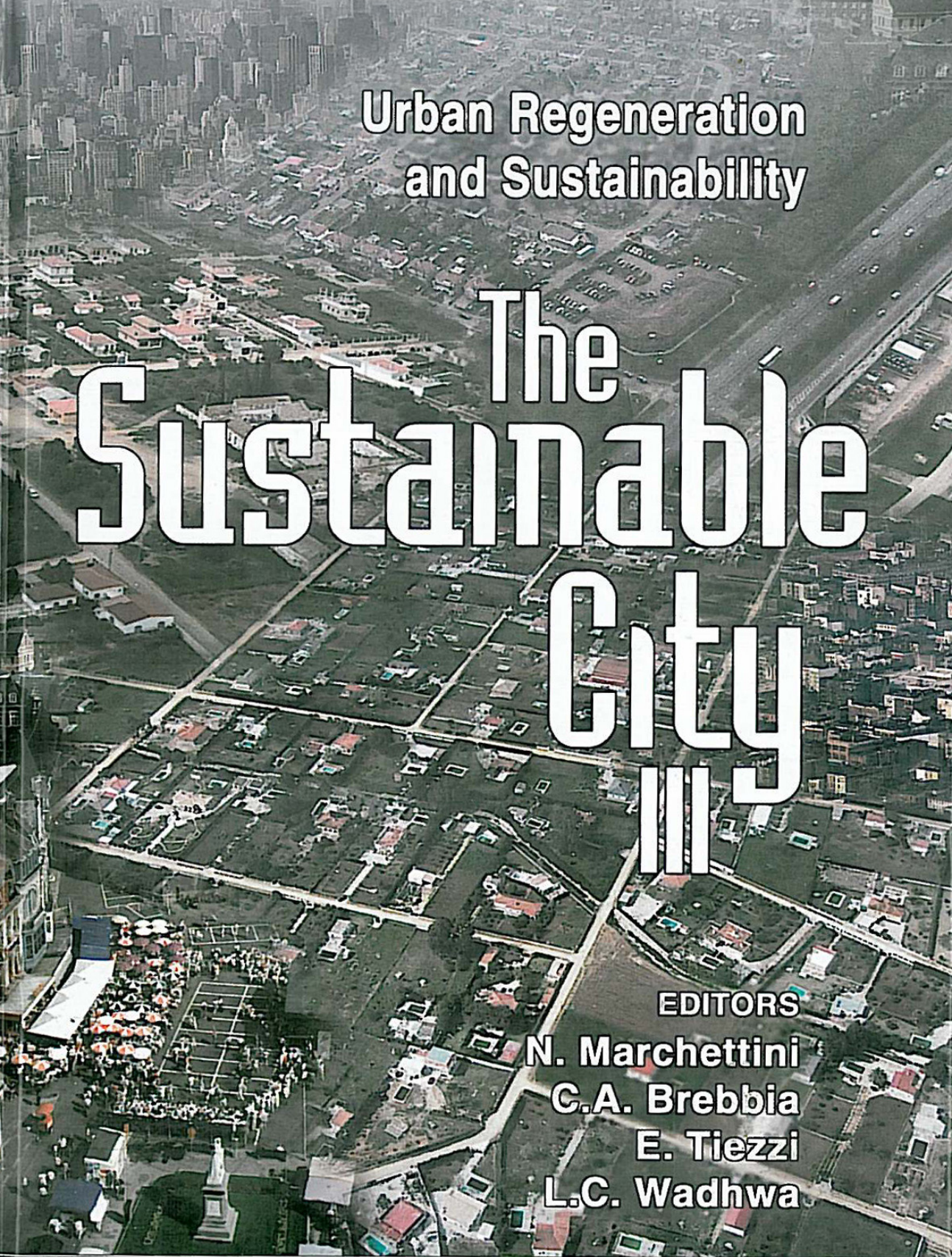

Urban Regeneration and Sustainability

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Emergy flows and sustainable indicators: the strategic environmental assessment for a master plan

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Abstract

The dynamics we observe in human settlements, concerning many overlaid levels and dimensional scales, suggest the emergence of a new urban geography focussed on flows of energies and matter. Nowadays, these new practices are effectively desirable because they provide significant information about the dynamics occurring within a certain area and finally they can be practically involved in many processes of urban planning and territorial management. Furthermore, the appraisal of territorial sustainability is based on the information resulting from specific analysis and synthetic indicators, taking into account all the resources, processes and outputs that characterise a certain system. In fact, an indicator of sustainability is quite different from a traditional indicator of environmental state because it has to be referred to as a target and it depends on a lot of events; it deals with the environmental, economic and social aspects of development.

