theta)$, which is not so easy in general. Using available information (s), he must perform a sensitivity analysis. Commonly $p(\theta)$ is elicited and is of subjective nature. The use of available information or generating evaluating different scenarios allows eliciting the probabilities in the case of a finite set of events.In the continuous case the DM must elicit a prior density within a certain conjugate family, see Smith (2010).

Note that when we deal with a utility function we use the opposite of a loss function and we look for the maximization of its expected value.

Alho-Kangas (1997) considered a non-informative prior proportional to σ^{-1} for $(\alpha,\sigma), \alpha=(\alpha_1,...\alpha_{I-1})^T$. Then a procedure for generating α by simulation allows computing the posterior of the priorities of the decision alternatives. The variance of this posterior is positive if the pairwise comparisons are inconsistent $(\sigma^2 > 0)$. Saaty`s inconsistency fixes that $r_{ij} \neq r_{it}r_{tj}$ (Saaty (1980)). The consistency implies that the estimate of α is a parameter as the estimator has no variance. The uncertainty of a pair of DM`s or experts (judges) is not reflected in the posterior when the priorities are proportional.

When the opinion of a judge is describable by a continuous distribution function (s) he can be asked fixing the best guesses values of the ratio between two attributes and a value of the probability in an interval where this value lies.

3. Numerical Experiences

3.1 The Data Base

Using the data obtained from Madariaga (2004) three experts with a similar experience considered the variables Relative abundance, Mean age and Expected production potentialities of the areas. They used their expertise in forest management.

The data were analyzed and each DM used a "four rounds Delphi" procedure for arriving to a consensus.

The usual Delphi methods look to produce an adequate level of consensus. The experts are interviewed and the results are feed backed to them, who reforms their judgment looking for a consensus. The three experts analyzed the information at hand and performed for reaching a consensus for estimating the priorities. The regression method and Saaty`s AHP were used for fixing them.

3.2. Comparison of Regression and Saaty method.

The results obtained using the regression and Saaty methods sustain that there are considerable differences between the methods and that the DM`s criteria converges within the methods.

Tables 3.1 and 3..2 present the obtained results in the four rounds. For the variable Relative abundance Saaty offers good results since the second round. However, Regression has a faster convergence respect to the variable *Mean age* and has a slightly better behavior in the variable *Expected Production Potentialities.*

	R1	R1	R2	R 2
	Reg.	Saat	Reg.	Saat
RA				
DM1	0,65	0,88	0,67	0,86
DM2	0,68	0,81	0,67	0,83
DM3	0,97	0,84	0,84	0,87
MA				
DM1	0,38	0,49	0,40	0,44
DM2	0,42	0,36	0,42	0,49
DM3	0,38	0,51	0,41	0,45
EPP				
DM1	0,78	0,37	0,83	0,23
DM2	0,78	0,14	0,86	0,26
DM3	0,90	0,39	0,88	0,34

Table 3.1. Estimates of the mean priorities of 3 DM`s in rounds 1 and.2

	R3	R3	R4	R 4
	Reg.	Saat	Reg.	Saat
RA				
DM1	0,66	0,85	0,65	0,84
DM2	0,67	0,84	0,66	0,84
DM3	0,75	0,84	0,69	0,84
MA				
DM1	0,41	0,45	0,41	0,45
DM2	0,41	0,47	0,41	0,46
DM3	0,41	0,45	0,41	0,45
EPP				
DM1	0.83	0,25	0,84	0,27
DM2	0,87	0,22	0,87	0,24
DM3	0,88	0,30	0,85	0,28

Table 3.2 Estimates of the mean priorities of 3 DM`s in rounds 3 and.4

The variance structure of the estimated variance is presented in tables 3.3-3.5. The analysis of the relative abundance suggests that the inconsistency is seriously diminished at the end of the process. For the mean age the convergence is very fast and a perfect coincidence is obtained at the third round. The expected production potentialities presented a large interpersonal inconsistency in all the rounds and a non convergence is obtained. The other components seem to converge with the development of the process. These results sustain considering that there are large discrepancies in terms of considering the production potentialities of the areas among the judges.

	$\hat{\sigma}_1^2$	$\hat{\sigma}_2^2$	$\hat{\sigma}_3^2$	$\hat{\sigma}^2$
RA				
Round1	0,22	0,32	0,15	0,84
Round 2	0,10	0,13	0,06	0,35
Round 3	0,07	0,04	0,07	0,25
Round 4	0,07	0,08	0,07	0,29

Table 3.3. Estimated variance components of Relative Abundance for Delphi`s rounds

	$\hat{\sigma}_1^2$	$\hat{\sigma}_2^2$	$\hat{\sigma}_3^2$	$\hat{\sigma}^2$
MA				
Round1	0,14	0,08	0,10	0,42
Round 2	0,03	0,05	0,01	0,10
Round 3	0,00	0,00	0,00	0,00
Round 4	0,00	0,00	0,00	0,00

