Application of a Model for Evaluating the Environmental Sustainability of Cultures in Hill and Mountain Areas The case of berries and fruit chestnuts in Northern Italy

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Abstract

This study proposes to evaluate the environmental sustainability of certain productive processes, which may be of interest for the enhancement, and economic development of specific hill and mountain areas of northern Italy. In order to make a comprehensive appraisal of the impact of the various activities in each geographical context, we adopted a methodology based on AHP multicriteria analysis. In particular, this method was applied to the cultivation of berries and fruit chestnut, also with reference to alternative cultures already consolidated in the areas under investigation.

Keywords: *Model, sustainability, environment, mountain, cultivations, profitability*

Objectives

The research project has the objective of evaluating, for certain hill and mountain areas in northern Italy, some alternative cultures capable of enhancing the rural environment while fully respecting its natural, economic and social characteristics. This choice of subject was prompted by the consideration that the progressive depopulation of hill and mountain areas is profoundly altering the environmental equilibria, leading to the degeneration - and in some cases even to the hydrogeological disarrangement - of those territories. One of the principal reasons for the depopulation of these areas is the inadequacy of available sources of income, which are increasingly curtailed by the growing concentration of economic activities in the plains. Within the ambit of initiatives proposed for the safeguard of marginal areas, those relating to agriculture take on particular significance by virtue of their connatural environmental scope.

For this study, in view of the great variability of situations on the Italian territory, we chose to focus attention on three areas, situated respectively in the provinces of Cuneo, Trento and Bologna, characterised by an agricultural activity that is still largely representative, though with visible signs of declining employment, and a rural environment of high intrinsic value, making it especially suitable for cultural and ecological initiatives aimed at attracting visitors. With regard to the production processes, we chose those, which could best satisfy the aforesaid requirements within each local situation. In particular, they concern: the cultivation of berries (raspberry, blackberry,

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cranberry and currant) and the cultivation of fruit chestnut. This is the starting point of the study, subsequently followed by the application of a multi-criteria model in order to analyse the above-mentioned cultures from the environmental standpoint.

The description of the study is subdivided into three parts:

➲ a description of the evaluation method adopted, indicating the specific characteristics, which make it particularly suitable for this type of analysis. Its individual procedural phases are described, together with the matrices necessary for its implementation;

➲ the second part describes the application of the chosen evaluation method on the identified areas and the respective chosen crops, with a detailed examination of the results;

➲ finally, there are some concluding remarks on the applicability, or lack thereof, of these methods of environmental sustainability analysis, and their flexibility in expressing an appraisal of different crop alternatives within a given area.

The objective of the project is therefore to evaluate both the socio-economic repercussions, which the different cultivations may have on the territories under consideration, and their impact on the natural constituents of each area.

The method

Assessing the impact on the environment in its entirety proves to be an arduous task, due to the difficulty of defining the boundaries of the field of study. Among the many methods available, the one chosen for this project was "qualitative multi-criteria analysis", in which the evaluation is made by aggregating a series of appraisals, measured on appropriate value scales. This type of analysis falls into the category of "non-monetary" methods, which are generally preferred for the analysis of complex systems, in which not all the relevant factors can be appropriately expressed in purely economic terms, as would be required by monetary methods. Moreover, among the various non-monetary methods, multi-criteria[1] evaluations were preferred because they proved more appropriate for the task at hand. In fact, by breaking down the context being investigated into its many constituent attributes, these methods allow for a comprehensive analysis: by adopting appropriate value scales, it is possible to evaluate all the factors – be they economic, physical-chemical, social or cultural – which may impact on the situation.

More specifically, the type of multi-criteria analysis chosen was the AHP technique (Analytic Hierarchy Process), which has frequently been adopted for evaluations concerning the natural environment, as well as for investigations within an urban and territorial context. The results obtained through hierarchical analysis also make it possible to determine the optimal allocation of the available resources, both in terms of social equity and of economic efficiency[2]. In the case in point, this method was chosen chiefly because it offers two important advantages:

- it permits the evaluation and comparison of elements having different qualitative and quantitative[3] characters;
- by breaking down the environment into different levels, it permits a more precise and rational analysis of each level; on completion of the analysis, aggregating the scores obtained for each of the identified parameters yields a more reliable global end result.

