RAMEA: A Decision Support System for Regional Sustainable Development

by

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Abstract

RAMEA is a Regional NAMEA, an environmental accounting system which combines economic accounts (measured in monetary terms) and environmental accounts (measured in physical units) into a single framework useful for the evaluation of the integrated economic-environmental-social performance of regions. Here we restrict our attention to the economic-environmental issues. RAMEA can be used as a decision support system, to inform and help regional policy-makers to identify and to quantify potential environmental and economic impacts associated with regional development policy measures.

RAMEA's framework is based on a well established approach (UN and Eurostat Guidelines) and robust data from official statistics: it is coherent with similar tools at national level (NAMEA) and compiled in a relatively inexpensive way, deriving its numbers from national and regional accounts. RAMEA allows analysing the pressures placed on the environment by the economic sectors and households, with the possibility of extracting sustainability indicators, see if pressures are decoupling from economic growth, benchmark the cross-country differences in terms of eco-efficiency and understand the reasons behind these differences (using Shift-Share analysis).

Based on an EU funded regional cooperation project, this paper emphasizes the opportunities owed to RAMEA and to related economic and statistical tools in supporting regional sustainable development policies/strategies.

Keywords: NAMEA, Sustainable Development, Environmental accounting

1. Introduction

"*If the GDP is Up, Why is America Down?*" In this 1995 article by USA's Atlantic Monthly magazine, the authors described a time when the economy was booming according to the standard economic measures - productivity and employment were high and inflation was under control. However, the American people were not experiencing the euphoria they should have been according to the figures (Matthews 2006).

As it is known, Gross Domestic Product (GDP) was introduced following the Great Depression, in order to help politicians steer the economy towards key economic objectives and provide a solid basis to address economic policy decisions. Today GDP has become rightly the foremost measure of economic activity (Almunia 2007). As a universally recognised and accepted system, it allows us to compare the economic performance of different countries worldwide and to track economic developments over an extended period of time.

However, without calling into questions its merits, the GDP was never intended to be used as a measure of well-being, standard of living, or progress. Indeed, its creator Simon Kuznets in 1962 (cited in Matthews 2006:3), warned against its misuse: "*Distinctions must be kept in mind between quantity and quality of growth, between its costs and returns, and between the short and the long run. […] Goals for 'more' growth should specify more growth of what and for what*".

In the past 40 years experts have been searching to reduce the focus on GDP as the key measure of national progress, by replacing GDP with an accepted measure or sets of measures, or also by modifying or supplementing the national accounts with some other more thorough reflecting the wellbeing of societies.

The System of National Accounts (SNA1993) consists of the supply and use tables and institutional sector accounts. These tables and accounts address economic aspects of wellbeing like National Income, total investment, disposable income and capital formation. In The Netherlands the central framework of the National Accounts has been extended with social and environmental accounts: the relationship between the environment and the national economy is provided by the National Accounting Matrix including Environmental Accounts (NAMEA), introduced by the Dutch Statistics in 1993 and developed since 1995 by Eurostat (Statistical Office of the European Communities).

The objective of this paper is to present the results of an EU regional cooperation project on the application of the NAMEA methodology at regional level, called RAMEA (Regionalized nAMEA-type matrix).

One of our purposes is to get you more acquainted on how an environmental accounting system, like RAMEA, could be useful to evaluate the economic and environmental performance of regions and to inform regional policies/strategies about sustainable development, coherently with the tools developed at national level (NAMEA).

The main objectives of these synergic studies have been aimed at defining helpful accounting tools to:

- link the economic knowledge on production and consumption activities to the emissions in air exerted on the environment;
- build a tool useful for reports, studies, scenarios, regional planning;
- provide useful indicators for the policy makers to measure, control and forecast key regional performances;

- identify how a region could develop economically and socially without causing environmental damages

Moreover, RAMEA could be scheduled for different kinds of analyses, to explore some of the possibilities that this type of tool offer to the regional planning/reporting, e.g.: monitoring regional air emissions and eco-efficiency, comparing regional eco-efficiency with the national one (Shift-Share analysis) and understanding the effects and responsibilities of production and consumption chains on the environment.

2. The NAMEA

According to the SEEA - System of Economic and Environmental Accounts (UN 2003), the term "hybrid flow accounts" is used to denote a single accounting framework containing both national accounts in monetary terms and physical flow accounts (absorption of natural resources and ecosystem inputs and generation of residuals): the acronym NAMEA has become a generic term for this type of tables.

NAMEA stands for "National Accounting Matrix with Environmental Accounts" and its methodology goes back to the analysis of physical economy by Leontief in 1970 (cited in UN 2003:12), who firstly combined input-output modelling and environmental accounts.

The term NAMEA was developed throughout the 1990's by Statistics Netherlands (CBS - Centraal Bureau voor de Statistiek), in particular with the work of Keuning and de Haan (de Haan and Keuning 1996, Keuning *et al*. 1999, de Haan and Keuning 2001, de Haan and Kee 2004). Dutch NAMEA was first released as a pilot in 1993, as a National Accounting Matrix (NAM) extended with environmental accounts (EA).

As a result of those studies, NAMEA now is a statistical information system that gives the possibility to analyse the pressures placed on the environment by production and consumption activities, extending the economic aggregates (value added, output, consumption) with related environmental indicators (global warming potential, acidification, eutrophication, ozone layer depletion, waste, land use): a matrix scheme which allows studying the economy-environment interrelationship with the robustness offered by statistical data (Figure 1).

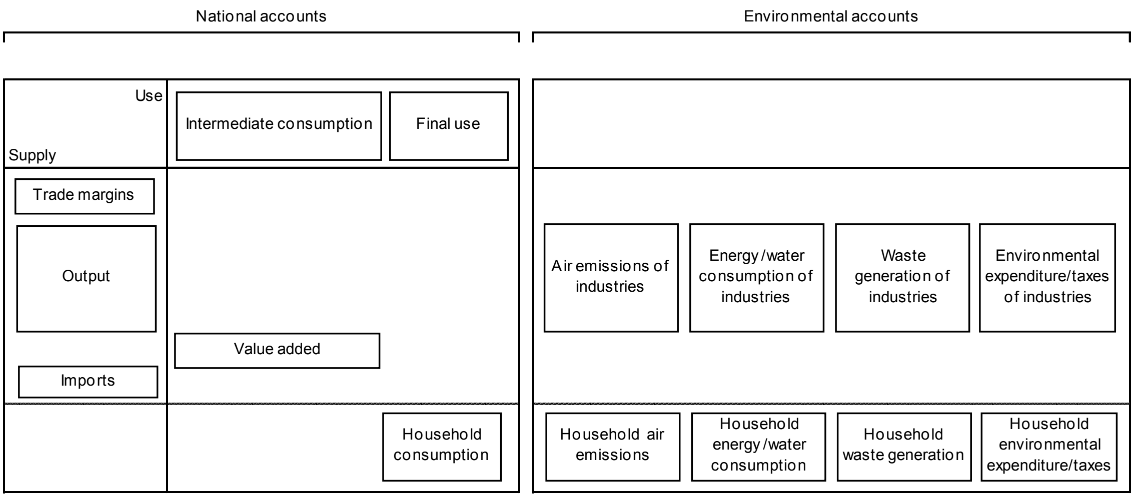

Figure 1 - Schematic description of a simplified NAMEA (Eurostat 2007)

The NAMEA system is thus a descriptive one: different types of statistical data are consistently organised, in order to highlight contributions of industries and households to both economic and environmental performances of the economic system analysed (each production/consumption activity is directly linked with the environmental pressures generated to support the activity itself). Important feature of NAMEA framework is that it maintains a strict border between economic and environmental aspects, the last appearing as "environmental requirements" of the economy (de Haan 2004): because environmental requirements are not related with market transactions, they are not assigned a monetary value and no modelling assumption is needed to estimate monetary value of environmental assets.

In 1994 the European Union, with its Communication COM(94)670, stated that "*further integration of environmental and economic information systems aiming at a 'greening' of National Accounts following the satellite approach should be intensified in accordance with a common framework and using a common reference*".

Following EU Communication, in 1995 Eurostat started working on NAMEA accounts, regarding them as one of the satellite accounts with top priority at European and International level. Together with some pilot studies which involved most of the Member States (Eurostat 1999, 2001), a first set of standard tables for air emissions was prepared (Eurostat 2000): these tables focus on air emissions, taking into account that the most advanced projects regard atmospheric pollutants (see Figure 2). In 2007 Eurostat released a revised version of its "Compilation Guide" and, in 2008, promoted a survey to understand to what extent the NAMEA matrices are developed in Member States.