Table 3.4. . Estimated variance components of Mean Age for Delphi`s rounds

	$\hat{\sigma}_1^2$	$\hat{\sigma}_2^2$	$\hat{\sigma}_3^2$	$\hat{\sigma}^2$
EPP				
Round1	0,20	0,12	0,30	0,92
Round 2	0,11	0,16	0,10	0,47
Round 3	0,06	0,10	0,30	0,76
Round 4	0,17	0,09	0,35	0,86

Table 3.5.. Estimated variance components of Expected Production Potentialities for Delphi`s rounds

3.3. Comparison of estimates computed using Regression and Bayes method.

The use of regression and Bayes procedure is evaluated in 5 plans proposed by the judges. The results in table 3.6 suggest that median and posterior means are very different in two of the five cases and only in two cases they are similar. The errors of the posterior means are the smaller. Regression and Bayes estimation are generally close and the posterior means belong to the confidence interval computed using the regression model. See table3.6.

Plan					
RE	0,61	0,35	0,93	0,41	0,60
Bounds of Confidence Interval					
Lower Upper	0,50 0,72	0,19 0,54	0,88 0,98	0,18 0,58	0.52 0,68
ME	0,55	0,64	0,83	0,45	0,80
Bounds of Confidence Interval					
Lower upper	0,46 0,62	0,59 0,69	0,74 0,90	0,23 0,67	0,65 0,95
PME	0,51	0,32	0,91	0,44	0,67
Bounds of Confidence Interval					
Lower upper	0,47 0,55	0,29 0,35	0,89 0,93	0,40 0,48	0,62 0,72

Table 3.6. estimates of priorities of 5 plans using α=0,05. (RE: regression estimation, ME: Median Estimates, PME: Posterior Means Estimates

4. Similarity of the evaluation made by the experts of the development plans

The experts proposed 10 plans and they classified the areas, considering the specifications of them in "exploitable", if they can be used immediately by an industry, "in stock" if they should be maintained in reserve.

Measuring the similarity of the evaluation of the experts is needed both for considering the consensus of the experts and for detecting the partitioning of the inventoried areas.

Take judge X and Y. They evaluated independently the areas inventoried and the counts of their classification produce the table 4.1

		by Y		
		E A	AS	Total
by X	EA	a	b	$a+b$
	AS	c	d	$c+d$
Total		$a+c$	$b+d$	N

Table 4.1 Contingency table of the cross classification (EA: Explotaible Areas, AS: areas in stock)

a : number of consensual exploitable areas.

b : number of areas considered exploitable by X and not by Y

c : number of areas considered exploitable by Y and not by X

d : number of consensual stock-able areas

Albbatineh et al. (2006) proposed a linear family of similarity indexes. Are popular the following indexes:

- Rand : $R = \dfrac{T(YS)}{N}$
- Czekanowski: $CZ = \dfrac{2a}{2a+b+c}$
- A popular non linear index is
- Jaccard: $J = \dfrac{a}{a+b+c} = \dfrac{CZ}{2-CZ}$

Albatineh et al. (2011) presented them and together with other 13 indexes that can be described by mutual relationships. Some approximations to the expectations and variances of R, CZ and J can be obtained using Taylor Series approximations or regression motivated formulas.

The number of areas considered was 8726. They were classified independently. The classification function of an expert $i, i=1,2,3$ is defined as:

$f_i(z) = 1\,(-1)$ if z is classified as "ready" ("in stock"). To classify an area k as 'ready to exploitation' or 'in stock', it is possible to apply the majority criteria; the classification function is then defined as:

$$C(z) = sign(f_1 + f_2 + f_3)(z)$$

Here sign denotes the function sign and $C(z) = 1(-1)$ means that the area z is ready (in stock) for being exploited.

In the above criteria, the classification of each area is determined by the experts' opinion on the area in question. None information on the similarity of the experts judgments has been taken in account, however, such information could be important for the classification.

In our study, we have compared the pairs of judges A=(1,2), B=(1,3), C=(2,3). See the results in table 4.2. They established that the judges 1 an 2 are more coincident in their classification than other considered groups. As their expertise was similar it is worthy considering if the third expert is better or worse than the other two. This fact was beyond the objectives of our study. We include the group D=(1,2,3). We used a majority rule for computing the inputs in table 4.1 for computing the indexes for D. The coincidences of the three experts provided a and d. The number of cases where two experts considered that areas were “Exploitable Areas” was b and the number of “Areas in stock” c was obtained from the cases where two experts gave this evaluation. Note that J gives the most pessimistic idea on the similarity of the evaluations in all the cases.

INDEX	A	B	C	D
R	0,83	0,80	0,75	0,73
CZ	0,95	0,83	0,78	0,64
J	0,65	0,59	0,58	0,35

Table 4.2. Similarity of the classification of the areas

The managers considered the decision rule

“Use the classification of an area as ‘ready’ (in stock) if experts 1and 2. If it is not the case, the classification given by expert 1 is accepted.”

They justified this rule arguing that the similarity of the judgments of experts 1 and 3 was higher than between 2 and 3..

