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AGRICULTURAL UNIVERSITY OF SZCZECIN
FACULTY OF ECONOMICS AND ORGANIZATION OF FOOD ECONOMY

MODELLING OF ECONOMY IN SPECIALLY PROTECTED REGIONS

Proceedings of the international conference held on 9-11 june 1994 in Drawno, Poland

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AN INPUT/OUTPUT AND MULTILEVEL APPROACH TO PLANNING FOREST RESOURCE AND PROTECTED AREAS IN ITALY[1]

Iacopo Bernetti, Leonardo Casini, Augusto Marinelli

University of Florence

1. Introduction

This work illustrates the initial results of research currently being carried out at the Agruculture and Forestry Economic Assessment Department at the University of Florence. The aim of the research is the construction of a set of econometric models for the forestry and environmental sector. The premises of this project are found in the European Union's new course of economic policy towards the achievement of a sustained development. In other words, not an economic development no beter qualified or identifiable as a mere increase in gross domestic product, but rather, and quoting the program of the European Union itself, "in favour of the environment and of sustainable development", a development that is "genuine only if it improves the quality of life" or more precisely, and according to the Burtland

[1]Research financed by C.N.R.

Commission, a development that guarantees the quality of life and the continued access to the natural resources, and avoids permanent damage to the environment. The project has involved the construction of two closely complementary models. The first is descriptive and based on the extension of the national input/output matrix. The second, prescriptive in character, is a model of multilevel planning for evaluating the efficiency in the forestry and environmental sector.

2. The descriptive model: extension of the input/output matrix

The aim of extending the national input/output matrix is to make clear the linkages between the forest-environment system and the Italian economy. To this end, work has been carried out using the 44 branches national matrix. The extension of the matrix concerned the following sectors:

- forest-wood products sectors;
- parks and forest recreation sector;
- agritourism sector.

At present, the extension relating to the forest-wood products and parks and outdoor recreation sectors has been affected.

The information necessary for disaggregating the forest-wood products sectors was obtained by means of a special sample survey. The approach used was a stratified type sampling (by size of company, based on number of employees) in an number of representative regions in various Italian geographical areas. The sectors analysed were the following:

- timber harvesting;
- saw-mills;

- industries manufacturing semi-finished wood products;
- wholesale timber trade;
- industrial producing wooden packaging;
- wood furniture factories.

The elementary unit of observation was the single enterprise and information was obtained by means of direct interviews, presenting each firm with a specific questionnaire. The sample data permitted the calculation of technical coefficients and the structure of flows at market prices of the various sectors. By means of these two elements it was possible to determine the new columns of the matrix. Finally, the corresponding rows were established on the basis of information present in the questionnaires relating to the destination of output in each sector.

In the case of the "parks and outdoor recreation" sector two kinds of survey were used, the first relating to the determination of "productive technologies" in the protected areas, the second with the aim of identifying the consumptions relating to outdoor recreational activities.

In the case of the first survey, the minimum unit sampled was the nature reserve. The stratification of the sample was applied to the topology of the various areas, classified thus:
- national parks;
- regional parks;
- nature reserves.

The survey was carried out by means of the acquisition of the balance sheets of administrative units. The various items were attributed to the appropriate branches of the matrix, and through transferring the results to the universe, it was possible to construct the corresponding technical coefficient. Integrating these data with the available statistical information on public spending earmarked for reserves and protected areas, it was possible to determine the structure of the flows at production cost of the sector.

An assessment of added value of the sector deserves further mention. To this end, in addition to the "traditional"evaluation on the basis of cost, a new row (complementary) was added to the matrix, relating to the assessment of the value of social benefit provided by parks and nature reserves *(CUMBERLAND, 1966)*. This assessment was obtained by evaluating the number of visit "produced" by the various types of protected area by way of a specific shadow price, obtained on the basis of the case histories of studies carried out in Italy.

As previously mentioned, the second survey aimed to determine the vector of net final demand activated by the parks. In this instance too, work proceeded by means of direct surveys on a sample of protected area falling within the three typologies previously indicated. The specific aims of the investigation was to assess the importance of the sector in the national economy, as well as to determine the impulse exerted by protected areas on the local economy of the territory containing the park.

On the basis of technical coefficient and flows matrices, activation coefficients and Keynesian-Leontievian multipliers were calculated. The information obtainable by means of this elaboration differs according to the sector under analysis. In general, the wood products sectors, as far as the structure of the productive process and the destination of products are concerned, show considerable capacities of activation towards other sectors, whereas, from the point of view of activation received, they appear sensitive almost exclusively to productive increases registered within the sectors themselves.

