An Environmental Accounting Model for a Natural Reserve

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Abstract: The implementation of environmental accounting in a Natural Reserve produced some significant results in terms of restrictions. First of all, environmental accounting introduced a limitation in scale, which was inapplicable on a micro scale. A second restriction concerned the physical unit measure that was used instead of a monetary unit measure. Finally, a third limitation was related to the fact that environmental accounting only takes costs into account, and not environmental benefits. These three limitations led us to develop an environmental accounting model that considered both consumed and produced resources in the Natural Reserve. The model aimed at supplementing monetary accounting (based on cost and revenue) with environmental accounting, which not only reflects environmental cost, but also environmental revenue; i.e. environmental benefit. The difference between costs and benefits, both economic and environmental, assessed the value produced or consumed by the Natural Reserve.

***Keywords*: natural marine reserve, environmental accounting, ecosystem functions, LTFP.**

I. Introduction

Since 2004 the University of Udine (Italy) and the Italian branch of the World Wildlife Fund have worked together to establish an environmental accounting model for the Miramare Natural Marine Reserve (Trieste, Italy) (MNMR). The implementation of environmental accounting has produced some significant results in terms of limitations. First of all, environmental accounting introduced a limitation in scale. The Namea (ISTAT[1]) and Epea (EUROSTAT) models are effective on a macro scale, but are inapplicable on a micro scale. This is the case in natural areas. Natural resource accounting of natural resources overcomes this limitation, but introduces a second restriction: the implementation of a physical unit measure instead of a monetary unit measure. Finally a third limitation regards the accounting of environmental costs, but not environmental benefits. If environmental benefits are ignored, the environmental accounting system will only take the effects of the resources consumed into account, but not the resources produced by ecosystems.

In section II the methodology is outlined and the environmental accounting model is given. In section III there is a brief description of the Miramare Reserve and there is an illustration of how the model was adjusted to the specific case. Section IV provides an analysis of the results and section V concludes.

II. Methodology

The three limitations mentioned above (scale, unit measure and cost but not benefit) led us to develop an environmental accounting model that considered resources both consumed and produced in the MNMR. The model aimed at supplementing monetary accounting (based on cost and revenue) with environmental accounting, which not only reflects environmental cost, but also "environmental revenue"; i.e. environmental benefit. The difference between economic and environmental costs and benefits assessed the value produced or consumed by the MNMR. The model assesses flows between the biosphere and technosphere (Figure 1) [1] and is indicated as a "Natural resources asset account" [2], [3]. The study analysed two of the four flows: the biosphere-technosphere flow, which assessed environmental benefits and economic revenue; and the technosphere-biosphere flow, which assessed environmental and monetary costs.

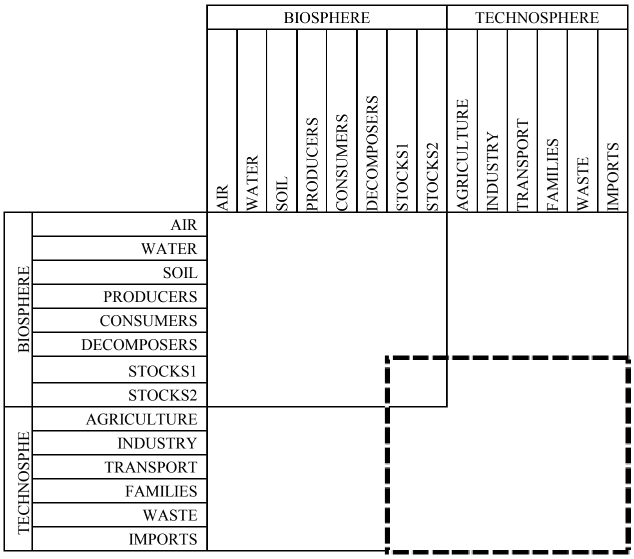

Figure 1: Biosphere – technosphere flow matrix

TABLE I: ENVIRONMENTAL ACCOUNTING MODEL FOR THE MNMR

Asset accounts for the MNMR		
Natural stock account	Natural flow account	
Natural stock: quantity quality	Costs: monetary (park overheads) environmental (environmental costs)	Benefits: monetary (park revenues) environmental (environmental benefits)

We can see that the environmental accounting structure for the MNMR is the same as that of the natural resources asset account, and includes a natural capital dimension (natural stock account) and a flow dimension (natural flow account) (Table I).