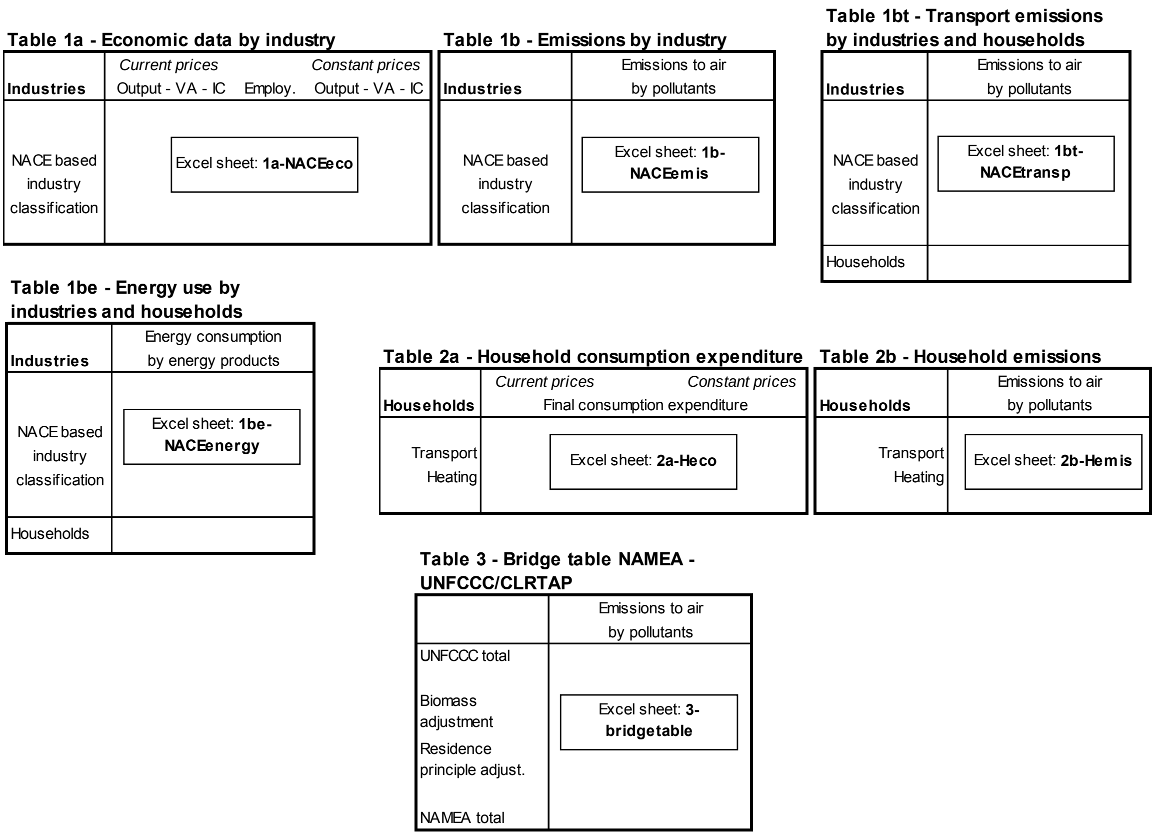

Figure 2 - Overview of the NAMEA-air standard tables (Eurostat 2007)

Apart from air emissions, it is possible to extend the EA module to include a wide range of environmental pressures: energy accounts, water extractions and discharges, polluting releases to water, production of solid waste, land use and environmental taxes (Schenau and Hoekstra 2006). The final step is to incorporate social aspects into the economic-environment framework, realising the fullest form of a NAMEA: again we should cite the work of CBS, which integrated NAMEA and SAM – Social Accounting Matrix (UN 1993:XX) into a so-called "Social Accounting Matrix Including Environmental Accounts" (SAMEA), which leads to the development of a "System of Economic and Social Accounting Matrices and Extensions", or SESAME (Keuning 1999).

An online survey about international applications of NAMEA, lead to the results that most of the EU countries have compiled it at national level (often with good time series); some international experiences exist (in particular in Japan and South Korea), even if not always the term NAMEA is used, while the regional application is not so explored (Table 1).

Table 1 - International applications of NAMEA and Regional NAMEA (Eurostat 2008; Ariyoshi 2006; Choi *et al*. 2003, Imori and Guilhoto 2008)

Country	NAMEA	Regional NAMEA
Austria	1999-2003	
Belgium	1995-2002	
Brazil	2004	
Bulgaria	2001-2003	
Denmark	1995-2003	
Estonia	2003	
France	1995-2003	
Germany	1995-2003	
Hungary	2000-2003	
Ireland	1995-2003	
Italy	1995-2003	1995, 2000, 2003
Japan	2001-2006	2004-2006
Norway	1995-2003	
Poland	1995-2003	2003
Portugal	1995-2003	
Slovenia	2000-2003	
South Korea	1995-2000	
Spain	1995-2003	
Sweden	1995-2003	
Switzerland	2002	
The Netherlands	1995-2003	2001-2003
United Kingdom	1995-2003	2003

Following Goralczyk and Stauvermann (2007), it can be concluded that "*the NAMEA is a multi-purpose information system, which is able to inform the public and policy-makers about the status quo of the environmental assets and environmental pollution*", useful to organize and analyse economic and environmental data in relation to policy objectives.

3. The RAMEA

RAMEA is one of the 16 cooperation projects financed by the INTERREG IIIC Program 2005-2007 under GROW, the Regional Framework Operation (RFO) which main topic is to help European regions in adopting strategies coherent with the Lisbon and Gothenburg Agendas goals.

RAMEA project started in May 2006, with the involvement of seven institutes from four EU regions: ARPA (Environment Agency of Emilia-Romagna Region - lead partner, Italy), MEERI (Polish Academy of Sciences Mineral and Energy Economy Research Institute, Malopolska Region, Poland) SEEDA (South East England Development Agency, UK), SEERA (South East England Regional Assembly, UK), SCPnet (Sustainable Consumption and Production Network, UK) Cambridge Econometrics (UK) and TELOS (Noord Brabant Centre for Sustainable Development, the Netherlands).

The project partners shared a common path to develop four Regional NAMEA matrices (RAMEA), environmental accounting systems useful to evaluate the economic and environmental performance of regions involved and to inform regional policies/strategies about sustainable development. Indeed, linking environmental and economic indicators encourages and facilitates the involvement of the decision makers, who are likely to be more familiar with socio-economic concepts (such as GDP), but who are having to pay an increasing amount of attention to the effects of economic activities on the environment.

RAMEA is based on an international accepted methodology (UN, Eurostat), reliable data (official statistical accounts) and standardized systems (SEEA2003, SNA1993, ESA1995[1]): these conditions assure its coherency with similar tools at national level (NAMEA) and allow benchmarking between regions/nations. A RAMEA could be compiled in a relatively inexpensive way, deriving its numbers from national and regional accounts.

The Figure 3 shows the framework chosen by project partners. The main characteristics of this common framework are:

- 27 industries (NACE rev. 1.1 classification) and 2 household categories (COICOP 07 Transports plus Other consumptions);
- 5 economic variables (Output, Value Added, Intermediate Consumption, Final Consumption and Employment);
- 9 air emissions (CO_2, N_2O, CH_4, NO_X, SO_X, NH_3, NMVOC, CO, PM) plus 2 aggregated impact categories (Global Warming Potential and Acidification).

	RAM								
	Current Prices (Millions of euros)				Costant Prices (Millions of euros)				ftes/n. jobs
	Output	Value Added	Intermed. Consumpt.	Final Consumpt.	Output	Value Added	Intermed. Consumpt.	Final Consumpt.	Employment
NACE rev. 1.1 industry classification (27 codes)									
Household									
Total									

	EA										
	GHG emissions (Mg)				Acidification (Mg)				Local air quality (Mg)		
	CO_2	N_2O	CH_4	CO2 eq	NO_X	SO_x	NH_3	H+ eq	NMVOC	CO	PM
NACE rev. 1.1 industry classification (27 codes)											
Household											
Total											

Figure 3 - RAMEA: common framework

Because application to policies is a fundamental requisite for environmental accounting tools that aspire to more than just mere compilation of data, RAMEA has been thought as a Decision Support System for Regional Sustainable Development. In particular:

[1] ESA - European System of Accounts

- as a monitoring system, RAMEA allows analysing the pressures placed on the environment by the economic sectors and households, helps identifying the “hot spots” in terms of environmental pressures and potential decoupling patterns, and allows the construction of eco-efficiency indexes: we can understand, as an example, the regional key sectors for CO_2 emissions, establish a direct link with their economic performances, see if a positive/negative relation exists between economic growth and environmental pollution and develop eco-efficiency indexes;
- as a forecasting tool, RAMEA, together with the help of environmental input-output analysis, allows Scenario analysis: e.g. after having identified the key sectors for CO_2 we may evaluate and quantify the effects of different regional policies/strategies aiming to the reduction of emissions, including the baseline scenario (no action).
- as a benchmarking tool RAMEA gives the possibility of comparisons between regions: the partners compared the performances of the four regions (and of the four nations of which regions are part) in term of eco-efficiency of eight macro economic sectors (Agriculture, Mining/Quarrying, Manufacturing activities, Electricity, Construction, Commerce, Transport, Other services).