As regards the park and outdoor recreation sector, the matrix of activation coefficients provides complementary results by examining the new column of parks and the column of final consumptions in outdoor recreation activites. In fact, as far as parks considered as a new sector are concerned, we can obtain information regarding the activation generated directly on the economic system by public spending. Through the vector of expenditure in final consumption, on the other hand, it is possible to verify the long-run effects generated on the national economy by visitor's spending.

The extended input/output matrix constitutes a flexible methodological instrument capable of adapting itself to the concrete demands of the people operating in the sector and of the public institutions working in the field of the economy and research. The simulations that may be effected are the following:
- effects of variation in final demand;
- effects of change in productive technologies;
- effects of the change in the system of prices.

The national descriptive model, from both the methodological as well as the applicative point of view, is closely linked to the prescriptive model that will shortly be illustrated. Indeed many of the elements in the model of the analysis of public spending efficiency derive from the use of the input/output methodologies, even though disaggregated at a regional or local level. Moreover, the results attainable with the prescriptive model will constitute the basis for the construction of simulation scenarios of the extended input/output matrix.

3. The prescriptive model

3.1. Structure of the model

Government action intended for the sustainable development of mountain areas may be directed towards a diversified set of integrated activities. From the point of view of the analysis, the problem can be treated as an evaluation of a set of investments that compete for the use of the capital resource (budget of public spending earmarked for the projects). The problem can be formalized by means of a model of multilevel programming *(HOF and PICKENS, 1987; HOF and BALTIC, 1991, 1992)*. This works with a lower level composed of a set of regional models (one for each Italian region, making up a total of 20 models,), which meet at a higher level represented by a national model.

There are many advantages to this system. First, with this approach it is possible to perform the analysis by using various theoretical principles, such at the CostBenefit Analysis, the Cost-Effectiveness Analysis (after establishing the desired result, choose the planning alternative that minimizes the cost), The Cost-Efficiency Analysis (departing from a given cost, choose the planning alternative that maximizes the result), the Multiple Criteria Analysis and the Social Welfare Functions. Moreover, the formalization of the analysis in a model facilitates the integration of information from other disciplines. Indeed, the approach adopted has allowed us to integrate econometric, ecological and hydrological models. A further advantage of a mathematical formalization of the problem is the remarkable detail (and therefore adherence to reality) with which the various projects can be represented. Finally, a multilevel model is consistent with the administrative decentralisation that characterizes government action in the forestry and environmental sector in Italy. This, in fact, is carried on operatively through regional plans that are decided upon and financed at national level. The model proposed, at national level, works by choosing between various alternatives of regional plan. The regional plan alternatives are in turn developed by regional sub-models. Every regional plan alternative can derive from a different public spending budget, from a different objective function, or from a different formulation of environmental oriented constraints (e.g. constraints that place the emphasis on environmental conservation, employment, protection from wild fires, protection of the soil etc.). Figure 1 illustrates the structure of the multilevel model.

The formulation chosen for the model is essentially static and refers to the possiblity of action over a period of 5 years. The effects of the investments are expressed with annual indicators and refer implicitly to an indefinite number of years. The model does not consider explicitly the period of time necessary for the intervention to reach its full effect. The fact of not considering the lapse of time in which the various effects are registered is consistent, under certain conditions, with the principle of intergenerational equity. Indeed, the adoption of an intertemporal rate would involve underestimating the social benefit and cost of future generations compared with present ones.

3.2. The regional model

The construction of the lower level of the multilevel model, in other words, the formulation of the various regional sub-models has been carried out according to the following steps:

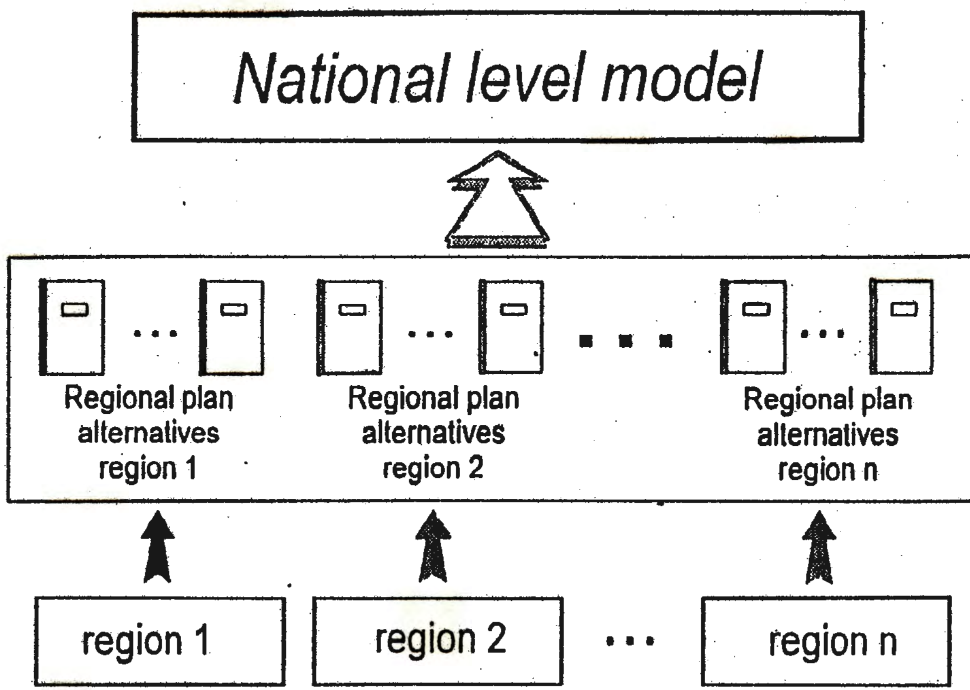
National level model
Regional plan alternatives region 1
Regional plan alternatives region 2
Regional plan alternatives region n
region 1
region 2
region n

Figure 1

1. determination of the various projects of sustained development that may be carried out in mountain and forest areas;
2. individuation of the indicators of sustainable development;
3. evaluation of the indicators by means of specific models;
4. establishment (dimensioning) of the ideal target of the various projects;
5. construction of the mathematical programming model and generation of the regional plan alternatives.

3.2.1. The decision variables

The decision variables of regional level models are the various environmental investment projects. At present, the projects under consideration within the context of a sustained development of forested mountain areas, compatible with the environment are the following:

1. new production-oriented forest planting (hectares);
2. improvement of high coniferous forests (hectares);
3. improvement of high broad-leaved forests (hectares);
4. coppice conversion to high forest (hectares);
5. protective reforestation (hectares);
6. forestry maintenance to protective woods (hectares);
7. defence plans and action against forest fires (various plans with different efficiency);
8. institution of new parks and nature reserves (number of parks).

3.2.2. Objectives of sustainable development

The objectives of sustainable development used in the model can be divided into two large categories: objectives of economic development and environmental objectives.
At present, the following objectives have been considered in the model:

- **economic development**
  - production of timber (max)
  - direct employment (max)
  - induced employment (max)
  - added value, direct and induced, in the agroforestry sector (max)
  - added value, direct and induced, in other sectors of the economy (max)
- **environment**
  - recreation in forest areas (max)
  - naturalistic value of new parks and nature reserves (max)
  - forest area protected from the passage of fire (max)
  - regulation of water flow (max)

3.2.3. Evaluation of the indicators of sustainable development

The next phase in the construction of the models concerned the assessment of the indices of sustainable development by way of specific methodologies.

Increment in the production of industrial wood. The evaluation was carried out on the basis of a technical index established by increase in the average annual growth of industrial wood as a result of the project, calculated by species, by region and by type of project undertaken.

Assessment of added value and employment induced by the increment in wood production (short- and long-run). In Italy the deficit at the level of timber production is equal to more than 18 million cubic metres in terms of round equivalent. One of the objectives of forestry policies aimed at increasing the area of forest destined for wood production is the reduction of this deficit. This involves an activation of the economic system, in terms of added value and employment, which may be assessed through the use of Input/Output matrices appropriately disaggregated for the sectors involved.

Assessment of increment in outdoor recreation in new nature reserves. To this end, the increases in the number of visitors resulting from about thirty existing protected areas have been surveyed by means of direct investigation. In the application of these reference data, corrections have been made according to the type of protected area (national park, regional park, state reserve, etc.) and to the number of inhabitants in the provinces of the park and in neighbouring provinces.

Assessment of added value and employment induced by new nature reserves. Having determined the increase in tourism resulting from the institution of the new parks, it is possible to make an assessment of the effects of activation on the local economy, in terms of added value and employment. Also in this case the evaluation was made using local Input/Output matrices referring to the territory of each park (*MARINELLI, CASINI and ROMANO, 1990; Casini, 1993*). In order to obtain the maximum adherence to the local economic situation, a simplified method was employed in the assessment that follows the framework of *ZHENG and HAROU (1988)*. This method does not require the availability of a complete Input/Output matrices (usually impossible in the case of local economic systems), but only the assessment of the technologies of the sectors most affected by the institution of the park.