III. Results

La A Ministry of Environment decree established the Miramare Natural Marine Reserve in 1986, and its management was assigned to the Italian branch of the

[1] Istituto nazionale di statistica, National Institute of Statistics of Italy.

World Wildlife Fund. The MNMR is located in the Gulf of Trieste, which is situated in the northern part of the Adriatic Sea. The land surface covers 30 ha., while the surrounding sea area is 90 ha. The environment is marine and coastal, and the land is rocky along the coast. Information regarding the MNMR has been disseminated in the surrounding area by means of scientific research, environmental education projects, and local and national media exposure. Moreover, projects have been set up regarding local tourist management and fishing regulation.

A. *Natural stock account*

It is difficult to assess the value of the Reserve's natural capital and its natural resources (water, flora, fauna and soil)., and at this stage of our research we have not yet reached an adequate estimate. To do so would require an accurate census of the fish population. Clearly, in the cases of fish and fauna there is a wide margin for error. Therefore a quantitative and qualitative accounting method has been adopted to measure natural capital. The qualitative aspect is based on the Initial Environmental Analysis (IEA), which was carried out during the implementation stage of the Environmental Management System (EMS) [4]. During the analysis care was taken to indicate any sensitive species, whether of community or priority interest. As regards the qualitative aspect reference was made to the results of a visual census[2].

B. *Natural flow account*

In order to construct a natural flow account for the MNMR flows of energy and matter that move from the technosphere to the biosphere and vice versa needed to be traced. Moreover, input/output matrixes would be required to reconstruct these movements [5], [6]. In order to allocate monetary value to natural flow a cost-benefit approach has to be adopted.

In this case costs are:

- monetary (costs contained in the profit and loss account),
- environmental (flows between the technosphere and the biosphere),

and benefits are:

- monetary (revenues contained in the profit and loss account),
- environmental (flows between biosphere the and the technosphere).

Two conditions are required to complete the framework:

1. the same unit of measure must be used in all the accounts, namely a monetary unit;
2. the cost and revenue items must also be the same for both the income statement and the environmental account, as is the case for the input/output matrix used in the national environmental account.

1) *Technosphere-Biosphere flows*

a) *Environmental costs*

The method used to classify environmental costs derives from Nebbia's analysis of the input/output matrix [1]. He found that the national accounting breaks down human activity into technosphere sectors. The environmental accounting for a protected area divides human activity according to management goals. It is by means of these goals that the administrative body achieves the reserve's objectives. There are a total of six goals [4]:

- A: protection of the environment and exploitation of natural resources;
- B: promotion and dissemination of marine environment knowledge;
- C: environmental education;
- D: scientific research;
- E: the promotion of sustainable development;
- F: financing overheads and one-off costs.

Each of these goals benefits from a flow of energy and matter from the biosphere. The IEA was used to identify the flows [4]. Indeed EC Regulation n. 761/2001 (Emas 2) provides for the fact that the objective of the IEA is to identify significant environmental interaction and to evaluate the degree of environmental impact caused by this interaction. Impact is related to the following factors:

- anthropic presence (knowledge regarding the marine environment and its management, promotion of environmentally-friendly business activity);
- raw materials use (upkeep residuals, urban waste);
- consumption of fuel for motor vehicles;
- consumption of heating fuel;
- consumption of electricity;
- water consumption;
- administration expenses.