The latter point leads to one important value added of the project. We saw that NAMEA methodology and datasets are well developed at European and International level (Table 1), while the regional level is not so explored, at least at EU level. But the regional scale for economic-environmental accounting, in the opinion of the authors, has a crucial role in building a pathway for sustainable development, realising a link between global and local scale (i.e. “think globally, act locally”). RAMEA could be regarded as the first example of four EU regions that cooperate in building a regional NAMEA following a shared methodology and benchmark their integrated economic-environmental performance with the aim of improving knowledge base for sustainable development policies.

In this paper we briefly present the results of RAMEA for Emilia-Romagna, Noord-Brabant and Malopolska. More information can be found in the project website (www.ramea.eu)

3.1 RAMEA in Emilia-Romagna, Italy

The first pilot of RAMEA in Emilia-Romagna has been realized by Arpa Emilia-Romagna, in close collaboration with IRPET (Institute for Economic Planning in Tuscany) and ISTAT (Italian Statistics).

Two matrices were produced (1995 and 2000), using:

- regional economic data supplied by IRPET for 30 economic sectors plus 3 types of household consumptions, using a multi-sector and multi-regional econometric model able to produce economic accounting matrices, consistent with national accounting ones (Casini Benvenuti and Paniccià, 2003);
- official database of 21 pollutant air emissions at provincial level produced by APAT, the National Environment Agency.

The methodology to link the two sets of data is based on the so-called “air emission inventory first approach” (Eurostat 2007). It mainly deals with the activities carried out to shift from the CORINAIR process-oriented source nomenclature (SNAP97) to the RAMEA socio-economic nomenclature (NACE codes plus COICOP classification) and in particular: (i) the analysis of the qualitative link between each SNAP97 process and RAMEA economic activities and (ii) the quantitative allocation of the emissions of each SNAP97 process to the related RAMEA activities. Since there is no standard connection between SNAP and NACE/COICOP, the attribution of emission data to economic accounts depends on the economic structure of the region. Moreover, only emission whose source is anthropic is taken into account, excluding all emissions related to natural phenomena. The application of this approach to Emilia-Romagna could benefit from previous pilots of regional NAMEA for two Italian regions, Toscana and Lazio (Bertini *et al*. 2007, ISTAT 2006a-b), together with the compilation of national NAMEA for Italy (De Lauretis *et al*. 2002, Tudini and Vetrella 2003, Tudini and Vetrella 2004).

In addition to the common framework agreed, RAMEA for Emilia-Romagna includes an Input-Output matrix which form the basis of the NAM part (and gives the possibility to highlight sustainable consumption and production patterns) and data on nine heavy metals emissions (As, Hg, Pb, Zn, Cd, Cr, Se, Cu and Ni). Table 2 shows a simplified scheme of RAMEA, in which four economic aggregates and five environmental themes are presented.

Table 2 - RAMEA for Emilia-Romagna - aggregated version (2000, %)

Emilia-Romagna 2000		RAM				EA				
		Economic aggregates				GHG	Acidification	Local air quality (Mg)		
NACE	**Industries**	**Output**	**Value Added**	**Final Cons.**	**Labour input**	**CO2 eq**	**H+ eq**	**NMVOC**	**CO**	**PM**
A,B	Agriculture, hunting, forestry, fishing	2,6%	3,5%		6,2%	12,2%	47,0%	4,6%	9,8%	24,2%
C	Mining/quarrying	0,1%	0,2%		0,1%	0,1%	0,1%	0,2%	0,0%	0,2%
D	Manufacturing activities	39,6%	26,6%		27,4%	31,5%	21,2%	30,7%	2,4%	31,3%
E	Electricity, gas, water supply	1,5%	1,3%		0,5%	14,3%	10,2%	3,2%	0,5%	4,6%
F	Construction	5,4%	4,9%		5,8%	0,2%	0,1%	3,9%	0,1%	2,2%
G,H	Wholesale, retail trade, hotels, restaurants	14,4%	17,2%		21,4%	2,0%	0,7%	1,7%	0,5%	0,9%
I	Transport, storage, communication	6,2%	6,8%		5,8%	7,0%	7,5%	6,9%	5,6%	13,2%
J-Q	Other services	30,1%	39,5%		32,8%	6,2%	1,9%	1,3%	2,1%	2,1%
COICOP	**Households**									
07	Transport			12,7%		12,3%	9,1%	34,1%	70,3%	13,3%
-	Other consumptions			87,3%		14,2%	2,1%	13,3%	8,7%	8,0%
Total - Industries		**100,0%**	**100,0%**		**100,0%**	**73,5%**	**88,8%**	**52,6%**	**21,0%**	**78,7%**
Total - Households				**100,0%**		**26,5%**	**11,2%**	**47,4%**	**79,0%**	**21,3%**
Total		**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**	**100,0%**

The above version of RAMEA highlights the different contribution of economic sectors and households to the economy and the environment as a percentage of total, facilitating a simple but interesting analysis of the data:

- Manufacturing (D) is the sector with the higher contribution to the regional output (39.6%) and the second for the employment (27.4%), but has also a high impact on the environment (GHG 31.5%, acidification 21.2% and PM 31.3%);
- Electricity sector (E) makes a very little contribution to the regional output and value added (1.5% and 1.3% respectively) and employment (0.5%) but makes a significant environmental impact in terms of GHG (14.3%) and acidification (10.2%);
- Agriculture and fishing (A+B) sector makes little contribution to the regional output (2.6%) and value added (3.5%), but is relatively important in term of GHG (12.2%) and PM (24.2%) and is the highest for acidification (47%);
- Households have an impact on environment that can not be overlooked, particularly for emissions such as CO_2 (31%) PM (21%), NMVOC (47%) and CO (79%)

We have also developed an analysis of the intensity of emission of our regional economic system, compared to the national average for the GHG and for all sectors. The indicator "Intensity of emission", as "Emissions/ Value Added", has been used in this analysis as a measure of the eco-efficiency.

By means of a Shift-Share analysis we have isolated and quantified the role of the productive structure as a cause in the average gap between Emilia-Romagna (E-R) and Italian efficiency of emissions, obtaining also, in a complementary way, a measure of the role of the specific efficiency of emissions of productive fields. A general approach on how to derive and analyse the Shift-Share signs is explained in Foderà *et al*. (2005), Zaccomer (2005), Biffignandi and Fabrizi (2006) and Mazzanti *et al*. (2006). We also refer to the Chapter 4 to have more comprehensive view of Shift-Share analysis and possible uses of a RAMEA matrix as a Decision Support System. The choice of this methodology derives from the search of effects and factors that could explain the relative efficiency of Emilia-Romagna, compared to Italy, which could be shown in a more exhaustive way than a descriptive statistic analysis. A deviation matrix between the regional and national average, generated by a descriptive statistic analysis, can be investigated by an application of a Shift-Share analysis to carry out detailed considerations on such differentials (Table 3). In this study the total differentials of efficiency for GHG do not remain in favour of E-R for every sector.