The AHP technique consists of three fundamental procedures: "subdivision", "comparative appraisals" and "summary of priorities", which will be identified and examined during the analytical process. For this project, the application of the method was divided into five phases: a) *information; b) construction of the hierarchy; c) attribution of the weights; d) identification of the value scale; e) final comparison.*

a) Information

This phase started with the identification of the most significant geographical areas in which to carry out the study. We then proceeded to collect the necessary data for describing the natural, structural and social characteristics of the areas under investigation, as well as the prevailing cultivations and the methods traditionally employed. This made it possible to identify cultures with comparable characteristics to those of the investigated species, and which might constitute a concrete production alternative. Moreover, in each area under investigation, we also identified productive structures and services where we could contact experts and/or professionals of the sector, capable of expressing reliable and objective opinions, to whom we could submit the evaluation matrices.

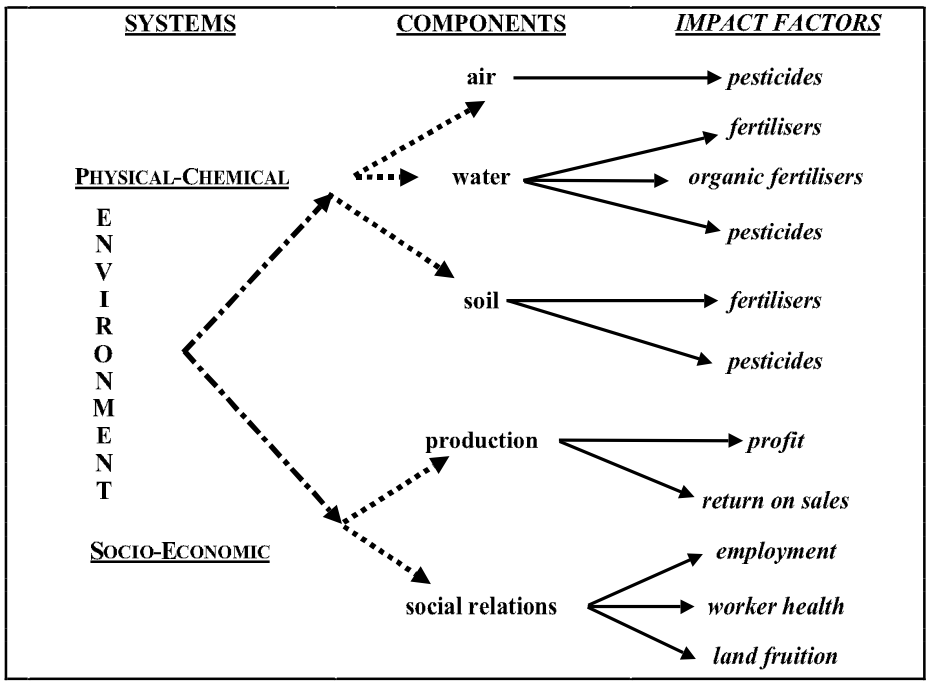
b) Construction of the hierarchy

In this project, the term "environment" is taken to encompass the set of factors which characterise a given production area, from both the economic-productive and agronomic-climatic standpoints, as well as all the relevant social factors. We therefore began with the determination of the levels into which the environment can be subdivided, and the constituent elements of each level. In particular, we identified three levels of parameters, pertaining to two principal systems:

- chemical-physical system
- socio-economic system (Tab. 1);

each of these was in turn subdivided into two further levels of parameters.

Table 1 - Hierarchical resolution of the environment



Source: Department of Agricultural Economics and Engineering, University of Bologna, Italy.

The chemical-physical system groups together those natural elements, which are affected by the production processes: air, water and the soil. The factors pertinent to agri-

cultural activity taken into consideration, which exert a positive or negative impact as the case may be, are organic fertilisers, mineral fertilisers and pesticides[4]. Through evaluation of these substances we determined the different nutrient and plant-protection requirements of the proposed alternative cultures, and hence the different contaminant load entailed by each culture during its productive cycle. The impact of these factors on the three constituent elements of the physical-chemical system was measured in terms of product weight distributed per hectare, with the baseline assumptions that a zero application rate of such substances has zero impact - i.e. does not alter the environment in any way - and that the effects on air, water and soil increase proportionally with the application rate of fertilisers and pesticides, according to a scale developed in conjunction with expert agronomists and plant-disease specialists.