Environmental impacts are linked to the consumption of matter and energy, or the return of used resources. In order to transform these impacts into environmental costs, the IEA consumption accounting method was used [4]. An estimate of the environmental cost for various consumption items is achieved by using equivalent tonnes of CO_2 as the unit of measurement and estimating the external cost per kilogram of CO_2 to obtain a monetary value. The next step is to apply the environmental costs, which have been measured in monetary terms, to the six goals that make up sections of the MNMR technosphere.

b) *Monetary costs*

After classifying environmental costs we moved on to the reclassification of the costs taken from the 2004 income statement of 31.12.2004. To do this we used the Long Term Financial Plan approach[3] [7]. This meant that all the cost items on the reserve's income statement were reclassified according to the six Ministry of Environment goals.

[2] A visual census is a non-invasive technique used to monitor fish species by means of observers provided with boards or underwater cameras.

[3] The Long Term Financial Plan was presented by the Conservation Finance Alliance together with The Nature Conservancy at the 5th World Parks Congress, which was held in Durban (South Africa) in September 2003. The LTFP is a long-term model for finance plan management regarding parks and protected areas. The cost items are recorded for management plans and sub-plans and cost centres.

2) *Biosphere-technosphere flows*

a) *Environmental benefits*

The input/output matrix describing the relationship between the biosphere and the technosphere divides the biosphere up into natural inorganic entities (air, water and soil) and types of living organisms (producers, consumers and decomposers). However, since the reserve only covers an area of 121 ha. this subdivision might not have suited the research aims, and so we decided to substitute it with an ecosystem approach based on subdivision according to function.

In the last few decades there has been an increasing interest in the valuation of ecosystem functions and environmental goods and services [8]-[16]. De Groot's specification [11] regarding ecosystem functions, which was taken up by Costanza et al. [9], should be interpreted as the ability of natural processes and components to provide goods and services that meet human needs both directly and indirectly.

TABLE II: ESTIMATE FUNCTIONS

Suggested by Costanza et al. [9]	*Suggested by MNMR biologists*
	Gas regulation
Nutrient cycle	
Biological control	
	Habitat/refugia
Food production	
~~Raw materials~~	
	Recreation
Cultural	

The continental shelf is the main feature of the MNMR's marine ecosystem, and is the basis for the functions that Costanza et al. [9] identified in Table II. The following functions are estimated: nutrient cycle, biological control, food production, recreation, and culture (the value of scientific and educational capital). Some of the functions were proposed by MNMR biologists. However, due to insufficient data this initial analysis has not considered the functions of gas regulation and habitat/refugia. Moreover, given the small surface area we did not believe that it would be appropriate to estimate raw materials production.

b) *Monetary benefits*

Having defined technosphere sectors and biosphere categories it is now possible to construct the biosphere-technosphere input/output matrix for the MNMR as illustrated in Figure 2. The matrix summarises the model's structure and the approach outlined in the previous sections, which can be encapsulated in the following points:

- the monetary value of biosphere/technosphere flows are estimated by means of:
  - an estimate of the monetary value of the reserve's functions,
  - a reclassification of income;
- the monetary value of technosphere/biosphere flows are estimated by means of:
  - an estimate of the monetary value of the reserve's environmental impact (based on the IEA),
  - a reclassification of costs on the basis of the LTFP model.

By using a single unit of measurement (monetary) and a sole classification we were able to unify three separate instruments: the IEA, the LTFP and the environmental accounting.

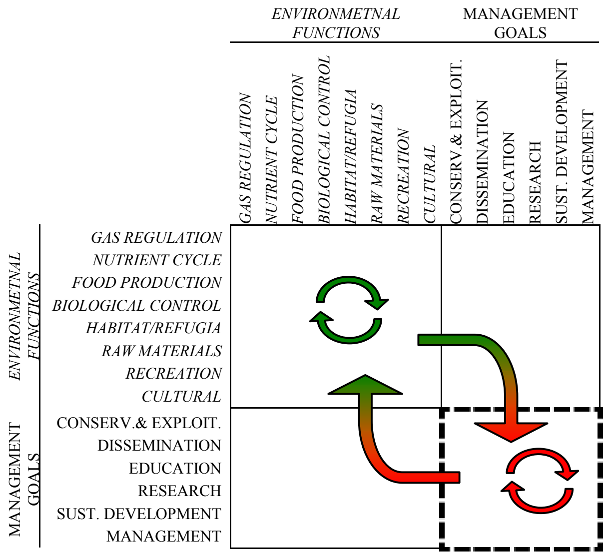

Figure 2: Natural flows account for the MNMR..

