PROBLEMS RELATED TO THE DEVELOPMENT OF INTEGRATED SYSTEMS FOR ECONOMIC AND ENVIRONMENTAL ACCOUNTING: A PRELIMINARY ANALYSIS OF THE ECONOMIC-ENVIRONMENTAL IMPACT OF HUMAN ACTIVITIES ON THE MARINE POLLUTION IN THE BASILICATA REGION

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1. INTRODUCTION

The analysis of interrelations between economy and environment has for some time been a matter of political and social concern that throughout the years has inspired diverse areas of scientific research.

For example it is now well known how particular forms of pollution can affect the epidemiological structure of an area, and consequently its human capital (Mastrodonato 1991, 1997). These can also have a relevant influence on the productive structure and capacity of certain areas, even to the point of determining a "negative environmental added value" (Alvaro, 1999).

Such considerations have caused a rapid growth of research aimed at individuating models of sustainable development. Since studies of that kind have to highlight mutual dependencies between economic and environmental variables, they require a detailed preliminary analysis of the national accounting systems currently in use.

This is because the national account describes the economic activities of a nation, or one of its regions, quantitatively in terms of variables like stock and flow (Nicolardi, 1996).

Only by means of an integrated economic an environmental description of the territory is it thus possible to propose models of sustainable territorial development that permit actual realization of economic plans.

Nevertheless, there are still many important conceptual and operative problems to be confronted. Above all they regard the modalities of sampling, classification and interpretation of the environmental variables, as well as the possibility of attributing environmental damages to activities that generate them, as shall be specified in detail below.

Another problem is the lack of a univocal approach to the monetary quantification of these variables in the literature.

2. A SUMMARY OF THE INTEGRATED SYSTEM OF ECONOMIC AND ENVIRONMENTAL NATIONAL ACCOUNTS

The definition of projects concerning environmental accounting has been subject to many efforts by the national institutes of statistics in the European Union, coordinated by Eurostat. These projects aim to individuate environmental accounts, either parallel to the systems of national accounting currently in use (ESA, SNA) or integrated into them.

In this regard, the most important subjects under study, concern the operative modalities for arriving at such a desired integration. From a technical point of view, the suggested models are substantially single matrical structures containing the "classical" national accounting and the environmental account, or environmental satellite accounts.

The latter approach has advantages with respect to the former, principally due to the relative ease of construction and the nonnecessity of interfering with the original structure of the national accounting. A disadvantage is the increased difficulty of recognizing the interrelations.

The most important projects that presently appear to be in a phase of development (see Battellini *et al.*, 1996; Bombana *et al.*, 1999) are the NAMEA (*National Account Matrix including Environmental Accounts*), the SERIEE (*Système Européen de Rassemblement de l'Information Economique sur l'Environnement*) and the SIP (*Sectoral Infrastructure Projects*).

Many of these projects, at least as far as the situation in Italy is concerned, can still be considered in a phase of exploration and definition, whereas some partial but interesting progress has been made in constructing the NAMEA. To understand the difficulties and questions that have come up, it is useful to consider the salient features relative to the methodological aspects.

The SERIEE may technically be classified as a satellite account regarding environmental protection. It is in other words a standard of accounting that is introduced in parallel to the existing structures of national accounting, i.e. simply placed next to it, without interfering with the economic account.

The SERIEE methodology assumes that the satellite account determine the environmental protection costs, identifying the classification, the subjects and the economic activities that finance them.

For that purpose the SERIEE manual identifies the activities to be taken into consideration for individuating the costs of environmental protection, as well as the environmental contexts in which these costs can be considered.

Finally it is prescribed that these estimates must be made separately for the three institutional sectors considered (general goverment, households, private corporations), though ensuring successive consolidation.

This methodology has certain advantages, first of all related to the theoretical ease of construction of the integrated scheme, as it is simply a satellite account. Nevertheless, this project is still considered to be in an exploratory phase, at least in Italy, as it requires a preliminary reclassification of the company and national accounts. This is currently impossible, as there are no legal norms that oblige

these economic operators to an accounting practice constructed for the purpose of highlighting environmental factors. As far as the household sector is concerned, experimental applications of this SERIEE scheme give substantial evidence of difficulties that cannot be overcome in a reasonably short time.