The socio-economic system comprises elements associated with the profits obtainable from a culture and its return on sales, as well as elements relating to its social function, such as the ability to create employment, safeguard the health of workers and provide satisfactory "land fruition". This last-mentioned term describes the extent to which a species can adapt to the countryside context in which it is cultivated, thereby constituting an attraction for tourists and a recreational asset for people in general.

The annual profits of the various cultures, expressed in Euro and Italian lire per hectare, were calculated as the difference between revenues and costs[5]. The measure of return on sales was instead calculated as the ratio of profits to the value of product sold, and the corresponding indicator was expressed in percentage terms. The employment parameter was measured as the hours of work/hectare/year of manpower necessary to cultivate the different species under investigation. In connection with the health of workers, the hazardousness of the different plant protection products effectively distributed on the field was evaluated on the basis of existing toxicity classes[6]. The level of land fruition potentially offered by each of the investigated cultures was evaluated by consulting local experts in the sector. The resulting index was expressed in qualitative terms, it proving rather difficult to use a numerical measure.

After breaking down the global environmental context into the various constituent elements identified (thus concluding the first fundamental phase of the method, i.e. the "subdivision"), we proceeded to construct the evaluation matrices, used for implementing the appraisals of the persons interviewed, and for their subsequent comparison ("comparative appraisals" phase). These are square matrices, which contain the same elements, in the same order, along both rows and columns. The matrices contain the impact appraisal scores concerning each class of parameters, for each level, and in relation to the higher level element.

c) Attribution of weights

The weight assigned to each of the parameters identified in each hierarchical level indicates the relative importance attributed to that parameter in the overall environmental assessment. These weights were determined through consultation with local experts of the sector, for each of the three investigated localities. The appraisals were inserted into the above mentioned matrices, attributing them a value based on the "pairwise comparison" method, and translating them into numerical values using the Saaty Scale, which is the one most commonly used for such cases. Next, in order to determine what weight to attribute to each impact factor ("summary of priorities" phase of the project), the matrices were resolved to obtain a weight index for each parameter. This index was calculated as the normalised geometric mean of the appraisals attributed to the parameter itself, in relation to the weight attributed to the higher-level element in the hierarchy.

The weight index for each parameter, is therefore given by:

$$\overline{XgP_i}norm = \frac{\overline{XgP_i}}{\sum_{i=1}^{n} \overline{XgP_i}}$$

where

XgP_inorm = normalised geometric mean, ranging from 0 to 1, giving the weight of the impact factor in relation with the higher level element

$Xg(Pi)$ = geometric mean for each i parameter, along the row

$\Sigma Xg(Pi)$= sum of the geometric means of all the i parameters in the level.

After obtaining this value for each impact factor, it is multiplied with the weight obtained for the higher-level element in the hierarchy, in order to obtain the final weight of the impact factor. Before proceeding with the final calculation, we checked for the absence of "perversity" or "consistency" errors above an established threshold (10%), by running an internal consistency test on each pairwise comparison matrix; and for all matrices the outcome was negative[7].

d) Determination of the value scale

For each of the identified parameters, a value scale was devised in which, depending on the "impact intensity" of that element in each culture, it is assigned a sustainability score. The scale consists of five score classes, starting from a minimum value of 0.2 up to a maximum of 1 (Tab. 2).

Table 2- Merit scale used in the study

Physical-Chemical Elements				
MERIT SCALE		USES		
Appraisal	Score	Organic fertilisers q/ha/year	Fertilisers fertiliser q/ha/year	Pesticides Kg/ha/year
insignificant	0.2	> 150	> 20	> 100
low	0.4	76-150	11-20	51-100
average	0.6	26-75	6-10	11-50
medium-high	0.8	< 25	< 5	< 10
high	1.0	0	0	0

Socio-Economic Elements							
MERIT SCALE		Profit Levels		Return on sales	Employ ment	Worker health	Land fruition
Appraisal	Score	000 Lit/ha/year	Euro/ha/ year	%	hours/ ha/year	risk co= efficient	expert assess- ment
insignificant	0.2	0; <0	0; <0	0; <0	0-10	4-5	insignificant
low	0.4	0-500	0-256	<1	11-50	3	low
average	0.6	501-1.000	257-513	1-2,5	51-200	2	average
medium-high	0.8	1-3.000	514-1.539	2,5-5	201-800	1	medium-high
high	1	>3.000	>1.540	>5	>801	0	high