IV. ANALYSIS

A. *Estimate of environmental and monetary benefits for the MNMR*

The gas regulation function carried out by the MNMR ecosystems has not been estimated in monetary terms because, since this was the first application of our accounting model, the data were not available. From a methodological point of view, the estimate should have measured the carbon content stored during the formation of marine sediment due to the work of bivalves, as well as the regulation function carried out by seaweed strata.

The nutrient cycle function considers the average concentrations of phosphorous and nitrogen. Replacement cost is used to estimate the value of this function, i.e. the cost of removing phosphorous and nitrogen mechanically. In the last 15 years there has been an increase in the concentration of these elements in the MNMR. This supports the hypothesis that marine ecosystems store production residuals deriving from outside the area. Replacement costs for continental shelves vary between $752/ha. and $2,110/ha. per year [9]. By taking a precautionary stance (the lowest figure), and applying suitable inflation and dollar-euro exchange rates, a value of €773.86/ha. per year is reached. Since the MNMR covers an area of 121ha., the annual value of its contribution to the nutrient cycle can be estimated as €93,636.88.

Food production takes both fishing and angling into consideration. It has been estimated that professional fishermen catch 630,000 kg of fish per year from within the vicinity of the MNMR [4], [17]. By multiplying the total weight of the fish by their market value we can obtain an estimate of the monetary value of the food production function. The value of red meat fish (sardines, mackerel, etc.) is not included because these species are only present in the area due to sea currents. Moreover, as it is difficult to accurately locate the positions of fishing boats only 50% of the catch is allocated to the reserve. On the contrary, as far as the anglers who fish close to the reserve are concerned the total catch is allocated to the area. An overall estimate of the food production function amounts to €84,025.50.

As far as the biological control function is concerned, Costanza et al. [9] assume that control exerted by the high trophic levels is at least 30% of the fish catch value. Consequently, if we take the food production estimate mentioned above we will obtain a figure of €25,207.65 for the biological control function.

As regards the habitat/refugia function, the widespread presence inside the reserve of 13 fish/fauna species has been monitored (out of 116 recorded in the Adriatic and Mediterranean Seas) [18], as well as 3 species found in confined areas (Pleuronectidae, Syngnathidae e Blenniidae). Most probably the reserve acts as a recruitment area, since a large quantity of small creatures can be found just after the reproduction period. In order to produce a monetary value for the habitat/refugia function it would be necessary to calculate the reproduction rate or the annual increase in the most commercially valuable fish species. In this way a corresponding value can be given to a portion of the food production function. However, it has not yet been possible to estimate reproduction rates inside the MNMR. Because of the reserve's size and characteristics an estimate of the raw materials function is not feasible.

Tourism in the MNMR has been divided into two categories: recreation and culture. The former regards free-time activities, while the latter is more closely related to learning and education and refers to the cultural function mentioned in Costanza et al. [9]. Three categories of consumers of recreational activity have been analysed: visitors to the visitors' centre, and people taking part in underwater activities: scuba divers and snorkellers. Contingent valuation methods have been used to give a monetary value to the benefits deriving from each of the recreational activities. This results in estimating the recreational demand function from which the so-called consumer surplus can be derived, i.e. the value that the consumer assigns to the services offered by the reserve extra to the price of the entrance fee. An estimate of the surplus is obtained by estimating the demand function. This can be achieved by linking the number of visitors (quantity) to the variable dimension of tickets (price). The overall benefit is obtained by adding surplus and price. A surplus figure of €22,250.16 has been estimated for the visitors' centre and figures between €6,962.94 and €15,140.20 have been reached for each the underwater activities. The price, which derives from total entrance income, is €29,849.50 (10,301 visitors) for the visitors' centre, €19, 256 (899 divers) for scuba diving, and €15,592.50 (1,583 enthusiasts) for snorkeling.