Apart from these considerations, there are even more relevant conceptual problems: Can this methodology provide the geographical homogeneity required for important comparative territorial valuations? More precisely: Can the results from two different geographical areas, which for the sake of hypothesis react differently to identical environmental problems due to differences in ecological awareness, at least in theory be considered comparable?

At the present moment, the answer is evidently negative. It is necessary to pass beyond the national level and impose the actions to be taken in defence of the environment internationally, and successively develop standardized accounting schemes that highlight the costs of environmental defence in a homogeneous manner. Only after this will a systematic construction of the SERIEE be possible.

The theoretical framework of the projects belonging to the SIP class (*Sectoral Infrastructure Projects*) appear to be conceptually different.

These projects are inspired by the models suggested by the OECD: "Pressure - State - Response". The logic behind these models is to identify the variables of environmental strain that modify the state of an ecosystem and determine a response (political or social, and therefore environmental) that modifies the future value of the same variables, and then continue the process in an iterative manner. Specifically, the SIP projects aim to construct sets of sectorial environmental strain indicators, expressed in physical rather than economic terms.

Nevertheless, this kind of projects are usually similar to the economic-environmental accounting projects, to the extent they choose the sectors of analysis based on the integrated interests of environmental and economic politics, although they are directed toward the identification of the quantitative relations.

This project, which is not terminated yet, require the quantitative indices to be associated to economic indices as soon as they are defined in order to develop an integrated system of economic and environmental accounting.

This program is undoubtedly of methodologic and applicative interest. Brought to an end, it would contribute to overcome the unsolved problems associated with the construction of the NAMEA.

The theoretical framework of the NAMEA presents extremely interesting aspects. More precisely it assumes that an environmental form (EA) be placed next to an economic one (a NAM that reports the account of goods and services and the account of production, as well as the economic and financial accounts of the institutional sectors).

The environmental form must highlight:
1) the quantitative relations between the economic operators and the environment, identifying the strain exerted on the environment by the economic activities;
2) an adequate monetary valuation of the environmental variables, obtained by identifying the costs associated with environmental monitoring and control, as well as the costs of repairing environmental damage;

3) the accounts relative to the eco-industrial sector, the consistency and the variation in environmental damage.

Unfortunately, this project, which is ambitious and in principle theoretically and technically imaginable, is still in a phase of rather limited and partial development.

The principal problem appearing at this stage is the necessity of developing an information system that is able to come up with a sort of "registry" of pollutants divided by institutional sectors.

In Italy nothing of the kind exists yet. In particular, the only detailed informations available are relative to atmospheric pollution.

Consequently, the only concrete realizations of the NAMEA project concern the relations between economy and environment relative to the atmospheric pollutants measured by the CORINAIR project.

The NAMEA recently constructed by ISTAT contains an environmental form. But it can only be configured as a satellite account that exclusively reports quantitative measures of pollutants attributed to an economic sector, without assigning any monetary valuation to them. This is a substantial, but necessary deviation from the original project.

Since the methodology is not fully developed, the emerging difficulties have delayed the construction for about ten years. In November 2004, the only matrices available in Italy referred to the period 1990 - 1994.

3. ALTERNATIVE APPROACHES TOWARD IDENTIFICATION OF ENVIRONMENTAL AGENTS IN THE CONSTRUCTION OF THE NAMEA

In light of the above considerations, it appears substantially impossible to extract thematically relevant information in sufficient detail. Then it is appropriate to try alternative methods of analysis to highlight the interrelations between economy and environment.

In particular, one of the most urgent problems is the necessity of individuating areas for which there exist detailed economic and environmental information. Also needed are methods of analysis able to:

1) identify the most appropriate modalities for registrating the observed variables;
2) provide a way of attributing the environmental problems to the economic activities that generate them;
3) ensure the quantifiability of the environmental outputs;
4) permit the collocation of these environmental outputs in the schemes of national accounting.

The scarcity and inadequacy of environmental economic statistics is such that confronting these thematics on a national scale seems impracticable, no matter how desirable. For that reason it is convenient to carry out an analysis on a regional scale. By testing an applied methodology in pilot studies on a regional scale, it is verified whether it is adaptable to the national scale.

In a previous note (Vannella, 2001) the marine pollution of the coast along the Basilicata region has been studied for the purpose of quantifying it in the manner requested by the above-mentioned projects of integrated economic and environmental systems of accounting.

