Modelling of economic balances appliable to protected area management

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1. Introduction

In 2004 the university of Udine and WWF Italy have started to cooperate in order to develop a model of environmental balance for Miramare Natural Marine Reserve (RNMM).
Environmental balance is included in national economic balances, and in particular in "satellite accounts". These tools allow to compare environmental and economic factors (Cervigni et al., 2005). In particular, according to the EU V Program of Environmental Action, the following are considered: Material flow accounting, Mfa, National accounts matrix including environmental accounts (Namea), Environmental protection expenditure account (Epea), Natural resources accounts. The environmental account for RNMM has been calculated following this approach. RNMM is located in Northern Adriatic and covers 121 ha. The above indicated models are not always appliable however. The first unit is a limit of scale. Then, some models (ep. Namea and Epea) are not appliable to some organizations. Material flow accounting and Natural resources accounts are the only models that can be fully considered. Another limit is related to the difficulty of evaluating physical values of the natural resource. The third limit is related to the fact that these models consider only general incomes and outcomes, but do not quantify the wealth produced by ecosystems.

2. Methods

Keeping in mind the above mentioned limits, a model of environmental account was developed, in order to quantify the resources used and produced by RNMM. The model integrates economic and environmental balances, including in both cases both costs and benefits. The difference between the two gives an estimation of the resources used and produced by RNMM. The model is called matrix of flows between biosphere and technosphere (Fig. 1) (OECD, 2004; UN et al., 2003). This model considers two of the four flows: biosphere-technosphere, to assess environmental benefits and economic gains; technosphere-biosphere, to assess environmental and economic costs. Hence, RNMM environmental account maintains the structure of a natural resource balance and it is articulated in a patrimonial dimension (environmental estate account) and a flow dimension (environmental flow account) (Tabella 1).

3. Results

Miramare Natural Marine Reserve has been managed by WWF Italy since 1986. It is located in the gulf of Trieste and it covers 30 ha of land and 90 ha of sea. The environment is coastal marine with rocky shores. RNMM is very active in the fields of sensibilization and divulgation of conservation topics, research, environmental education, integrated management of protected areas (RNMM, 2004).

A) Environmental estate account

Giving an economic estimation of RNMM structures and natural resources is not an easy task. In particular, the fish estate should be economically assessed, and this is a particularly difficult task. For this reason, the estate was assessed in some cases only from a qualitative perspective. The qualitative aspects are referred to the Initial Environmental Analysis (AAI) carried out during the implementation of EMAS (Zuppa et al., 2004), also indicating the most sensitive species. The quantitative assessment of fish estate were done through visual census data.

B) Environmental flow account

This means that all flows of energy and matter from biosphere to technosphere and back must be quantified. The process requires the creation of input/output matrix (Gustavson et al., 2002; Pnalm, 2003). A cost-benefit analysis must then be applied, where costs are:

• economic,

• environmental (technosphere-biosphere flows),

and the benefits are:

• economic ,

• environmental (biosphere-technosphere flows).

Two conditions must be satisfied:

1. an homogeneous unit of measure for all costs

2. homogeneous costs and benefits for environmental and economic accounts

1) Technosphere-biosphere flows

a) environmental costs

The classification of environmental costs starts from the analysis of Nebbia input-output matrix (1996), that subdivides human activities in technosphere sectors. In a protected area the human activities are the management objectives, which in the case of RNMM are (Zuppa et al., 2004):

A: environmental safeguard and valorization of natural resources,

B: divulgation of knowledge on the marine environment,

C: environmental education,

D: scientific research,

E: promotion of sustainable development,

F: ordinary functioning and extraordinary expenses.

Each of these objectives benefits of a matter and energy flow coming from the biosphere. The flows were determined using the AAI (Zuppa et al., 2004) that, as indicated by Reg. CE n. 761/2001 (Emas 2), has the objective of determining the relevant environmental interactions and of assessing the level of environmental

impacts. The latter are related to:

- *human presence,*
- *use of natural resources and waste production,*
- *use of fuel for transport,*
- *use of fuel for heating,*
- *use of electric energy,*
- *use of water,*
- *expenses of the management body.*

The impacts are expressed in terms of use of energy and matter and of production of waste. The transformation of impacts in costs is based on the consumes indicated in AAI (Zuppa et al., 2004) and on the conversion of energy used in tons of CO_2 produced, and then on the conversion of all these parameters in monetary terms. Then the economic costs are converted in environmental costs, assigning them to the 6 objectives that form the technosphere sector of RNMM.

b) economic costs

The economic costs were calculated from the financial report for 2004, following the Long Term Financial Plan approach (Conservation Finance Alliance, 2002). All costs were reclassified according to the 6 objectives mentioned above

2) Biosphere-technosphere flows

a) environmental benefits

The biosphere is subdivided into natural inorganic components (air, water, soil) and living sector (producers, consumers and scavengers). However, due to the small size of RNMM, the subdivision was done in terms of functions rather than components.

The assessment of ecosystem functions has received increasing attention in recent years (Bishop e Romano, 1998; Costanza et al.,1997a,b; Daily, 1997; de Groot, 1992 e 1994; Daily et al., 2000; Mitchell e Carson, 1989; Pearce, 1993; Turner, 1993). The definition given by de Groot (1992) and Costanza et al. (1997a) of ecosystem functions is related to the ability of natural processes and components to provide products and services that can satisfy human needs, both directly or indirectly.

RNMM marine ecosystem is the continental shelf, for which Costanza et al. (1997a) have indicated the functions shown in table II. The following components are assessed: Nutrient cycling, Biological control, Food production, Recreation, Cultural value. In first approximation, we have not considered Gas regulation and Habitat/refugia as data were missing, and Raw material production as it is very small.

b) economic benefits

They are included as selffinancing.