Moreover, the economic effects of tourism can be defined as direct, indirect or induced. Direct effects derive from tourist spending (added value), whereas indirect and induced effects are tourism's contribution to the creation of income. They are estimated by multiplying the added value by a Leontiev multiplier of 1.54 [19]. Therefore, it is necessary to estimate daily tourist spending according to spending type and flow categories (accommodation, catering and publications). The following data have been gathered through our questionnaires: accommodation spending €4,065.52; catering €103,299.50; merchandising and publications €5,180.38. By applying an income activation parameter, an overall figure of €173,319.91 has been obtained for revenues produced directly and indirectly in the MNMR. By adding the benefit (incomes plus surplus) the function's value reaches a figure of €267,231.01. As regards the natural flow account, which includes income and expenditure from the income statement, revenues have been subtracted, leaving a final amount of €202,533.01.

The cultural function has been divided into two macro areas: science and education. The former regards the reserve as a kind of field laboratory, and a quantitative and qualitative analysis of the function can be achieved by using the following indicators: number of researchers based on man-days (from which a monetary value can be obtained); research projects (project budget); agreements with Universities and Scientific Institutes for research and conferences. However, these data are not yet available and therefore estimates are based on data deriving from literature [9]. In this case the average value per hectare per year is €29.84, giving a total of €3,610.64. The second macro area includes educational activity that took place in 2004. Two hundred and fifteen schools organised visits to the MNMR for a total of 4,300 pupils. From accounting data it was calculated that educational activity produced revenues of €30,583.71 in 2004. Therefore, the overall cultural function value amounts to €34,194.35 (Table III). Table III also gives the grand total of €1,280,011.97 for monetary and environmental benefits.

TABLE III: ENVIRONMENTAL BENEFITS PER FUNCTION AND MONETARY BENEFITS

	Functions	Benefits €
Environmental benefits	*Gas regulation*	Not available
	Nutrient cycle	93,636.88
	Food production	84,025.50
	Biological control	25,207.65
	Habitat/refugia	Not available
	Raw materials	Not estimated
	Recreational	202,533.01
	Cultural	34,194.35
Monetary benefits	Revenues	64,698.00
	Public funding	775,716.58
	Total benefits	1,280,011.97

B. Estimate of the environmental and monetary costs for the MNMR

Firstly, the anthropic impact on the MNMR was considered. Tourism generates several consumer externalities, among which the use of motor vehicles to reach the area, and the use of complementary and accessory materials for carrying out recreational activities. Factors related to anthropic presence (transport, consumer durables, consumer non-durables, etc.) contribute to the production of carbon dioxide. Although the unit of measure is different, the logic behind the transformation of human presence into carbon dioxide emissions is the same as the logic and method behind the approach used to calculate the ecological footprint [20], [21]. Indeed, whereas in the case of the ecological footprint total consumption is converted into equivalent surface area measured in hectares, here the equivalent unit of measure is kilograms of CO2. By using a CO2 production coefficient of 6.41 tonnes per inhabitant per year, and considering that on average a trip to the MNMR will last half a day, we can calculate that 17,083 visits will translate into 8,541 inhabitant days giving a total of 149,887.7 kg of CO2. As the cost per kilogram of CO2 emitted is on average 3.099 eurocents[4], an estimated monetary value of €4,645.50 can be allocated to the consumer externalities produced by visitors to the reserve. As regards the allocation of CO2 production to the six goals, anthropic presence was weighted for each of the following activities: environmental education through educational activities and submarine visits (C) €4,645.50; promotion of sustainable development by means of fish-tourism (E) €3,889.25.