Table 3 - Shift Share matrix

Total economic activities	$\sum X_e$	$\sum X$	$\sum (X_e-X)$	$\sum(m_e+p_e+a_e)$	$\sum m_e$	$\sum p_e$	$\sum a_e$
GHG	0,3404994	0,4129593	-0,0724599	-0,0724599	-0,0248043	-0,0752752	0,0276196
deviation %			-18%				
A+B: Agriculture, hunting, forestry, fishing	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	1,6036195	1,6925946	0,0090750	0,0090750	0,0122109	-0,0024940	-0,0006419
deviation %			19%				
C: Mining/quarrying	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,2843369	0,1346742	-0,0002194	-0,0002194	-0,0004528	0,0007365	-0,0005032
deviation %			-33%				
D: Manufacturing activities	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,5483483	0,4914558	0,0439822	0,0439822	0,0288229	0,0118227	0,0033366
deviation %			43%				
E: Electricity, gas, water supply	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	5,0695846	9,0570952	-0,1124754	-0,1124754	-0,0603154	-0,0787146	0,0265547
deviation %			-63%				
F: Construction	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0149001	0,0491699	-0,0017309	-0,0017309	-0,0000421	-0,0017182	0,0000294
deviation %			-70%				
G+H: Wholesale, retail trade, hotels, restaurants	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0531170	0,1169122	-0,0103809	-0,0103809	0,0005637	-0,0106371	-0,0003076
deviation %			-53%				
I: Transport, storage, communication	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,4763596	0,5165247	-0,0053817	-0,0053817	-0,0026492	-0,0029385	0,0002060
deviation %			-14%				
J-Q: Other services	X^s_e	X^s	$(X^s_e*P^s_e) - (X^s*P^s)$	$m_s+p_s+a_s$	m_s	p_s	a_s
GHG	0,0730957	0,0538107	0,0046713	0,0046713	-0,0029422	0,0086680	-0,0010545
deviation %			19%				

The regional average Intensity of emission (X_e) for GHG is the summation of sectorial intensity of emission, weighted for the ratios of sectors for the Total Value Added (P_e). The national average Intensity (*X*) is defined in the same way. The region can show a total greater or lower intensity of emission compared to the national average caused by the combination of the three Shift-Share effects: Industry mix (*m*), Differential (*p*), Allocative (*a*).

The total difference between regional and national average Intensity of emission equals the summation of the three effects. The Industry mix estimates the part of greater/lower intensity of emissions due to the sector structure of the economic system. The difference between regional and national average intensity of emission could depend on differences in the specific intensity of emissions of some or all considered fields marking out the Differential effect. Finally, the Allocative component adds further analytic information: the covariance between sectorial structure (assuming parity of efficiency) and difference between sectorial intensity of emission (assuming parity of sectorial structure) indicates how much and if the system has a productive specialization in the fields where it carries out a comparative advantage of efficiency. The more elevated the indicator, the less efficient the considered system or sector and viceversa.

This is reflected in the interpretation of differential between E-R and Italy; so if $X_e – X > 0$, E-R is relatively less efficient (i.e. produces more emissions for unit of Value Added than the national average). The same is true for the signs of the three effects: when they are algebraically negative they mark an advantage of efficiency for the region E-R.

These effects show influences deriving from the sectorial structure and then from “the history of development” of the economic system, or they could be concerning the average state of productive technologies (and then of emissions) in the region compared to the national average. For example, it could happen that a higher value of regional intensity of emission is only due to reasons of productive structure in terms of fields on which an energetic-environmental policy can not have great influence directly; it could have greater chance of action instead, if the relative total regional inefficiency were due to specific environmental inefficiency of the fields, caused by their technologies or by inefficient public regulation assets. As a result of such reasoning and elaborations a pilot Decision Support Matrix is proposed, in aid to policy makers: it shows the possible scenarios, depending on the possible combination of Shift-Share effects and identifies strategies for sector policy (Bonazzi and Sansoni 2008).

3.2 RAMEA in Noord Brabant, the Netherlands

Regarding the construction of a RAMEA for Noord Brabant, we had three problems to solve:

A. Environmental data is not available at regional level, only at national one
B. Data on inter-regional trade is missing
C. Regional data on consumer behaviour is only partly available

Solutions:

ad A. Because of the fact that the regional structure of industries in the Netherlands are very similar and that there is a strong correlation between the regional and national economic activities, we have used the regional share of the national output of each industry as a multiplier to derive the regional emissions.

ad B. Because of the fact that it is very complicated and expensive to compile economic data with respect to inter-regional trade, we have decided to ignore interregional trade or to make the assumption that inter-regional trade within all industries are balanced.

ad C. Because of the fact that the consumer behaviour regarding demand for heating, net income, number of family members is very identical in the Netherlands, we have taken into account the share of the regional numbers of inhabitants in relation to the national number of inhabitants as a multiplier, to derive the emissions caused by the regional inhabitants for heating. Regarding the demand for car gasoline, regional and national data for driven kilometres are available.

Taking into account that national and regional statistics of the Netherlands compiled by the Central Bureau of Statistics (CBS) are very reliable and very detailed (40 COROP areas and 38 economic activities), we are able to derive the following matrix (Table 4).

Table 4 - Absolute contributions of sectors to output and CO2 emissions (CBS 2005, 2006)

2002	Output Noord-Brabant	Output NL	Ratio Noord-Brabant/NL	CO_2 NL	CO_2 Noord-Brabant
SIC '93	Million euro	Million euro		Million kg	Million kg
Total economic activities	135375	870427	0,155527	162311	25243,76
A+B Agriculture hunting forestry fishing	3963	23200	0,170819	9793	1672,83
C Mining/quarrying	166	13491	0,012304	2557	31,4626
DA Food, beverages, tobacco	11475	46552	0,246499	4585	1130,196
DB+DC Textile, leather products	1262	4196	0,300763	314	94,43947
21 Paper products	809	5505	0,146957	1339	196,7758
22 Publishing and printing	1615	13165	0,122674	237	29,07368
DF Coke, refined petroleum, nuclear fuel	143	15108	0,009465	11387	107,7801
DG Chemical products	7598	36007	0,211015	15437	3257,431
DH Rubber and plastic products	1252	5984	0,209225	229	47,91243
27 Manufacture of basic metals	994	5671	0,175278	6701	1174,536
28 Manufacture of metal products	2730	14022	0,194694	562	109,4181
DK Machinery and equipment	5266	16167	0,325725	336	109,4437
DL Electrical and optical equipment	6342	18241	0,347678	380	132,1178
DM Manufacture of transport equipment	3248	13759	0,236064	222	52,40613
Manufacturing n.e.c.	3470	17015	0,203938	2839	578,9791
E Electricity, gas, water supply	5113	23889	0,214032	53987	11554,92
F Construction 451-455	11237	64880	0,173197	1359	235,3743
51 Wholesale trade	8003	57163	0,140003	1621	226,9451
50+52+55 Retail trade, cars, repair	9097	59492	0,152911	2285	349,4024
60 Land transport	2882	16721	0,172358	7784	1341,636
61+62 Air transport, water transport	150	12894	0,011633	18369	213,6924
63 Auxiliary transport activities	1136	13014	0,087291	486	42,42324
J Financial intermediation	27194	218792	0,124292	4521	561,9222
L Pub. admin., defence, social security	6231	51358	0,121325	2985	362,1546
M Education	3057	22622	0,135134	985	133,1069
N Health and social work	6470	47187	0,137114	2006	275,0508
90 Environmental services	874	7093	0,12322	6478	798,2197
92+93 Other service activities	3598	27239	0,13209	1702	224,8172

In the second and third column the data of production is presented, from this we got the factor, which is used to multiply the emissions of these sectors at a national level to derive the emissions in Noord-Brabant. In the same way we could also derive all other contributions of pollutants of Noord-Brabant in the NL. The factor 15.55 we have used for the aggregate production is identical to the factor which was calculated by TME (2005).

Table 5 - Absolute contributions of macro-sectors to output and CO_2 emissions (CBS 2005, 2006)

2002	Output Noord-Brabant	Output NL	Ratio	CO_2 NL Million kg	CO_2 Noord-Brabant Million kg
Agriculture and Fishery A+B	3963	23200	0,170819	9793	1672,83
Industrial production C-F	62720	313652	0,199967	102471	20490,8
Non-Commercial services L-P	20230	155499	0,130097	14156	1841,657
Commercial Services G-K	48462	378076	0,128181	35891	4600,529
$\sum$	135375	870427	0,155527	162311	25243,76

At next we will look at the relative contribution of the sectors to production and to CO_2 emissions. We will see that for example the food sector (DA) contributes 8.47% to output in Noord-Brabant, but only 4.4% to Noord-Brabant's CO_2 emissions. Contrary to that the energy sector (E) contributes only 3.77% to Noord-Brabant's output, and however 45% to Noord-Brabant's CO_2 emissions.