Ecological models used for assessing the ecological value of new nature reserves. The evaluation of the environmental quality of the parks and nature reserves has been effected by considering and aggregating various models deriving from applied ecology. The criteria adopted are the following:
- biogeographical chracteristics;
- naturalness and rarity of ecosystems.

As regards the biogeographical criterion, this is based on the model of "species-area" curves. It has been proposed by numerous authors, with some variations, for establishing principles in the desing of protected areas in such a way as to maximize the diversity of species and the stability of ecosystems. The model adopted is that of *DIAMOND (1975)*, and is based on a series of mostly hierarchical relationships. In addition to geographical planning criteria, also proposed at an international level *(e.g. World Conservation Strategy, IUNC, 1980)*, indices of naturalistic and conservation value have been considered in the assessment. The criteria adopted are based on the following factors:

- **naturalistic value:**
  - spontaneity of the development of phytocenosis
  - intensity of anthropic intervention
  - richness of flora

  - degree of evolution of the ecosystem
  - spontaneity of flora

- **scientific-conservation value:**
  - presence of endemic species or biogeographical value
  - degree of species diffusion
  - rarity of plant types
  - endemicity of plant association
  - presence threatened with extinction.

Assessment of the expected reduction of average annual surface area destroyed by fire. The index of effectiveness of fire prevention is therefore given by that surface area in which specific forestry interventions and infrastructures are introduced in such a way as to arrive at an intensity of fire that does not cause serious damage to the wood *(BOVIO, 1992)*.

Assessment of runoff volume on hillslope. The method used, that of the "Soil Conservation Service Curve Number Procedure", permits the assessment of runoff volume through an indicator between 1 and 100 (called Curve Number or CN) which is determined according to the characteristics of land use, working techniques, soil structure, texture and permeability.

3.2.4. The dimension of ideal targets.

The next phase in the construction of the model consisted in determining the optimum extent of government action. In synthesis, the following factors were singled out:

- maximum land surface that may be used for new plantations;

– maximum land surface for forest improvement;
– new parks;
– fire prevention project alternatives;
– new protective forests;
– protective forests to be subjected to forest maintenance interventions.

3.2.5. Assessment of the cost of the projects

An evaluation of the cost of the interventions differs according to the bodies which materially undertake them. There are two possibilities: projects carried out directly by public institutions and projects in which the State acts indirectly by financial incentive. In the latter case, in the construction of the model, we have used the form of incentive provided for by REGG: CEE 2078 and 2080.

3.2.6. Construction of the model and method of solution

On the basis of the elements described in the preceding sections, it is now possible to establish the structure of the mathematical programming model at regional level. The model has a mixed integer (binary)-continuous variables formulation.

The continuous variables are:
- hectares of new production-oriented forest plantation by species;
- hectares of improvement of high coniferous forests by species;
- hectares of improvement of high broad-leaved forests by species;
- hectares of coppice conversion to high forest;

- hectares of protective reforestation;
- hectares of foretry maintenance to protective woods;

The integer binary variables are:

- fire management plans;
- new parks and nature reserves.

The technical coefficients of the various objective functions are represented by the indices of sustainable development described in the previous paragraphs and by the cost of the intervention. The structural constraints of the model are of two types. For the continuous variables there are constraints of maximum land surface that can be set aside for the various projects, represented by the ideal targets singled out. In the case of new park areas, on the other hand, the only constraint (for each new park proposed) is a binary one, that is, the integer variable must be equal to 1 or 0 (1 = new park establishment, 0 = no new park establishment). In the case of fire-management plans, the sum of the various binary variables (corresponding to various fire management plans) must be equal to 1, in such a way as to activate only a single plan alternative for each region. A generic structure of the regional model in matrix form is shown in table 1.

Having once established the model it is possible to generate a set of regional plan alternatives that are efficient from the Paretian point of view. As previously mentioned, one of the advantages of the formulation adopted is the possibility of determining the solutions by way of various approaches. Among this we may mention the Cost-Efficiency Analysis, the Cost-Benefit Analysis and the Multiple-Criteria Analysis.