The measurements were taken over the course of one year only, but the interesting results obtained suggested extending the period in order to validate (or reject) the results.

The area of investigation was suggested by the coexistence of factors that are interesting for the purpose of this work:

- a presence on the regional territory of persistent economic activity that is often impeded by environmental problems (intensive agriculture around Metaponto, exploitation of hydrocarbon deposists in Val d'Agri);
- availability of measurement data obtained by the realization of an adequate environmental monitoring plan, analogue to measurements taken (or to be taken in accordance with explicit legal norms) elsewhere on the national territory;
- a strong interest by certain organizations (the Basilicata region, ARPA, *Metapontum Agrobios* and the National Research Council CNR) in the analysis of economic and environmental thematics.

4. DATA AND METHODOLOGIES APPLIED

As previously outlined, the models deriving from the NAMEA attribute, at least quantitatively, the various forms of pollution to the economic agents that generate them. But the current environmental measurements are not made with this purpose in mind. It is therefore necessary to start with the available data and individuate methods of analysis to extract territorial information from existing measurements and associate it with pressing economic factors.

The observations made available for the present work, are the results of a monitoring plan carried out by *Metapontum Agrobios* in Metaponto-Bernalda (province of Matera), based on the measurement of 22 physical, chemical and biological properties (Table 1) observed at eight locations (five along the Ionian coast, distributed along local river deltas, as well as three along the Tyrrhenian coast), at three distances from shore (500, 1000 and 3000 meters). For each combination of season, year, period and distance, only one observation has been made.

The available measurements stretch over three years (from 96/97 to 98/99). In each time window between October and September, 16 samples have been made, i.e. once a month except the period June-September, when samples have been taken every fifteenth day.

It should be emphasized that the sampling plan is in complete accordance with italian legal norms (D.P.R. 979/82), and that the law in question aims to lay out homogeneous national criteria for identifying and disclosing eutrophication phenomena and the "state of health" of the italian seas.

Above all it is helpful to understand if there exists a variability of the observed phenomenon that indicates characteristic properties of the territory.

None of the measured variables exceed the alarm levels fixed by the legislator. As far as they are disclosed by the legally prescribed measurements, no pathological situations appear.

However, this evaluation is not satisfying, neither for confirming the inexistence of structural pollution, nor for proceeding to identify the generating causes. It is quite possible that some environmental pathologies can be identified only by a simultaneous analysis of several variables or combinations of variables.

Successively, it has therefore been considered relevant to verify if there exist territorial characterizations or, given the nature of the phenomenon, possible significant influences caused by seasonal or yearly variations.

For that purpose the possibility of applying parametric procedures has been considerate, as such methods guarantee a certain robustness of hypothesis testing and interpretation of the phenomenon.

It must be emphasized how the particular sample design (laid out in advance by the lawmaker and being the only existing source of relevant information) gives rise to methodological problems.

Specifically, the sample design assumes the presence of a spatio-temporal series, which clearly has an influence on the not complete interindependence of the statistical units. It should be noted, however, that the spatio-temporal correlation could turn out to be (and indeed did turn out to be) weaker than it might seem at first glance. It can be expected that sudden variations in the volume and the physio-chemical composition of fluvial waters present on the territory, from time to time might provoke sudden variations in the parameters observed in pairs of temporally or geographically adjacent measurements.

TABLE 1

Correlation coefficients between the observed variables and the extracted factors

Progressive number	Observed variables	Principal components								Common Factor variance
		I	II	III	IV	V	VI	VII	VIII	
1	surface temperature	-0.77		0.43						0.93
2	bottom temperature	-0.82		0.50						0.91
3	surface salinity		-0.75							0.67
4	bottom salinity		-0.45	0.49						0.59
5	surface oxygen									0.87
6	bottom oxygen	0.88								0.87
7	percentage of surface oxygen saturation	0.84		0.87						0.82
8	percentage og bottom oxygen saturation			0.91						0.86
9	surface pH					0.97				0.96
10	bottom pH					0.98				0.96
11	transparency (m)				-0.72					0.65
12	surfae chlorophyl				0.80					0.76
13	bottom chlorophyl				0.80					0.70
14	nitrites		0.58	0.39						0.69
15	nitrates		0.77							0.68
16	ammonium		0.80							0.77
17	phosphates							0.81		0.77
18	total phosphor							0.87		0.78
19	total coliform bacilli	0.40					0.75			0.80
20	fecal coliforms						0.58		-0.37	0.53
21	fecal streptococci						0.89			0.81
22	total phytoplankton cells								0.85	0.81