C) Matrix of input/output relation between biosphere and technosphere of RNMM

The general features indicated in fig 2 were used to create the matrix. The matrix summarizes the model described above, and in particular allows to:

- *assess the economic value of biosphere/tecnosphere flows by:*
  - *assessing the economic value of RNMM functions,*

– *reclassifying management gains;*

- *assess the economic value of tecnosphere/biosphere flows by:*
  – *assessing the economic value of environmental impacts*
  – *reclassifying the costs using the model LTFP.*

In this way three different tools were homogenized by using a monetary unit of measure: AAI, LTFP and environmental account.

4. Analysis

Assessment of environmental and economic benefits of RNMM

The Nutrient cycling function considers the average concentration of nitrogen and phosphorous. The replacement cost are considered, that is the estimation of how much would cost to mechanically remove the nitrogen and phosphorous. In the last 15 years the concentration of these compounds has increased in RNMM indicating that marine ecosystems tend to cumulate the output of productive processes occuring elsewhere. Replacement costs for continental shelf are in the range $ 752–2.110 per ha per year (Costanza et al., 1997b). For RNMM the cost becomes € 773,86/ha/year. Considering RNMM size, its annual contribution to the nutrient cycle is of € 93.636,88. The food production considers fishing activities. Fishermen that work close to RNMM produce ca 630.000 kg of fish per year (Zuppa et al., 2004) (Odorico & Costantini, 2002). Altogether, the function food production can be estimated in € 84.025,50. The total value of the function biological control, mainly related to fish production, is € 25.207,65. Considering the function Habitat/refugia fish monitoring have highlighted the presence of 13 endemic species (out of 116 for the mediterranean) (Castellarin et al., 2001) and of 3 species at limited geographic distribution (Pleuronectidae, Syngnathidae, Blenniidae). RNMM is also an important recruitment area. However, the economic value of this function cannot be calculated at present.

Tourism activities have been subdivided into Recreation and Cultural. Recreation is related to visitor centre, scuba diving and seawatching. The benefit was calculated considering surplus values (values given by the fruitors to the different recreational activities) and prices paid. Surplus is of € 22.250,16 for the visitor centre and between € 6.962,94 and € 15.140,20 for diving. The price is of € 29.849,50 (10.301 fruitors) for the visitor centre; € 19.256,00 (899 fruitors) for scuba diving; € 15.592,50 (1.583 fruitors) for seawatching. The economic expenses for tourism must consider also additional costs: sleeping € 4.065,52; food € 103.299,50; gadgets € 5.180,38. Hence, the direct and indirect wealth produced by RNMM is of € 173.319,91. If we sum up the total benefits (including the surplus) we reach a value of € 267.231,01. The net amount is of € 202.533,01.

The function Cultural includes: scientific and educational. The first one must consider: number of researchers in terms of days/man, budget of projects, scientific institutions with which accordances were signed, research and conference activities. As there are no data an estimation was made following Costanza et al., 1997b, that gives a value per ha per year of € 29,84 for a total of € 3.610, 64. Educational is referred to 2004. 215 schools visited RNMM for a total of 4.300 units. The incomes are of € 30.583,71. Hence the total value of the function Cultural is of € 34.194,35 (Table 3). The total RNMM incomes are of 105.066,99 and the public tranfer is over 735000 euros. The total economic and environmental benefits can thus be calculated at € 1.280.011,97, as shown in Table 3.

Assessment of environmental and economic costs of RNMM

First of all, the impacts caused by human presence are considered. Human presence can be especially related to the production of CO_2, using a method of reasoning similar to that adopted for the calculation of the Ecologi-

cal Footprint (Chambers et al., 2002; Wackernagel e Rees, 1996). Considering the coefficient of CO_2 production of 6,41 t/person/year , the 17.083 RNMM visitors can be translated in 149.887,70 kg of CO_2. The costs for every kg of CO_2 emitted have been estimated in 3,099 cents, thus the total cost of visitors (visitor centre and divers) is of 4.645,02 euros. In addition, 1.255 days/man were devoted to fishery tourism, and this is translated in €682,49 euros of environmental costs. The fuel consumes for 2004 translates in an environmental cost of €215,95. The electric energy environmental cost is of €1,19, water costs are €3,07. All these costs can be mainly related to objective F. Environmental costs are indicated in table IV and subdivided into each management objective.
The 2004 financial account has then been reclassified following the model of Long term financial plan (LTFP) in order to subdivide the costs among management objectives(Table 5) (Marangon e Tempesta, 1998; Marangon and Visintin, 2005). The total environmental and economic costs are of €825.155,98.
The difference from totals of table 3 and of tables 4 and 5 indicates that the net benefit, that is the wealth produced by RNMM, is of 454.855,99 euros per year.

5. Discussion

Taking into account the three limits mentioned in the introduction (scale, physical unit of measure, environmental costs), we suggested the development of an accounting model that considers what RNMM produces, and that can coordinate and summarize different tools: LTFP (reclassification of costs and benefits), AAI (monetary evaluation of environmental costs) and Costanza model on ecosystem evaluation (monetary evaluation of environmental benefits).
The RNMM has a positive environmental account of 455.000 euros. How can this piece of information be interpreted? First of all, it is possible to conclude that RNMM follows the principles of sustainable development. Hence, the management policies accomplish the reserve objectives. In particular, the net benefit (wealth produced) is of €454.855,99. If we consider that public funding is of about 735.000 euros, we can conclude that this is covered for about 62% by the flow of net benefits produced. Further studies are however required for a more detailed assessment of the economic and environmental accounts of a protected area.