Tab. 1. Regional Level Model

---------------------- 25 - 50 decision variables for each region--------------------------

Decision Variables	Forest improvement				New Parks				Wildfire management projects			Regulation of water flows		MCA	CB	CEA
Objectives	Fi1	...		Fin	Np	...		Npn	P1	...	Pn	R1	...Rn			
Production of Timber	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P1
Recreation in forest	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P2
Naturalistic Value	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P3
Protection from wildfire	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P4
Regulation of water flows	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P5
Employment	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P6
Added value	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P7
Added value in agroforestry sector	x	x	x	x	x	x	x	x	x	x	x	x	x	max	+	>= P8
Costs	x	x	x	x	x	x	x	x	x	x	x	x	x	<= C		min
Constraints															*RHS*	
New plantation surface	1													<=	T1	
Forest improvement surface		...	1											<=	T2	
...				...										<=	T3	
...														<=	T4	
new parks					1									<=	T5	
...						1								<=	T6	
...							1							<=	T7	
Fire management projects									1	1	1			<=	1	
Protective forests												1		<=	T8	
..												..		<=	T9	
..													1	<=	T10	

3.3. The national model

As previously mentioned, the plan alternatives determined by way of the region models come together to form the model at the national level. The importance of the national level model therefore lies in the possibility of studying the possible results attainable through the instruments of forestry policy in a context of sustainable development of the mountain area, with the aim of obtaining the maximum efficiency from public spending.

The structure of the model at the national level is totally in binary variables. In fact, the decisional variables are represented by the plan alternatives for the various regions, as determined at regional level. The objectives of the national model are therefore the same as those at regional level, since each plan alternative is characterized by a vector of levels of achievement obtained in each objective. The structure of the constraints is such that it leads to the choice of a single plan alternative for each region. Formally the structure is the following:

$$\begin{cases} \max \sum_{r=1}^{20} \sum_{k=1}^{K_r} A_1^{k,r} \, X^{k,r} \\ \max \sum_{r=1}^{20} \sum_{k=1}^{K_r} A_j^{k,r} \, X^{k,r} \\ \max \sum_{r=1}^{20} \sum_{k=1}^{K_r} A_8^{k,r} \, X^{k,r} \\ \max \sum_{r=1}^{20} \sum_{k=1}^{K_r} C^{r,k} \, X^{r,k} \end{cases}$$

s.a.

$\sum_{k=1}^{K_r} X^{k,r} = 1$ per $r = 1, ..., 20$

$X^{k,r} = \{0, 1\}$ per $r = 1, ..., 20$ and $k = 1, ..., K_r$

with $r = 1, ..., 20$ r–th region, K_r number of plans in the r–th region, $A_j^{k,r}$ level reached by the j-th objective for the region r and the k–th plan, $X^{r,k}$ binary variable relative to the plan alternative k for the region r and $C^{r,k}$ cost of the plan alternative k for the region r.

Tab. 2. National level model

Decision variables *Objectives*	Region 1 A1,1	 A1,2 ...	Region 2 A2,1	 A2,2 ...	...	Region n An,1	 An,2 ...	MCA	CB	CEA
Production of Timber	x	x	x	x	x ...	x	x	max	+	>= P1
Recreation in forest	x	x	x	x	x ...	x	x	max	+	>= P2
Naturalistic Value	x	x	x	x	x ...	x	x	max	+	>= P3
Protection from wildfire	x	x	x	x	x ...	x	x	max	+	>= P4
Regulation of water flows	x	x	x	x	x ...	x	x	max	+	>= P5
Employment	x	x	x	x	x ...	x	x	max	+	>= P6
Added value	x	x	x	x	x ...	x	x	max	+	>= P7
Added value in agroforestry sector	x	x	x	x	x ...	x	x	max	+	>= P8
Costs	x	x	x	x	x ...	x	x	<= C		min
Constraints								RHS		
Region 1	1	1						=1		
Region 2			1	1				=1		
...	...		...		...	...		...		
Region n						1	1	=1		
Other constraints										
...	x	x	x	x	x	x	x	<=F		
...								...		

The model's methods of solution at national level also follow the methods of Cost-Efficiency Analysis, Cost-Benefit Analysis and Multiple-Criteria Analysis. The problems involved however, are different, since in this case it is necessary to choose a single solution rather than a set of plan alternatives.

In the case of Cost-Efficiency Analysis the problem consists in determining the most satisfactory level of achievement of the various objectives of sustainable development from a social point of view. This is equivalent, on a national scale, to fixing minimum or satisfactory standard parameters. An alternative solution could be the establishment of minimum levels through comparison with the average values of industrialized countries, or those in which a more evolved environmental policy has been put into operation.

In the case of Cost-Benefit Analysis, a correct evaluation made using this procedure must pass through the establishment of a monetary Social Welfare Function. This will be the object of further research.

For the Multiple-Criteria Analysis too, there is the problem of establishing a vector of social weights in order to internalize information of a sociodemographic and geographic nature. The future object of research will be the study of a cardinal Social Utility Function capable of assimilating these elements in the most complete and realistic way possible.

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