Table 6 - Relative contribution of sectors to output and CO_2 emissions (CBS 2005, 2006)

SIC '93	Noord-Brabant % output	NL % output	NL % CO_2	Noord-Brabant % CO_2
Total economic activities	100	100	100	100
A+B Agriculture hunting forestry fishing	2,92742	2,66536	6,03348	6,62671
C Mining/quarrying	0,12262	1,54993	1,57537	0,12464
DA Food, beverages, tobacco	8,47645	5,34818	2,82482	4,47713
DB+DC Textile, leather products	0,93223	0,48206	0,19346	0,37411
21 Paper products	0,5976	0,63245	0,82496	0,7795
22 Publishing, printing	1,19298	1,51248	0,14602	0,11517
DF Coke, refined petroleum, nuclear fuel	0,10563	1,7357	7,01554	0,42696
DG Chemical products	5,61256	4,13671	9,51075	12,9039
DH Rubber and plastic products	0,92484	0,68748	0,14109	0,1898
27 Manufacture of basic metals	0,73426	0,65152	4,12849	4,65278
28 Manufacture of metal products	2,01662	1,61093	0,34625	0,43345
DK Machinery and equipment	3,88994	1,85736	0,20701	0,43355
DL Electrical and optical equipment	4,68476	2,09564	0,23412	0,52337
DM Manufacture of transport equipment	2,39926	1,58072	0,13677	0,2076
Manufacturing n.e.c.	2,56325	1,95479	1,74911	2,29355
E Electricity, gas, water supply	3,77692	2,74452	33,2615	45,7734

SIC '93	Noord-Brabant % output	NL % output	NL % CO_2	Noord-Brabant % CO_2
F Construction	8,30065	7,45381	0,83728	0,93241
51 Wholesale trade	5,91173	6,56724	1,50698	1,35656
50+52 Retail trade, cars, repair	6,71985	6,83481	1,40779	1,38411
60 Land transport	2,1289	1,92101	4,79573	5,31472
61+62 Air transport, water transport	0,1108	1,48134	11,3172	0,84652
63 Auxiliary transport activities	0,83915	1,49513	0,29943	0,16805
J Financial intermediation	20,0879	25,1362	2,78539	2,22598
L Pub. Admin., defence, social security	4,60277	5,90032	1,83906	1,43463
M Education	2,25817	2,59895	0,60686	0,52729
N Health and social work	4,77932	5,42113	1,2359	1,08958
90 Environmental services	0,64561	0,81489	3,9911	3,16205
92+93 Other service activities	2,6578	3,12938	1,0486	0,89059

As proposed above, we calculate that the share of inhabitants who are living in Noord-Brabant (14.8%) is a good estimation factor to estimate the emissions of consumption in Noord-Brabant.

There exists relative good data on the private traffic in the NL and Noord-Brabant. With help of the data of ETIN Adviseurs it is easy to calculate Noord-Brabant's share of all driven km in NL. The percentage of Noord-Brabant is 15.5%. It should be noted that the emissions of public transport, forwarding, shipping, and haulage are factored in the production sectors. Consequently, we only have to calculate the emissions of Noord-Brabant's private car traffic.

Now we are able to extend the tables above with the emissions generated by consumers. Here we only differentiate between the emissions of private car traffic and emissions stemming from all other consumption activities, like heating.

Table 7 - Relative contribution of sectors and household to output and CO2 emissions (CBS 2005, 2006)

2002	NL Labour input %	Noord-Brabant Labour input %	NL % CO_2	Noord-Brabant % CO_2
Total economic activities (without consumptions)	100	100	81,12711	81,54291
A+B Agriculture hunting forestry fishing	3,462497	3,633459	4,894787	5,40361
C Mining/quarrying	0,140494	0,029946	1,278053	0,101631
DA Food, beverages, tobacco	2,0031724	2,864843	2,291698	3,650782
DB+DC Textile and leather products	0,3761613	0,7386704	0,156945	0,30506
21 Paper products	0,3686079	0,429227	0,669266	0,635629
22 Publishing, printing	1,3007025	1,0880415	0,118459	0,093914
DF Coke, refined petroleum, nuclear fuel	0,092152	0,039928	5,691508	0,348153
DG Chemical products	1,055971	1,696945	7,715799	10,52222
DH Rubber and plastic products	0,5121233	0,728688	0,11446	0,154768
27 Manufacture of basic metals	0,3504796	0,379317	3,349328	3,79401
28 Manufacture of metal products	1,5121988	2,026352	0,280902	0,353444

2002	NL Labour input %	Noord-Brabant Labour input %	NL % CO_2	Noord-Brabant % CO_2
DK Machinery and equipment	1,314298	2,166101	0,167941	0,353527
DL Electrical and optical equipment	1,385301	3,0045917	0,189934	0,426769
DM Manufacture of transport equipment	0,8127502	1,197843	0,110961	0,169283
Manufacturing n.e.c.	2,888435	3,6035137	1,419003	1,87023
E Electricity, gas, water supply	0,4713347	0,429227	26,98406	37,32494
F Construction	7,219578	8,1153923	0,679262	0,760311
51 Wholesale trade	6,647027	7,276901	0,810216	0,733083
50+52 Retail trade, cars, repair	12,42994	12,38770	1,554456	1,536145
60 Land transport	2,763048	3,064483	3,890638	4,333779
61+62 Air transport, water transport	0,774983	0,129766	9,181287	0,690274
63 Auxiliary transport activities	1,293149	0,898382	0,242915	0,137036
J+K+64 Financial intermediation, business services and communication	21,60737	18,47674	2,259709	1,815132
L Pub. Admin., defence, social security	7,183322	5,749650	1,491978	1,169839
M Education	4,905204	4,432022	0,492328	0,429965
N Health and social work	11,447995	10,381314	1,002649	0,888475
90 Environmental services	0,4033537	0,3294071	3,237867	2,578425
92+93 Other service activities	5,276833	4,691555	0,850702	0,726209
Private traffic of consumers	-	-	8,964362	8,97977
Other activities of consumers	-	-	9,908532	9,477312
Aggregated activities of consumers	-	-	18,87289	18,45708
Aggregated total	100	100	100	100

3.3 RAMEA in Malopolska, Poland

The RAMEA for Malopolska was prepared to allow the development of detailed analysis and models regarding the production and consumption as well as the environmental data. The particular application was to find the compromise between the sustainable development and other goals of the macroeconomic policy, i.e. not only the growth of GDP but also redistribution of income and trade balance (de Boo 1991). Besides that RAMEA should form the basis for the creation of sustainability indicators for the economy and households. The important feature of RAMEA in Malopolska was to support the regional programmes of environmental protection – this applied also to other regions participating in the project. The most important was the analysis of the interactions between the economy and environment with the special focus on the assessment of the impact of industry on the environment.

The RAMEA for Malopolska was prepared according to the guidelines of Eurostat (2007). In particular the tables provided in the guidelines were used. The chosen results are presented in Table 8 and Table 9. The data come from different publication of Polish Central Statistical Office (GUS) and from the National Emissions Inventory prepared according to the IPCC guidelines. Output within manufacturing sector is allocated on the basis of the production sold. Moreover the results in the table 6 are restricted to the CO_2 emissions from the plants generating substantial air pollution (PSAP) as these are monitored on the level of sectors and regions. In Malopolska these plants are responsible in total for 11 500 tonnes of dusts (8.5% of total for Poland) and 13 065 700 tones of gases (5.9% of total for Poland). It can be noted that indeed the Malopolska share of gases emissions (5.9%) is on the similar level as the share of electricity production (5.7%). Total emission of CO_2 from PSAP was equal to 219 374 100 tones in Poland and 12 890 755 tones for Malopolska, which is the share of 5.9%. The total CO_2 emission estimated for Poland by the National Emission Centre was equal to 319 082 000 tones. This means that the most polluting plans contribute to almost 69% of the total emissions of CO_2. The sources of the air emissions are power generation plants, industry, municipal and individual heating, transport, secondary sources (e.g. landfills), agriculture and natural sources (e.g. fires, dust storms, cosmic dusts, etc.). The Malopolska share of CO_2 emissions from the plants generating substantial air pollution is equal to approximately 6.39%, which is slightly lower than share the production sold of the industry (sector C, D and E) of 6.41%. The share of Malopolska output is equal to 7.11%, and this of GVA is observed at the level of 7.30%.

The more detailed analysis of economy shows that the biggest contributor to both the output and CO_2 emissions is the manufacturing sector (29.46% to the output, 25.51% to the labour input and 27.08% to the emissions) and within this sector the biggest share of CO_2 is attributed to manufacture of basic metals (15.45%), although it represents only 5.51% of the total production sold in the industry. On the other hand there are two divisions: food, beverages and tobacco and manufacturing of electrical and optical equipment – both of them represent around 15% of the total production sold in the industry while their environmental impact remains relatively low at the level below 0.5%. Sector of electricity, gas and water supply contributes only 2.95% to the output, 2.86% to the labour input, but as much as 64.15% to the emissions of CO_2.