Source: Department of Agricultural Economics and Engineering, University of Bologna, Italy.

e) Final comparison

The product obtained by multiplying the value score of each parameter by the weight attributed to that parameter from the pairwise comparisons for each culture is compared with the corresponding value obtained for the same parameter in the alternative culture. By making this comparison for all the elements of the hierarchy, it was possible to determine to what extent the studied cultures could offer improved results over the alternative reference cultures. Moreover, we can hypothesise that the situation delineated by the weights obtained from the matrices is the optimal one for each investigated area, thereby making it possible, by comparing the scores obtained for the studied species, to highlight for which characteristics and to what extent these species fall short of the ideal result.

Cases analysed

A total of three areas were studied, two involving the cultivation of berries (in Cuneo Province in Piedmont region, and Trento Province in Trentino-Alto Adige region) and the third involving the cultivation of fruit chestnut (in Bologna Province in Emilia-Romagna region). The term "berries" denotes a group of different species including: raspberry, blackberry, cranberry, currant, strawberry and gooseberry. The study considered only the first four of these species, which are the most important ones.

The above localities were chosen chiefly because they are mountain regions, threatened with depopulation due to the absence of alternative productions and employment opportunities. In addition, these areas are extremely sensitive to the environmental impact entailed by certain cultivation methods. This is also one of the specific reasons for choosing the above mentioned species: both chestnuts and berries can in fact be produced using integrated and/or organic farming methods, as the case may be, thereby assuring higher quality for the end consumer and augmenting their attractiveness on the marketplace. In addition, these crops are bound up with the agricultural traditions of the areas under study, with strong ties to the surrounding territory and the lifestyle, including eating habits, of the population.

The choice of these types of areas and forms of cultivations thus fits into the broader context of the European Union guidelines, as indicated by the most recent community policies: preservation of disadvantaged areas (mountain regions first and foremost) and productions with low environmental impact.

Berries in the Cuneo area

Characteristics of the territory and cultures

The study was conducted in the southeastern part of Cuneo Province, near the municipalities of Boves and Peveragno, at the foot of the high Pesio valley. Nearly half of the territory examined was mountainous, while plain and hilly terrain accounted for the remainder. Despite the often unsuitable orographic conditions, the agricultural sector was found to be of enormous importance, with the value of its output contributing a substantial share to the total for the province. Dairy farming is one of the principal activities, along with specialised fruit growing. In surface terms, on the other hand, a large number of hectares are occupied by pastures and permanent meadows, which are particularly suited to mountainous areas. Finally, there are also large expanses devoted to chestnut growing.

Analysis of the data of the last general agricultural census (1990) reveals a continuing drop in the number of farms and land areas devoted to agriculture, especially in mountainous areas. The most common farm structure in the territory under investigation is the small leaseholder farm (74.3% have a UAS of less than 5 ha), in which the farmer is helped exclusively or prevalently by family members. The cultivation of berries in

hill and mountain areas is a well-established tradition here. However, over the past few years there has been a certain falling off, primarily due to competition from Eastern European products. Among the cultures, raspberry is losing ground to the giant American blueberry, for which investments are on the rise. In 1996 the berry growing area exceeded 100 hectares, of which about half were devoted to blueberries. The sector appears to be evolving in this region: farmers are seizing the interesting opportunities offered by these cultures, and the fair receptivity encountered on the marketplace.

The results

On the basis of the elements collected during the study - detailed concisely in Exhibit 1 - it was possible to calculate the weighted scores and proceed to compare the different activities. Analysis of the data reveals that, in the Cuneo area, the cultivation of berries is characterised by limited use of mineral fertilisers and pesticides, and therefore has a lower polluting impact on the surrounding environment. Separating the socio-economic system, we can make two observations: firstly that the performance from the purely economic standpoint is not entirely satisfactory, mainly due to the high production costs which principally results from the intensive manpower requirements. However, this factor takes on a positive connotation from the social point of view: in fact, these cultivations create employment and help consolidate the strong ties with the surrounding territory and the traditions of the local population. The overall weighted score was found to be 56.87, of which more than half (32,27) is attributable to the socio-economic system (Tab. 3).