As concerns raw materials use, data supplied by the reserve for paper consumption in 2004 were converted into equivalent CO2 quantities, which amounted to €13.62. Despite the fact that paper consumption is common to all the goals, the figure was so low that it was allocated exclusively to overheads goal (F). The fuel consumed in the MNMR is used both for motor vehicles and heating. Consumption for 2004 converted into equivalent CO2 emissions translated into an environmental cost of €215.95. Since the consumption of fuel for motor vehicles is common to all the goals except for goal A (as stated in the IEA), the total was shared equally among all the other five goals (€35.99). LPG is used in the reserve for heating, which emits CO2 during combustion. From the Apat (Environmental Protection Agency) [23] it can be deduced that a kilogram of LPG will produce an equivalent of 3.02 kg of CO2. However, by adding together emissions of CH4 and N2O total CO2 amounts to 3.16 kg/kg of fuel. Therefore, consumption for 2004 translated into CO2 emissions is equal to €387.80. Given that, according to the IEA, the consumption of heating fuel falls entirely within goal F, the complete sum can be allocated to the reserve's overheads.

Electricity consumption was 54.42kWh, which translates into an environmental cost of €1.19. The IEA states that this figure should be shared equally among all the goals, but the figure was so low that it was allocated solely to goal F.

Annual water consumption amounted to 273.39m³, which was equivalent to an environmental cost of €3.07. Again, despite the fact that according to the IEA this figure should have been shared equally among goals B, C and F, it was so low that it was assigned solely to goal F. Table IV illustrates environmental costs for all the six MNMR management goals.

TABLE IV: ENVIRONMENTAL COSTS ALLOCATED TO MANAGEMENT GOALS

Goals	Anthropic presence	Raw materials	Motor vehicle fuel	Heating fuel	Electricity	Water
	€	€	€	€	€	€
A			35,99			
B			35,99			
C	4.645,50		35,99			
D			35,99			
E	3.889,25		35,99			
F		13,62	36,00	387,8	1,19	3,07
Costs	8.534,75	13,62	215,95	387,8	1,19	3,07

In order to conclude the cost analysis, the income statement costs have to be added to the environmental costs. The 2004 income statement was reclassified according to the LTFP model. In this way the totals could be allocated to the MNMR management goals (Table V).

TABLE V: MONETARY COSTS ALLOCATED TO MANAGEMENT GOALS

Goals	Sums allocated
A) Protection and exploitation	€ 10.680,00
B) Promotion and dissemination	€ 65.715,25
C) Environmental education	€ 214.165,56
D) Scientific research	€ 23.620,89
E) Sustainable development	€ 203.645,55
F) One-off costs	€ 81.853,35
F) Overheads	€ 219.526,24
Total amount allocated	€ 819.206,84

Now it is possible to obtain a figure for the net benefit in 2004, limited to flows from the biosphere to the technosphere and vice versa. By subtracting costs from benefits, both monetary and environmental (the difference between the totals in Tables III and V), we can see that the MNMR produced an annual net benefit of €460,805.13.

V. DISCUSSION

In consideration of the three limitations mentioned earlier (scale, physical measure unit and environmental costs) an accounting model was proposed that would take into account how much the reserve produced, and that would be capable of co-ordinating and amalgamating various instruments: LTFP (through the reclassification of costs and income), IEA (monetary valuation of environmental costs) and Costanza's model for ecosystem valuation (monetary valuation of environmental benefits).

From an analytical viewpoint the environmental balance for the MNMR was positive to the sum of approximately €461,000. How can this result be interpreted? Generally speaking, it can be said that the reserve's development model is in line with sustainability. If this were not so,

[4] Monetary valuation allows us to measure the environmental and social impact of energy production. However, the estimates are still inaccurate. The highly complex methodology only considers a limited number of impacts related to energy production. These initial estimates are based on a method devised for the ExternE EU project [22].

the balance would be negative. Therefore, natural capital policies fully achieve objectives regarding sustainable development, protection and exploitation. If we compare the net benefit figure of €460,805.13 with the financial analysis contained in the LFTP and with the €735,000 contributed by the Ministry of Environment and the Regional Council, we can conclude that 64% of public funding is covered by the net benefits produced by the reserve. It is as if public bodies contributed a net figure of approximately €274,000.

Finally, we feel that more research should be done in order to investigate the difficulties (incomplete assessment procedures and insufficient data) connected with the implementation of the model.

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