Besides, the high number of variables (prefixed by the sample design and laid out by the legislator) is caused by the fundamental necessity of getting a clear idea of a complex phenomenon that is almost completely unexplored in marine ambients. The procedural and methodological choices are motivated by the necessity of having at disposal explanatory elements that are reliable, and not easily obtainable in a different manner. It must also be pointed out as well that these choices are also motivated by the purposes of the present work, which is not dedicated to the study of the variabilities in the strict sense, but as far as it contributes to obtain general informations about the territorial characteristics that may or may not be discovered, with the possibility of classifying in accordance with a NAMEA scheme in mind.

In the light of the above comments, and having verified by the Malkovich – Afifi test (1973) the possibility of not rejecting the hypothesis of multinormality after transforming ($x' = \log(x+1)$) some of the variables (coliforms, streptococci and phytoplankton), a four-way interaction MANOVA has been performed (season, year, period, distance). Having done the analysis, Wilks' test (Mardia *et al.*, 1997) evidences the statistical significance of almost all the interactions of the first and second order (two way and tree way interaction).

Significant interactions have also been observed applying a three-way MANOVA to the data relative to each season, relative to each year and relative to the various distances.

It is particularly interesting to note how the eight separate three-way analyses (year, period, distance) performed on the values measured at all the eight locations constantly came up with a constant significance ($\alpha = 0.01$) of the interaction year x period. excluding the locations Bradano, Castrocuocco and Maratea for the interaction period x distance, and the locations Agri and Cavone for the interaction year x distance, the other interactions generally have a significance of $\alpha = 0.05$.

Proceeding in this manner, despite the limitations explained above, the complex and diverse results of the MANOVA highlight numerous elements that suggest the presence of territorial characteristics, although they have not provided satisfying answers to the questions brought forward.

This suggests a careful and more in-depth analysis, as the territorial characteristics are typical consequences of the influence of human activities on the "structure" of pollution.

For that purpose, to avoid problems deriving from correlations between pairs of variables and above all because of the complexity of the observed phenomena, the opportunity of applying methodologies of aggregative analysis on the original variables, or transformations of these, has been verified. Accordingly, a cluster analysis has been applied in order to see if there are groups made up of statistical units with a common spatial and/or temporal origin.

It is considered favorable (see Del Vecchio, 1992) to operate on the factors obtained using principal components that explain more than 90% of the total variability, since the original variables, that are selected to confirm whether "environmentally dangerous" characteristics exceed certain alarm levels and to observe

phases of decay of chemical residuals, present many significant mutual correlations indicating an information redundancy that might cause uncontrollable and relevant errors in the formation of homogeneous clusters.

Not having precise informations about the aggregative modalities of the characteristics, the centroid method has been applied to determine the number of optimal clusters, with 14 as the result. Consecutively, Forgy's method has been applied to identify them.

Compared to the results emerging from the MANOVA, the examination of the identified clusters (not reported due to typographical limitations) has confirmed the information regarding the variability and added information concerning the agglomerative aspects. Groups emerge that are characterised by units coming from adjacent seasons and temporal observations belonging to the same seasons.

These results invite to further in-depth analysis, since the appearance of spatio-temporal characteristics suggest the existence of pressure variables, operating at different modalities, locations and times, that determine the obtained results.

Another preliminary problem has also come up. Whatever scheme for economic and environmental accounting is selected, it is necessary to identify in advance the most suitable classification of the economic and environmental aggregates under consideration.

Given the purpose of the monitoring plan at disposal, which is quite different from the purpose of the present work, it has been considered whether the characteristics selected in advance were the most suitable for the latter purpose.

In order to find the so-called latent variables, a factor analysis has been carried out using the method of principal components and adapting the Varimax rotation method.

The choice of the number of factors (eight) is motivated by the necessity of explaining a sufficient part of the total variability, as well as the necessity of identifying the meaning of the components (Fabbris, 1997).