Table 8 – Contribution of production to output, gross value added, employment and CO_2 emissions according to the 2003 RAMEA for Malopolska (PL)

2003		Output Malopolska %	Production sold Malopolska %	Labour input Malopolska %	GVA Malopolska %	CO_2 emissions Malopolska %
Total economic activities		100	100	100	100	100
A+B	Agriculture hunting forestry fishing	3.499856	na	0.677992	2.843478	na
C	Mining/quarrying	0.885918	1.114104	0.478200	1.050875	0.294625
D	Manufacturing	29.461937	90.091414	25.510956	18.029389	27.078429
DA	Food, beverages, tobacco	na	15.368919	5.214469	na	0.445862
DB+DC	Textile, leather products	na	3.298587	2.687696	na	0.047796
DE	21 Paper products	na	1.228079	0.277528	na	0.077045
	22 Publishing, printing	na	4.339816	0.866352	na	
DF	Coke, refined petroleum, nuclear fuel	na	3.422765	0.173411	na	0.344562
DG	Chemical products	na	8.788070	1.597809	na	7.882121
DH	Rubber and plastic products	na	4.312124	1.189607	na	na
DJ	27 Manufacture of basic metals	na	5.511928	0.962379	na	15.448216
	28 Manufacture of metal products	na	8.082937	2.494587	na	
DK	Machinery and equipment	na	3.956205	2.126309	na	0.404486
DL	Electrical and optical equipment	na	14.214006	2.898041	na	0.088459
DM	Manufacture of transport equipment	na	3.893533	1.227420	na	0.306039

2003		Output Malopolska %	Production sold Malopolska %	Labour input Malopolska %	GVA Malopolska %	CO_2 emissions Malopolska %
Total economic activities		**100**	**100**	**100**	**100**	**100**
DN	Manufacturing n.e.c.	na	2.359965	1.034663	na	na
E	Electricity, gas and water supply	2.953531	8.794483	2.858645	2.771626	64.154147
F	Construction	7.872045	na	5.485314	6.346332	8.270199
G+H	Trade and repair, hotels	20.471797	na	16.170323	23.713581	na
I	Transport, storage and communication	6.181445	na	4.616851	6.039765	na
J	Financial intermediation	2.513062	na	2.691566	3.343859	na
K	Real estate, renting, business activities	11.457149	na	6.815796	13.392018	na
L	Pub. admin., defence, social security	3.999631	na	6.696026	6.361992	na
M	Education	3.569022	na	15.583433	6.322934	na
N	Health and social work	3.286388	na	9.541129	4.947069	na
O	Other community, social and personal service activities	3.471014	na	2.873770	4.148228	0.202600

The aggregation of RAMEA results presented in the table 7 is the result of the compromise that was reached to allow the comparison between regions participating in the project (RAMEA 2007). In that form RAMEA allows the multi-faceted analysis of the industry/households environmental impact in the region and as the consequence allow performing the focused action on the basis of analysis performed. Here, the most important is the identification of the most burdensome sources of environmental impact and the possibility of undertaking the actions that are focused on these sources as well as monitoring of these actions effectiveness (via the means of sustainability indicators). Not to be undervalued is the increase of the environmental consciousness in decision makers/making. Other regions are also interested in implementation of RAMEA to their territories – so there is the possibility of application of RAMEA in the neighbouring regions.

Long term goal of Environmental protection policy in Malopolska is the compliance with the air quality norms by consequent reduction of air pollution and emissions. This is planned to be achieved by: improving transport infrastructure (roads), promotion of ecological sources of energy – reduction of coal use and increase of renewable energy sources use.

Table 9 – RAMEA for Małopolska: aggregated version 2003 [%]

Małopolska 2003 [%]		RAM			EA				
		Economic aggregates			GHG	Acidification	Local air quality		
NACE	Industries	Output	GVA	Final Consumption	CO2 eq	H+ eq	NMVOC	CO	PM
A. B	Agriculture, hunting, forestry, fishing	3.5	2.8		0.0	0.1	3.3	-	3.5
C	Mining/quarrying	0.9	1.0		0.2	0.0	2.6	0.0	2.7
D	Manufacturing	29.5	18.0		20.3	0.0	7.8	15.7	14.1
E	Electricity, gas, water supply	3.0	2.8		48.1	0.1	1.2	1.1	6.9
F	Construction	7.9	6.3		0.0	0.0	-	0.5	-
G. H	Wholesale and retail trade, hotels, restaurants	20.5	23.7		-	0.0	-	-	-
I	Transport, storage, communication	6.2	6.0		0.0	0.0	18.4	-	6.8

Małopolska 2003 [%]		RAM			EA				
		Economic aggregates			GHG	Acidification	Local air quality		
NACE	Industries	Output	GVA	Final Consumption	CO2 eq	H+ eq	NMVOC	CO	PM
J-Q	Other services	28.7	39.3		0.2	0.0	49.4	0.1	7.3
07	Households - transport			8.8	17.3	41.2	0.0	17.4	7.7
04	Households - heating			10.3	13.9	58.5	17.3	65.3	50.8
-	Households - other			80.9					
Total – Industries		**100.0**	**100.0**		**68.9**	**0.2**	**82.7**	**17.3**	**41.4**
Total - Households				**100.0**	**31.1**	**99.8**	**17.3**	**82.7**	**58.6**
Total		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

4. Sustainability indicators and possible uses of RAMEA for policy and decision making

The sustainability indicators are strongly connected to the matter of operationalisation of sustainable development. It seems that the only feasible way to operationalise the concept that is claimed to be so vague and ill defined is via the means of indicators. This definitely requires the shift of perspective since the indicators on one hand allows for a great deal of freedom in their creation, but on the other hand they are bearing the risk of measuring not exactly the things that we want to measure. Therefore the quest for single suitability indicator is likely to fail – we need more then one indicator to express the complexity of the issue of sustainability. Also, with larger number of indicators we gain a cross-indicator self controlling mechanisms that verifies the sense of the indicators used.

The attempts to include the environmental account in the national accounts can be dated back to 1960 as it emerged along with the discussion about the welfare measures. The review of these attempts is provided by Lintott (1996) and they include MEW (Measure of Economic Welfare – 1973) by Nordhaus and Tobin, EAW (Economic Aspects of Welfare – 1981) by Zolotas and ISEW (Index of Sustainable Economic Welfare – 1990) by Daly and Cobb.

As it was outlined in the paper by Goralczyk and Stauvermann (2007) it is very important for the regional decision makers to have access to the sound sustainability indicators which will allow them to better understand the interactions between economic, environmental and social matters and to plan accordingly. This means that proper set of sustainability indicators will allow the conversion of regional policy goals into the measures to accomplish them and assess the progress (control and monitoring) as well as the legitimacy of implemented environmental policy. Due to the holistic approach built in RAMEA, the sustainability indicators based on that tool support dealing with the environmental problems where they occur instead of shifting them.

One first prominent indicator is the so-called eco-efficiency indicator (e_i) where we relate the quantity of emissions to the gross value added of an economic sector i;

(4.1) $$e_i = \frac{\text{emissions}\,(\text{kg})}{\text{GVA}\,(\text{Euro})}$$

The smaller the indicator, the more eco-efficient the sector; additionally, we can compare the regional eco-efficiency with the overall eco-efficiency of the country or with other national or foreign regions. From these indicators policy-makers are able to find directly, which sectors of the economy should increase their eco-efficiency.

A second useful indicator can be calculated, if we relate emissions of a sector to the numbers of employed people in the sector, to get something like emission intensity of working places.

A third indicator is to relate the relative contribution of a sector to emissions to the relative contribution to an economic variable:

$$(4.2) \qquad \eta_i = \frac{\frac{E_i}{E}}{\frac{GVA_i}{GVA}} = \frac{E_i}{E}\frac{GVA}{GVA_i}$$

where GVA is the aggregated gross value added, GVA_i is the gross value added of a sector i, E are the aggregated emissions and Ei are the emissions of the sector i. How shall this indicator be interpreted? If $\eta_i < 1$ the relative contribution of sector i to emissions is lower than its relative contribution to the gross value added, if $\eta_i = 1$ holds, then the relative contribution to emissions equals the relative contribution to the gross value added. If $\eta_i > 1$, the relative contribution of sector i to emissions is bigger than its relative contribution to the gross value added. That means a sector with a very low value of the indicator is relatively environmental friendly and a sector with high values of the indicator is relatively environmental harming.

Just another way to look at the tables is to make use of the - in regional economics - well-known Shift-Share analysis. The idea is to disentangle a change between two periods of time into three parts, to compare the regional development with the national one. What can be expected from such an analysis? It could be argued that the Shift-Share analysis makes it possible to account for the regional ecological competitiveness. Additionally it delivers a picture of how well a region's mix of industries is performing, where we also get results for all individual industrial sectors. The components of the analysis are:

- the differential effect;
- the industry mix;
- the allocative effect.