Table 3 - Cuneo: weighted scores for berries and for the reference product (apples)

	Weigh		Weights	Berries		Apples	
				points	weighted score	points	weighted score
air	**2.5165**	pesticides	**2.5165**	0.6	**1.5099**	0.2	**0.5033**
		fertilisers	**14.747**	0.8	**11.7976**	0.8	**1.2676**
water	**22.718**	organic fertiliser	**1.633**	0.6	**3.8028**	0.2	**0.6532**
		pesticides	**6.338**	0.4	**0.6532**	0.4	**0.6532**
soil	**9.765**	fertilisers	**4.8825**	0.8	**3.906**	0.8	**3.906**
		pesticides	**4.8825**	0.6	**2.9295**	0.2	**0.9765**
Total Physi-cal-Chemical	**35.00**		**35.00**		**24.599**		**19.1042**
production	**22.75**	profit	**14.75**	0.2	**2.95**	0.4	**5.9**
		return on sales	**8.00**	0.2	**1.6**	0.6	**4.8**
		employment	**11.788**	1	**11.788**	0.8	**9.4304**
social relations	**42.25**	worker health	**27.424**	0.6	**16.4544**	0.4	**10.9696**
		land fruition	**3.038**	0.8	**2.4304**	0.4	**1.2152**
Total Socio-Economic	**65.00**		**65.00**		**32.2728**		**26.4152**
TOTAL	**100.00**	**100.00**	**100.00**		**56.8718**		**45.5194**

Source: Department of Agricultural Economics and Engineering, University of Bologna, Italy.

Berries in Trento Province

Characteristics of the territory and cultures

The territory examined by the study was Alta Valsugana. This area comprises some twenty municipalities, although the area most active in the cultivation of berries is Valle dei Mocheni, and more specifically the localities of Sant'Orsola and Pergine. Due to the mountainous nature of the territory, the usable agricultural surface is somewhat limited, and accounts for only 33% of the total area; finally, there is a very large surface covered by forests. The principal types of cultures are permanent meadows and pastures, for the purposes of livestock farming which is quite widespread. Fruit growing also plays an important role, particularly apple growing. In terms of gross saleable product, apple growing accounts for more than 69% of the province's output (1994 data); berries, on the other hand, account for just 3%, though equivalent to almost 14 billion lira. The majority of farms are of small size, often less than 1 hectare, and fragmented into several plots. In general, they are family-run farms. In the area under investigation, berries are grown at altitudes ranging from 400 to 1200 metres, and hence under widely diverse climatic conditions. In 1996 the area devoted to berries was over one hundred hectares, half of which accounted for by raspberries. Other important species are currants and blackberries. The most common varieties of currants are redcurrants, while the production of blackcurrant varieties is quite low[8]. The diffusion of these species in Trentino Region has been promoted by means of public subsidies, and through comprehensive technical assistance provided by Ente per lo Sviluppo dell'Agricoltura Trentina (the Trento Institute for the Agricultural Development). Another important factor promoting their diffusion has been the links established with restaurants, hotels and other local establishments, where the berries are served and made known to a wide clientele. This also reinforces, in the consumer's mind, the association between these products and the mountain environment where they are grown and where they have been consumed.

The results

The cultivation of berries in the Trento area is characterised first and foremost by its positive economic performance, achieving considerable profits and a satisfactory return on sales (Exhibit 1). Despite the high production costs, the prices commanded on the marketplace have made it possible to satisfactorily remunerate the farmers. In consequence, the score obtained for return on sales is also much higher than that of the alternative crop, i.e. apples (weighted score of 4.00 for berries and of 1.00 for apples, which have also registered operating losses in certain years) (Tab. 4). Furthermore, these are highly manpower-intensive cultures with good potential for creating employment in activities with a low worker health risk factor.

The total score was approximately 53.85 for berries and, according to the above data, with the highest scores for socio-economic factors, particularly in relation to profit (25.00 against 5.00 for apples) and employment (19.47 for berries against 15.58 for the alternative crop). It should be noted that, from a purely agronomic standpoint, apples scored slightly more favourably than berries overall (23.69 against 23.63).