From the analysis of the matrix of correlations between the extracted factors and the original standarized variables (Table 1), clear interpretations of the factors emerge. A plausible illustration could be the following:

I: seasonal winter component;
II: pollution from nitrogen compounds;
III: seasonal summer component;
IV: algal bloom;
V: acidity;
VI: pollution from urban residuals;
VII: phosphor pollution;
VIII: presence of phytoplankton.

The extracted factors explain, also in light of the emerged communalities, the observed phenomenon sufficiently and in a useful way. The principal characterisations regard the Ionian locations, where torrential water currents transport significant quantities of nitrogen and phosphor compounds, mainly coming from the abundant fertilizing of the highly developed Metaponto plain, known for its intensive cultivation of profitable species.

5. SOME FINAL OBSERVATIONS

Encouraging results emerge from these analyses, especially when compared to the ones relative to the first year.

Firstly, it verified that there exists a relative nonheterogeneity of the phenomenon in terms of years, especially when considered in relation to the variability that can be attributed to the other factors of classification. This strengthens the hypothesis of absence of structural pollution emerging from the previous work.

Secondly, the identified clusters, although they are obviously more numerous than before, confirm the clear temporal and territorial characterizations that have emerged.

Finally, the factor analysis has demonstrated a significant interpretive capacity, and it allows the identification of the most relevant latent variables.

Since the principal objective is to verify the possibility of attributing, quantitatively and economically, the environmental problems to the human economic activities that generate them, it is interesting to look at the demographic and economic structure of the land behind the coast.

It is not hard to see that the demographic structure (Istat Annals, various years), characterized by the a large number of small urban centers, does not give rise to environmental preoccupations, which is compatible with the organic urban residuals always being well below the alarm limits.

But the pollution from nitrogen and phosphor is a different matter, although the levels are never of a pathological nature. It can be related principally to the intensive cultivation taking place on the Metaponto plain.

The influence exerted by these pollutants in relation to the fluvial transport, and the substantial nonheterogeneity relative to the years as far as these characteristics are concerned, strengthens the hypothesis of a functional relation with the agricultural activities on the nearby territory.

It is also necessary to keep in mind that the economy of the Basilicata region, although in a rapid evolution where the tertiary sector is becoming more important (Bank of Italy, various years), is still rather backwards (Istituto G. Tagliacarne, various years), the agriculture representing a large part of the gross domestic product (Unioncamere della Basilicata, various years).

From a conceptual point of view, the strong economic impact of that sector of activity is thus readily associated to a systematic relation with the structure of seawater pollution (although it is not pathologic).

Similar associations can be explained by the other latent variables that emerged (in a particular way by the seasonal summer and winter components and by the variables connected to eutrophication phenomena like that algal bloom and the presence of phytoplankton).

The unavailability of monitoring results covering the major rivers in the Basilicata region and more generally the land near the coast, has made it impossible to individuate interpretative models based on the SIP, whereas methodological doubts concerning the schemes of economic and environmental accounting

based on the costs of territorial protection have impeded the application of methodologies based on the SERIEE.

These last considerations, together with the emerged results that are illustrated, legitimize the application of models (for example of canonical analysis) that permit highlighting the most incisive economic-environmental relations on the territory under consideration. These elements are preliminary to any analysis of sustainable regional development.

The results obtained in this still ongoing research are comforting, and they appear to provide useful tools for solving the above-mentioned problems related to the integrability of economic and environmental accounting.

In the worst case, this suggests the possibility of constructing a regional NAMEA, which (unlike the one suggested by ISTAT):
- is able to confront and resolve problems of economic-environmental integration that have never been studied (ISTAT's NAMEA referring only to the atmospheric pollutants);
- is definitely obtainable much faster;
- highlights the economic-environmental interrelations on a regional, rather that national, scale.

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BIBLIOGRAPHY

G. ALVARO (1999), *Contabilità nazionale e statistica economica*, Cacucci Ed., Bari.

BANK OF ITALY (Various years), *Note sull'andamento dell'economia in Basilicata*.

F. BATTELLINI, A. TUDINI (1996), *Una matrice di conti economici integrati con indicatori ambientali per l'Italia*, in Annali di statistica, 13.