The differential component (or national share) shows us what part if the share of the regional emissions decrease (increase) is attributable to the decrease (increase) of emissions of the national economy. It will be calculated in the following way:

$$(4.3) \qquad NS_{ir}^{t} = E_{ir}^{t-1}\left(\frac{E_N^t - E_N^{t-1}}{E_N^{t-1}}\right)$$

where E represents the quantity of emissions, r represents a region, N the country, i the sector and t is a time index. The next component is the industry mix component, which is calculated by:

$$(4.4) \qquad IM_{ir}^{t} = E_{ir}^{t-1}\left(\left(\frac{E_{iN}^t - E_{iN}^{t-1}}{E_{iN}^{t-1}}\right) - \left(\frac{E_N^t - E_N^{t-1}}{E_N^{t-1}}\right)\right)$$

This component explains how much of the change of emissions can be attributed to the region's mix of industries. The last component is the allocative (or regional shift), which is defined by:

(4.5) $$RS_{ir}^{t} = E_{ir}^{t-1}\left(\left(\frac{E_{ir}^{t} - E_{ir}^{t-1}}{E_{ir}^{t-1}}\right) - \left(\frac{E_{iN}^{t} - E_{iN}^{t-1}}{E_{iN}^{t-1}}\right)\right)$$

This component tells us how much the emissions are decreased (increased) as a result of the characteristics of the region. It also identifies in how far a specific industry in a region is lagging or leading regarding the environment. Then the overall change of emissions is given by the sum of all components;

(4.6) $$\Delta E_{ir} = IM_{ir}^{t} + NS_{ir}^{t} + RS_{ir}^{t}$$

Maybe it is also interesting to know more about the reasons for an increase or decrease of emissions, where we have to take into account, that we are confronted with two effects. One effect is the volume effect, based on the quantity of produced goods. The second effect is caused by technological change, which typically decreases the emissions per output unit or in other words increases the eco-productivity. Beforehand the overall effect is unclear. Let us look at an example. It is well-known that the eco-productivity of cars has drastically increased the last 30 years, but at the same time the number of driven km and cars have drastically increased. On aggregate the emissions of private traffic has increased. In principle we decouple the volume change effect and the technological change effect. To calculate both effects we need the values of the production volume and quantity of emissions of two periods. Unfortunately, the production numbers are measured in basic prices not in constant ones. However it is easy to calculate the production volume changes by using the sectoral growth rates, which are part of the official regional and national accounts. After calculating the volume changes it is easy to calculate the growth rates of the production volume changes y, where it is defined by

$$y = \frac{Y_{t+1} - Y_t}{Y_t}$$

Here Y_t represents the production value in constant prices in period t. The growth rate of eco-productivity Y/E is then defined by:

$$\frac{\partial}{\partial t}\left(\frac{Y}{E}\right) = \frac{\frac{Y_{t+1}}{E_{t+1}} - \frac{Y_t}{E_t}}{\frac{Y_t}{E_t}}$$

If then

$$y < \frac{\partial}{\partial t}\left(\frac{Y}{E}\right)$$

holds, the sector became more sustainable. If the contrary holds the sector became more unsustainable. This indicator tells us something about the overall development of eco-productivity and gives some implicit advice, in what direction policy should work. For example if the relative increase of the volume exceeds the relative increase of eco-productivity, then it seems to be useful to choose a policy-measure which reduces the increase of the volume instead of a policy-measure which enhances the eco-productivity. The reason is to avoid the so-called rebound-effect, which means that a relative increase of eco-productivity must not be exceeded by the relative volume change.

Because of the fact that the term "sustainability" is not well defined and an endless number of definitions exist, we want to derive a minimal condition for social, economic and ecological sustainability. Because of the fact that we do not know the limits of the ecological system we are only able to derive a necessary condition for sustainability. However, if this condition will be violated it is clear that a region is not on a path to reach sustainability. To develop such a condition, it should be clear that economic sustainability is only measured by the GDP (*Y*). All other economic indicators are irrelevant. Regarding social sustainability it becomes more complicated, because e.g. the distribution of income is important and also unemployment, which is still present in Europe. Here we choose the unemployment rate as indicator. Regarding ecological sustainability we have of course a lot of ecological substances, here we choose CO_2 as a representative one.

<u>The minimal condition to reach ecological sustainability</u>:

To reach ecological sustainability, it is clear that emissions must be reduced. That means that the growth rate of emissions must be negative, $e < 0$. Using the definitions explained above, we get the following condition.

A necessary condition for ecological sustainability is then:

$$y < \frac{\partial}{\partial t}\left(\frac{Y}{E}\right)$$

the growth rate of production is lower than the growth rate of eco-productivity.

<u>The minimal condition to reach social sustainability:</u>

Given our indicator for social sustainability (unemployment), it is clear that the number of employees must increase. Defining the growth rate of employment by

$$l = \frac{L_{t+1} - L_t}{L_t}$$

where L_t represents the number of employees. Then it is clear that $l > 0$ should be realized. A necessary condition is then:

$$y < \frac{\partial}{\partial t}\left(\frac{Y}{L}\right)$$

the growth rate of production is lower than the growth rate growth rate of labour-productivity.

<u>The condition to reach economic sustainability:</u>

Following Hicks (1948) the necessary and sufficient condition for economic sustainability is $y \geq 0$. Then we get the following inequality:

$$\frac{\partial}{\partial t}\left(\frac{Y}{L}\right) < 0 \leq y < \frac{\partial}{\partial t}\left(\frac{Y}{E}\right)$$

Optimistically we assume that $y \geq 0$, if this condition is violated we are never on a sustainable path and all other considerations are not necessary. Then it follows that taking all conditions together gives:

$$y - l < y < y - e$$

This inequality reduces to

$l > 0 > e$

Proposition: Given a zero rate of economic growth, the minimal necessary condition for sustainability is $l > 0 > e$. The growth rate of employment is positive and the growth rate of emissions is negative.

The condition is only necessary, because we do not know if the speed of growth to sustainability is sufficiently high; it is a race against time. Nevertheless, this proposition has partly the strong implication that a steady-state growth of the economy could be sufficient for sustainability. Given this statement, we should than concentrate more on the efficiency of institutions and institutional organizations, which are mainly responsible for the state of our well-being and environment. Regarding economic growth there exist two prejudgements, which are questionable taking into account these results:

1. A growing economy works like a bandwagon, also the last compartment will reach the next station, which means that economic growth guarantees an improvement of the well-being of all people.
2. The next prejudgement relies on the “environmental Kuznets curve”, which expresses, that environmental damages will decrease with an increasing income.

However, there exists no convincing proof for one of the prejudgements, and we have shown that it is not necessary, that an economy must grow. Now, as an example, we will check if Noord-Brabant (NB) and the NL were in the period between 2001 and 2003 on a sustainable growth path.

Table 10 - Percent change in economic activities in the NL and NB (2001-2003, %)

Economic activities 2001-2003	change %
Employed persons NB	-1.4
Employed persons NL	-1.3
CO_2 NB	-2.5
CO_2 NL	-5.8
Production NB	1.01
Production NL	1.07

For NL we get then:

$-1.3>0>-5.8 \qquad y=1.07$

the condition was violated, because of decreasing employment. For Noord-Brabant, we get:

$-1.4>0>-2.5 \qquad y=1.01$

the condition was violated, because of declining employment. Unfortunately, the necessary condition was not fulfilled. Consequently, the NL and Noord-Brabant were on an unsustainable growth paths.

6. Conclusions

“*We cannot measure national spirit [or] national achievement by the Gross National Product. The GNP includes air pollution, and ambulances to clear our highways from carnage, […] the destruction of the redwoods and the death of Lake Superior. It grows with the production of napalm and missiles and nuclear warheads. [...] And if the GNP includes all this […] it does not allow for the health of our families, the quality of their education, or the joy of their play. [...] It measures everything, in short, except that which makes life worthwhile*" (Kennedy 1968).

Nowadays policy makers, economists and official Statistics often use GDP as an indicator of the welfare of the societies. However this link is not straightforward: welfare and the broader term well-being depend on more aspects than economic performance alone and therefore benefit from a multidimensional approach.

The reasons why the GDP is not considered to be an appropriate proxy for well-being are many:

- the GDP is simply a gross total of the market value of all final goods and services produced within a country in a given period of time;
- it takes into account only transactions in which money changes hands, resulting in an indicator that ignores improvements in, or harms to, our social structure or our environment;
- it is often referred to as “*a calculator that can add but not subtract*” since it does not make distinctions between productive and destructive activities. Higher crime rates, increased pollution, and destruction of natural resources can show up in the GDP as gains.