Table 4 - Trento: weighted scores for berries and the reference activity (apples)

	Weights		Weights	Berries		Apples	
				points	weighted score	points	weighted score
air	**2.876**	pesticides	**2.876**	0.6	**1.7256**	0.2	**0.5752**
water	**25.964**	fertilisers	**16.853**	0.6	**10.1118**	0.8	**13.4824**
		organic fertiliser	**7.244**	0.6	**4.3464**	0.2	**1.4488**
		pesticides	**1.867**	0.4	**0.7468**	0.2	**0.3734**
soil	**11.16**	fertilisers	**9.29962**	0.6	**5.57977**	0.8	**7.4397**
		pesticides	**1.86037**	0.6	**1.11622**	0.2	**0.37207**
Total Physi-cal-Chemical	**40.00**		**40.00**		**23.6266**		**23.6916**
production	**30.00**	profit	**25.00**	1	**25.00**	0.2	**5.00**
		return on sales	**5.00**	0.8	**4.00**	0.2	**1.00**
social rela-tions	**30.00**	employment	**19.473**	1	**19.473**	0.8	**15.5784**
		worker health	**8.37**	0.6	**5.022**	0.4	**3.348**
		land fruition	**2.157**	0.8	**1.7256**	0.6	**1.2942**
Total Socio-Economic	**60.00**		**60.00**		**30.2206**		**21.2206**
TOTAL	**100.00**		**100.00**		**53.8472**		**44.9122**

Source: Department of Agricultural Economics and Engineering, University of Bologna, Italy.

The Castel del Rio Chestnut

Characteristics of the territory and cultures

The chestnut growing area of Castel del Rio, today formally defined by the agricu l-tural-production regulations, corresponds to the part of Bologna Province which extends along the Santerno River valley. The area, of approximately 9,500 hectares, comprises the municipalities of Castel del Rio, Fontanelice and part of the neighbouring munic i-palities of Borgo Tossignano and Casalfiumanese. The agriculture of this area is strongly influenced by its physical characteristics, particularly by the steeply sloping terrain. For this reason, the principal cultivations (cereal and forage) are situated in the valleys or in the less steep mountains slopes. In general, these last-mentioned areas are covered by forests (mixed coppice). According to local data, the chestnut woods occupy approximately 550 hectares, many of which lie in the Castel del Rio municipality (about 75%). In this area, chestnut growing has played an important role in the past, both in environmental terms by helping to reduce erosion and hydrogeological disarrangement phenomena on the slopes, as well as in economic terms by offering farmers a reliable source of income. The chestnut growing area is strongly fragmented among a large number of owners (about 200), prevalently small farmers. The holdings of each farm are therefore modest (about 3 hectares), making it possible for the workload - which is particularly heavy during the harvest time - to be handled entirely by the farmer and his

family. The farm structure is often divided into several plots, which can be quite distant from each other and from the farm centre.

The most commonly cultivated variety is "Castel del Rio chestnut", known locally as the "domestic chestnut", which accounts for 98% of the total production. The product has an average size of around 70-80 fruits per kilogram. This is a high quality product, whose organoleptic characteristics make it well suited both to the needs of the fresh market and to those of the food processing industry.

The results

From the elements set out in Exhibit 1, and compared with the alternative culture (timber chestnut), which is equally valid from the environmental standpoint, the fruit chestnut produced better results in terms of the employment and land fruition aspects. In fact, both cultivations are characterised by a complete absence of chemical inputs (be they mineral or organic fertilizers, or pesticides). On the other hand, from the social point of view there are some significant differences: fruit chestnut creates more employment than the alternative, timber chestnut, and this factor is particularly important due to the meagre employment opportunities in the area. In addition, the cultivation of fruit chestnut is closely bound up with the agronomic and gastronomic traditions of the region and, according to the experts, constitutes an important attraction for tourists. In consequence, the final score was 64.40 for fruit chestnut, with a considerably advantage (+18.20) over the alternative culture for what concerns the socio-economic evaluation (Tab. 5).

Table 5 - Castel del Rio: weighted scores for fruit chestnut and the reference activity (timber chestnut)