M. BOMBANA, C. COSTANTINO, F. FALCITELLI, A. TUDINI, M. VANNOZZI (1999), *Framework for an information system on environmental pressures*, in Annali di Statistica, 18.

A. CAMUSSI, F. MÖLLER, E. OTTAVIANO, M. SARI GORLA M. (1986), *Metodi statistici per la sperimentazione biologica*, Zanichelli ed., Bologna.

F. DEL VECCHIO (1992), *Analisi statistica di dati multidimensionali*, Cacucci Ed., Bari.

L. FABBRIS (1997), *Statistica multivariata, analisi esplorativa dei dati*, Mc Graw-Hill Italia ed., Milano.

ISTAT (Various years), *Annuario Statistico Italiano*, Roma.

ISTITUTO GUGLIELMO TAGLIACARNE, UNIONCAMERE (Various years), *La geografia economica delle province*, Roma.

J. F. MALKOVICH, A. A. AFIFI (1973), *On tests for multivariate normality*, "Journal of the American Statistical Association", 68.

K.V., MARDIA, J.T. KENT, J.M. BIBBY (1997), *Multivariate analysis*, Academic Press, London.

A. MASTRODONATO (1991), *I capitali umani*, Trattato di Statistica economica - Vol. V, Cedam ED., Padova.

A. MASTRODONATO (1997), *Sviluppo sostenibile e capitale umano*, in "Atti del XXI Convegno Annuale della Rivista l'Industria", Bari 26-27 settembre 1997.

V. NICOLARDI (1996), *Strutture di Contabilità Nazionale*, in Quaderni dell'Istituto di Statistica of the University of Bari, 85.

UNION OF CHAMBERS OF COMMERCE IN THE BASILICATA REGION (Various years), *Osservatorio economico della Basilicata - La congiuntura economica*, Potenza.

G. VANNELLA (2001), *Un approccio multivariato all'analisi statistica economica ambientale sull'inquinamento marino lucano*, "Statistica", 2.

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RIASSUNTO

Alcuni problemi legati alla costruzione di Schemi Integrati di Contabilità Economica ed Ambientale: un'analisi propedeutica dell'impatto economico-ambientale delle attività antropiche sull'inquinamento marino lucano

Gli sforzi che negli ultimi anni si stanno conducendo per analizzare le interrelazioni tra economia ed ambiente, spingono alla definizione ed alla costruzione di Schemi Standardizzati Integrati di Contabilità Nazionale economica ed ambientale. Le ancora giovani metodologie esistenti in tale ambito comportano numerosi problemi teorici ed applicativi che determinano una costruzione dei suddetti Schemi parziale e caratterizzata da notevoli ritardi temporali. Nel presente lavoro si propone un approccio alternativo di analisi finalizzato alla individuazione delle imputabilità dei disagi ambientali alle attività economiche generatrici. In particolare si propone un complesso piano di analisi interpretativa condotto su scala regionale che, partendo da rilevazioni ambientali già esistenti su tutto il territorio nazionale, permette di evidenziare tipizzazioni territoriali ambientali, variabili latenti e variabilità dei complessi fenomeni in modo compatibile con le esigenze degli Schemi di Contabilità Nazionale Economica ed Ambientale, con riferimento a variabili ambientali prima non trattate nelle attuali NAMEA dell'Istat, ma soprattutto con tempi più rapidi e su scala regionale.

SUMMARY

Problems related to the development of integrated systems for economic and environmental accouning: A preliminary analysis of the economic-environmental impact of human activities on the marine pollution in the Basilicata region

The efforts made during the last years to analyze the interrelations between economy and environment, suggest defining and constructing standardized integrated systems for national economic and environmental accounting. The methodologies that currently exist are not fully developed and involve numerous theoretical and applicative problems that limit, and delay considerably, the construction of such systems. In this article an alternative approach to the analysis is suggested, which aims to attribute environmental prob-

lems to the economic activities that generate them. In particular, a complex procedure of explanatory analysis carried out on a regional scale is suggested. Based on environmental measurements already performed all over the national territory, the procedure identifies territorial and environmental characteristics and latent variables, as well as the variety of the intricate phenomena in a way that is compatible with the requirements of the national schemes for economic an environmental accounting. References are given to environmental variables on a regional scale that have not been previously considered in ISTAT's current NAMEA projects and that can be obtained faster.