GDP do not even measure the sustainability of growth. A country may achieve a temporarily high GDP by over-exploiting natural resources or by misallocating investment. In fact, a country may have an abundance of natural resources that do not have any value according to the GDP until they are destroyed and used for consumption. Non-market factors such as environmental externalities, household production, unpaid child-care, care for the sick or elderly are not counted in the GDP (Matthews 2006).

Following these thoughts NAMEA could be regarded as a comprehensive tool to complement GDP: it provides a valid, transparent and replicable methodology to go beyond conventional economic indicators, which are not sufficient to cover sustainable development issues. The application of NAMEA at regional level (RAMEA) can help policy makers in becoming aware of the integrated effects of consumption and production patterns on the environment, supporting the improvement of regional development policies, which are claimed to face the challenges of sustainability. Data provided by RAMEA (in combination with environmental Input-Output analysis) allows a deeper insight into regional production chains and indirect effects caused by the final demand of goods which production is intensive in terms of pollution.

One of the most interesting aspects is the possibility of benchmarking between regions/nations using a common data framework, which could help understanding strengths and weaknesses in term of different approaches of environmental prevention and economic objectives. The extension of RAMEA with social indicators, even if not treated in this paper, has been proposed and could complete the analysis on the three pillars of sustainability. RAMEA can also be used to inform the public about the decision-making process and chosen strategies to follow a sustainable growth path: to reach this aim, the development and use of integrated economic-environmental indicators can be invaluable.

References

Almunia J (2007), *Measuring progress, true wealth and well being*, speech at Beyond GDP Conference, November 2007, Brussels

Ariyoshi N (2006), *The Development of Japanese System for Integrated Environmental and Economic Accounting: Japanese SEEA and Japanese NAMEA*, Sendai

Bertini S, Tudini A, Vetrella G (2007) *Una NAMEA regionale per la Toscana (A Regional NAMEA for Tuscany Region)*, IRPET, Firenze, E-book, vol. 1, October, online version www.irpet.it/storage/pubblicazioneallegato/148_eBook%20n.1.pdf (in Italian)

Biffignandi S, Fabrizi E (2006), *The relationship between industry localization and Shift-Share analysis*, XLIII Scientific Meeting SIS, Giugno 2006, Torino

Bonazzi E, Sansoni M (2008) Valutazione dell'efficienza emissiva dei gas serra nella regione Emilia-Romagna: un'analisi statistica Shift-Share a supporto dei decisori pubblici, *Valutazione Ambientale*, Edicom Edizioni, vol. 13, 18-25 (in Italian)

Casini Benvenuti S and Paniccià R (2003) *A multi-regional input-output model for Italy*, IRPET, Firenze, Interventi note e rassegne, vol. 22/03, September, online version www.irpet.it/storage/pubblicazioneallegato/34_Interventin.22.pdf

CBS (2005) *The Statistical yearbook*, CBS, Voorburg

CBS (2006) *The Statistical yearbook*, CBS, Voorburg

Choi J S, Schoer K, Schweinert S (2003), Comparison of environmental economic performance in South Korea and Germany, DESTATIS, EEA online publication, Wiesbaden

Commission for European Communities (1994), *Directions for the EU on environmental Indicators and Green National Accounting - The Integration of Environmental and Economic Information Systems*, Communication COM (94) 670, Brussels

de Boo A J, Bosch P R, Gorter C N, Keuning S J (1991) *An environmental module and the complete system of national accounts*, CBS

de Haan M and Kee P (2004) Accounting for Sustainable Development: the NAMEA-based approach, in *Measuring Sustainable Development Integrated Economic, Environmental and Social Frameworks*, SourceOECD Environment and Sustainable Development, Vol. 10(2004), 210-227, September

de Haan M and Keuning S J (1996) Taking the Environment into Account: The NAMEA Approach, *Review of Income and Wealth*, Blackwell Publishing, vol. 42(2), 131-48, June

de Haan M and Keuning S J (2001) The NAMEA as validation instrument for environmental macroeconomics, *Integrated Assessment*, Kluwer Academic Publishers, vol.2, 79-87

De Lauretis R, Tudini A, Vetrella G (2002) *NAMEA air emission accounts: the Istat methodology*, Istat, Roma, online version from UN Statistical Division website http://unstats.un.org/unsd/envaccounting/ceea/archive/Air/Istat_2002_NAMEA.pdf

Eurostat (1999) Pilot studies on NAMEAs for air emissions with comparison at European level, *Studies and research - Economy and finance*, Luxembourg, 139 p.

Eurostat (2000) *NAMEA 2000 for air emissions – Manual and Set of standard tables*, Luxembourg, 35+32 p., July

Eurostat (2001) NAMEAs for air emissions - Results of pilot studies, *Studies and research - Economy and finance*, Luxembourg, 231 p.

Eurostat (2007) *NAMEA for Air Emissions - Compilation Guide*, Eurostat, Preliminary Draft by the ESTAT NAMEA TF, 107 p., September

Eurostat (2008) *Detailed Tables - NAMEA-Air Survey 2006*, Eurostat, Excel workbook, 361 p., January

Foderà R, Pipitone V, Tulumello A. (2005), *Un metodo di lettura del territorio: analisi di contesto per la progettazione integrata territoriale*, Final Report PIT-AGORA project (in Italian)

Goralczyk M, Stauvermann P J (2007) *The Usefulness of Hybrid Accounting Systems for Environmental Policy Advice regarding Sustainability*, paper for the 16th International Input-output Conference, Istanbul

Hicks JR (1948) The Valuation of the Social Income: A Comment on Professor Kuznets' Reflections, *Economica*, vol. 15(59), 163-72, August

Imori D, Guilhoto J J M (2008) *How the CO_2 emissions are related with the Brazilian productive structure*, poster for the International IO Meeting on Managing the Environment, Seville

ISTAT (2006) *Una NAMEA per la regione Lazio: analisi dei dati e note metodologiche*, ISTAT, Roma, online version (www.istat.it/ambiente/contesto/ambientale/nameaanalisi.pdf and www.istat.it/ambiente/contesto/ambientale/nameaguida.pdf) (in Italian)

Kennedy R F (1968) *Speech at University of Kansas*, 18th March

Keuning S J, van Dalen J, de Haan M (1999) The Netherlands' NAMEA; presentation, usage and future extensions, *Structural Change and Economic Dynamics*, Elsevier, vol. 10(1), 15-37, January

Lintott J (1996) Environmental accounting: useful to whom and for what? *Ecological Economics*, Elsevier, Vol. 16(3), 179-190, March

Matthews E (2006), *Measuring well-being and societal progress: a brief history and the latest news*, OECD-JRC Workshop June 2006, Milan

Mazzanti M, Montini A, Zoboli R (2006), *Struttura produttiva territoriale ed indicatori di efficienza ambientale attraverso la NAMEA regionale: Il caso del Lazio*, Università di Ferrara, Università di Bologna, Università Cattolica di Milano (in Italian)

RAMEA (2007), *RAMEA – Case Studies*, project report, online version www.arpa.emr.it/cms3/documenti/ramea/RAMEA_Case_Studies_web.pdf

Schenau S and Hoekstra R (2006) *Present status and future developments of the Dutch NAMEA*, paper for the International Workshop Interactive Analysis on Economy and Environment, Tokyo

TME (2005) *Milieu-Economische Analyse Brabant*, Institute for Applied Environmental Economics, Den Haag

Tudini A, Vetrella G (2003) *Italian NAMEA: air emission accounts for the year1999 - Final Report to Eurostat*, Istat, Roma, online version UN Statistical Division website (unstats.un.org/unsd/envaccounting/ceea/archive/Air/Italia_NAMEA_Air_1999.PDF)

Tudini A, Vetrella G (2004) *Italian NAMEA: 1990 – 2000 air emission accounts - Final Report to Eurostat*, Istat, Roma, online version UN Statistical Division website (unstats.un.org/unsd/envaccounting/ceea/archive/Air/Italian_NAMEA_1990-2000.PDF)

UN (1993) *System of National Accounts 1993*, United Nations, Eurostat, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank, United Nations publications Series F, n° 61, rev. 1, Final draft, 591 p., March

UN (2003) *Handbook of National Accounting – Integrated Environmental and Economic Accounting 2003*, United Nations, Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, World Bank, online version of the 1993 SNA (blue book) http://unstats.un.org/unsd/sna1993/toctop.asp

Zaccomer GP (2005), *La scomposizione della contrazione distrettuale: un'analisi Shift-Share con struttura spaziale sui dati del Registro delle Imprese*, Università di Udine, research note n. 5 (in Italian)