Note that the above considerations assume that all the experts have the same weight for making the decision. This problem needs of a further studies. Another problem to be analyzed is the modeling the decision procedure considering a group preference function, able to represent the consensus of the individual preferences of the experts following the ideas of the seminal paper of Dyer and Forman (1992).

5. Conclusions

We have presented a methodology for evaluating the harvest of maguey in un-cultivated areas with different characteristics. It was developed within a study of the possible industrialization of the actual artisanal production of mescal in Guerrero. The investigation developed in 2004 provided the data, which has been used to simulate the behavior of the application of the methodology.

The analysis of the areas took place considering the variables measured in the investigation of Maradiaga (2004).

The opinions of three experts in forest management, Analytic Hierarchy Process, Bayes and Regression methods have been used for determining the priorities.

The results suggest that a 4-rounds Delphi procedure allows obtaining consensus in the evaluation of the three variables. We observed that the criteria converge within the methods. These results sustain that the higher priority corresponds to the relative abundance of agave plants, followed by mean age of the plant population.

The similarity indexes of the evaluation of ten plans by the experts sustain the existence of a larger similarity between the judgments of experts 1 and 2.

There are large discrepancies among the judges by considering the production potentialities. The other components seem to be more coincident.

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References

[1] Albatineh, A. N., M. Niewindomska-Bugaj and D. P. Mihailkho: ‘’On similarity indeces and correction for chance agreement’’. J. of Clasif. 23, pp. 301-313, 2006.

[2] Albatineh, A. N. and Niewindomska-Bugaj, M.: Correcting Jaccard and other similarity indeces for chance agreement in cluster analysisis. Adv. Data Anal. And Clasif. 5, pp. 179-200, 2011

[3] Alonso, L., C. N. Bouza and D. Covarrubias: Using product type estimators for evaluating the exploitability of silvester maguey papalote (agave cupreatatrel et berger) with missing observations. To be published by Brazilian J. of Biometry, 2011

[4] Bana e Costa, C. and A.Jean-Claude Vansnick: A critical analysis of the eigenvalue method used to derive priorities in AHP. European Journal of Operational Research 187,pp.1422–1428, 2008

[5] Belton, V., T.Stewart: Multiple Criteria Decision Analysis: An Integrated Approach. Kluwer Academic Publishers,Dordrecht, 2002

[6] Dyer R.F., E. H. Forman Group: Decision Support with the Analytic Hierarchy Process. Decision Support System, 8, 2; pp. 99-124. 1992

[7] Forman, E., Gass, S.I.,. The analytic hierarchy process: An exposition. Operations Research 49 (4), pp. 469–486, 2001

[8] Golden, B., Wasil, E.A.,. Celebrating 25 years of AHP based decision making. Computers and Operations Research 30 (10), pp. 1419–1497, 2003

[9] Kangas, J., J.M. Alho: Analyzing uncertainties in experts’ opinions of forest science plan performance. Forest Sc. 43, pp. 521-528, 1997

[10] Kangas, J., J.M. Alho, O. Koehmainen and A. Mononen: Analyzing consistency of experts` judgments-case of assessing forest biodiversity. Forest Sc. 44, 4, pp. 610-617. 1998

[11] Kangas, J., R. Store, P. Leskinenen and L. Mehtätalo: Improving the quality of lands ca ecological forestplanning by utilizing advanced decision-support tools. Forest Ecology and Management, 132, pp. 157-171. 2000

[12] Maradiaga C. F. S. :Desarrollo de un Sistema de Inventario y Monitoreo de Maguey Papalote (Agave cupreata Trel. & Berger) en el estado de Guerrero. Fundación PRODUCE Guerrero A.C., Programa de Recursos Biológicos Colectivos (CONABIO) e Instituto de Investigación Científica Área Ciencias Naturales de la UAGro. Chilpancingo, Gro. México., 2004

[13] Saaty, T.L.,. A scaling method for priorities in hierarchical structures. Journal of Mathematical Psychology 15 (3), pp. 234–281. 1977

[14] Saaty, T.L.,. The Analytic Hierarchy Process. McGraw-Hill, New York. 1980

[15] Saaty, T.L.,. Fundamentals of the Analytic Hierarchy Process. RWS Publications, Pittsburgh, Pennsylvannia, 2000

[16] Saaty, T.L.,. Decision-making with the AHP: Why is the principal eigenvector necessary. European Journal of Operational Research 145 (1), pp. 85–91. 2003

[17] Saaty, T.L.,. ''The analytic hierarchy and analytic network processes for the measurement of intangible criteria and for decision-making'', Process: What the AHP is and what it is not. In: Figueira, J., Greco, S., Ehgott, M. (Eds.), Multiple Criteria Decision Analysis: State of the Art Surveys. Springer, New York, pp. 345–407. 2005

[18] Smith J. Q: Bayesian Decision Analysis. Principles and Practice. Cambridge University Press, Cambridge. 2010

[19] Smith, J.E., von Winterfeldt, D.,. Decision analysis in Management Science. Management Science 50 (5), pp. 561–574. 2004

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