	Weights		Weights	Fruit Chestnut		Timber Chestnut	
				points	weighted score	points	weighted score
air	**5.00**	pesticides	**5.00**	1	**5.00**	1	**5.00**
		fertilisers	**8.00**	1	**8.00**	1	**8.00**
water	**10.00**	organic fertiliser	**2.00**	1	**2.00**	1	**2.00**
		pesticides	-	1	-	1	-
soil	**15.00**	fertilisers	**13.00**	1	**13.00**	1	**13.00**
		pesticides	**2.00**	1	**2.00**	1	**2.00**
Total Physical-Chemical	**30.00**		**30.00**		**30.00**		**30.00**
production	**35.00**	profit	**30.00**	0.4	**12.00**	0.4	**12.00**
		return on sales	**5.00**	0.8	**4.00**	1	**5.00**
		employment	**23.00**	0.8	**18.40**	0.2	**4.60**
social relations	**35.00**	worker health	**3.00**	1	**3.00**	1	**3.00**
		land fruition	**9.00**	1	**9.00**	0.4	**3.60**
Total Socio-Economic	**70.00**		**70.00**		**34.40**		**16.20**
TOTAL	**100.00**		**100.00**		**64.40**		**46.20**

Source: Department of Agricultural Economics and Engineering, University of Bologna, Italy.

Conclusions

At the close of the study, certain considerations can be made concerning the chosen appraisal method and the overall results obtained. The procedure adopted provided suitable for attaining the objectives of the project, and we believe that it can also be readily used to evaluate the degree of adaptability, within specific territorial contexts, of cultures with strong environmental connotations. In addition to underscoring the extent to which a given culture is adapted to an area, it also allows for comparisons between alternative productions, taking into account a set of distinct impact factors. Considering that the current agricultural policy of the European Union places great emphasis on agro-environmental initiatives aimed at the safeguard and revitalization of marginal areas, particularly mountain regions, we believe that this type of evaluation methodology will prove especially useful and appropriate.

In the cases examined, it was possible to investigate the adaptability and ties of the productions considered in the three specified areas, as well as comparing them with suitable alternative cultures: both the berries and chestnuts, albeit without attaining the optimal result (equal to 100), were found to satisfy the physio-chemical and socio-economic requirements set out by the local experts in each area, and to do so better than the possible alternative cultures. Furthermore, by breaking down the overall result obtained from the weighted scores for each culture, the method makes it possible to identify for which elements a species exceeds or falls short of the other, and which score it is capable of achieving with respect to the optimal score. Therefore, this type of analysis also constitutes a useful tool for farmers, by enabling them to correct those elements for which a culture has done poorly in order to increase its performance, or to directly opt for an alternative species. The positive results obtained through multi-criteria analysis have been further validated by subsequent observations of the areas in question. In particular, in ValSugana the cultivation of berries has in effect stemmed the migration of the agricultural population, thereby laying the foundations for a more organic rural development, in which there is space for various other collateral activities, such as restaurants, farm holidays or marking out amateur hiking trails. A similar effect was also observed in the production area in Cuneo Province, where the cultures in question have helped support valid commercial activities connected with agriculture, as well as prompting various local associations to devise interesting gastronomic itineraries and nature trails. In the third area examined, the chestnut growing activity has stimulated a number of cultural initiatives, chiefly associated with country feasts and fairs, which attract a considerable number of visitors, thus enhancing the territory from the point of view of tourism.

Notes

[1] Other non-monetary evaluation methods are Planning Balance Sheet, Input-Output Analysis, etc.

[2] Grillenzoni M., Grittani G. (1994) "Estimo: teoria, procedure di valutazione e casi applicativi", Calderini, Bologna.

[3] In fact the data available during these evaluation processes are often of differing character and difficult to compare.

[4] This category includes herbicides and parasiticides.

[5] Production costs include inputs, energy costs (including fuel, lube and electricity for farm machinery and equipment), hiring services, labour, insurance on product, common costs (including maintenance and insurance of real estate; maintenance and insurance of farm machines; taxes and administration), financial charges, amortisations, net land rent.

[6] The classification of plant protection products is based on Presidential Decree 223/88, which adopts the EEC directives relating to the classification, packaging and labelling of "hazardous products" (excluding plant protection products belonging to hazard classes III and IV).

[7] In order to calculate the consistency index it was necessary to identify a coefficient K, defined as the "eigenvalue" of the matrix. For each factor in the matrix, it is given by the sum of the products of the normalised geometric mean for the value of each intersection of the matrix column:
$KP_1 = XgP_1norm * P_1P_1 + XgP_1norm * P_1P_2 + XgP_1norm * P_1P_3 + XgP_1norm * P_1P_4 + XgP_1norm * P_1P_n$

[8] This culture also performed well when marketed after a brief period of refrigerated storage. This fact has proved to be very important, because it allows sale of the product to be protracted into the Christmas season, when demand is greater and prices are higher.

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