The application of emergy methodology allows us to provide information about the dimensions and qualities of flows through systems and the outcomes are finally involved in the processes for the Strategic Environmental Assessment of the Structural Plan of Ravenna. The aim is to valuate strategies for future territorial management taking into account the whole system behaviour and its dynamics in exploiting resources.

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1 Introduction

This paper concerns an application of the emergy methodology to appraise and to direct strategic choices within the processes of territorial planning for the Structural Plan in the Municipality of Ravenna, Italy. In particular, this analysis is an assessment of all the consumptions of natural resources occurred within the territory of Ravenna during a period of a year. It considers, besides the common daily uses due to the people needs, all the main activities and land uses that actually have been practiced. In more general terms, this study is aimed to identify, quantify and qualify the main fluxes (changes of energy and matter) flowing through this system and its boundaries.

Furthermore, the outcomes of the analysis are conceived to be applied in the process known as Strategic Environmental Assessment (SEA) for the Plan. The SEA is strikingly involved in all the planning processes during their preparation and before the plan is adopted, by Law and according to the European Council Directive 42/2001.

The Regional Law of Emilia Romagna, L.R.20/2000, and the attached "atti di indirizzo", provides general directives about the expected issues of the local SEA. Its task is to verify the conformity of the planned decisions to the target of territorial sustainable development. More in detail, the process has to provide information for a deeper knowledge of the local environmental context and then to consciously direct the future strategic choices according to this acquired

The Law also says that this young practice necessarily requires an experimental phase and it suggests to develop and to test new methods allowing huge margins of flexibility.

In addition, the report "Strategia di azione ambientale per lo sviluppo sostenibile in Italia", provided by the Italian Minister for the Environment in 2002, and referring to the laws of sustainability by Herman Daly, affirms that a system is sustainable only if the whole amount of resource consumptions never overtakes the due constraints to their exploitation and never overcharges the capabilities of the ecosphere to absorb pollution and wastes. If this issue is not achieved, the economy will continue to overuse natural resources and compromise their quality and availability.

The report also says the description of relevant phenomenon for the sustainable development of a territory requires complex methodologies and synthetic indicators assuring the comparison of data. An indicator of sustainability is quite different from a traditional indicator of environmental state because it has to be referred to a target and it depends on a lot of events; it deals with the environmental, economic and social aspects of development.

In conclusion, as asserted in the Earth Summit of Rio de Janeiro in 1992, directives and strategies are all inspired to the idea that sustainability is a global target that needs to be addressed at the local level.

The application of the emergy analysis within the processes of the SEA is an absolutely new practice now tested for the first time.

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2 Methodology

The emergy methodology is issued to appraise the sustainability of a territory taking into account all the resources which the system feeds on, the transformation processes occurring within its boundaries and its outputs. The expected outcomes of the analysis are in the form of a whole balance concerning the resources deriving from the environment or, in general, the natural capital investment. It is an appraisal of the imp acts due to this local context on the global environment.

In fact, the resources consumption is a phenomenon directly referred to the global problem of resources exhaustion and, indirectly, to the global problem of the emission of greenhouse gases that let the weather change.

This paper will introduce the methodology layout and shorts definitions, referring to thermodynamic keynotes in related papers.

The concept of emergy is based on the assessment of all the natural resources that have been used to provide a certain product or process. For this reason, the name emergy means energy memory and it works to give a measure of quantity and also quality of energy. In fact, the classic theory of energy is not able to classify different energies according to their quality despite it is known that many joules of low quality energy are necessary to provide a few joules of high quality energy. The emergy methodology introduces the concept of Transformity just to give a possible measure of the quality of energy and to compare different kinds of energy by using a common unit, the solar emergy. We define Tranformity the quantity of solar energy necessary to produce a joule of a certain product or process. The emergy of that product or process is the quantity of solar energy spent to provide it. Its unit is the solar emergy joule (sej). So that the Transformity of a product is the emergy of the product divided its energy or its mass (sej/J or sej/g). The transformity is related to each specific process or product and it allows to translate each input in terms of solar emergy jouls (sej) Bigger being the flow of emergy related to a product or process, than bigger it is the consumption of solar emergy that means bigger it is the environmental cost (present and passed) or, at least, the investment of natural capital to let it available.

The analysis of fluxes by the emergy methodology is applied to the territory to define, in quantity and quality, the main changes of energy and matter classifying these fluxes according to their origin and destination.

The outcomes of the analysis will deal with the character of the territorial system according to which and how many resources are locally available or otherwise imported by the outside.

Furthermore, meanwhile the fluxes are drawn in a diagram as kind of vectors identified for their origin and direction, a second classification is made according to the renewability or non renewability of their sources. This scheme is the first provided information about the system behaviour and, even if it is very simple and linear, it works to represent its complexity.

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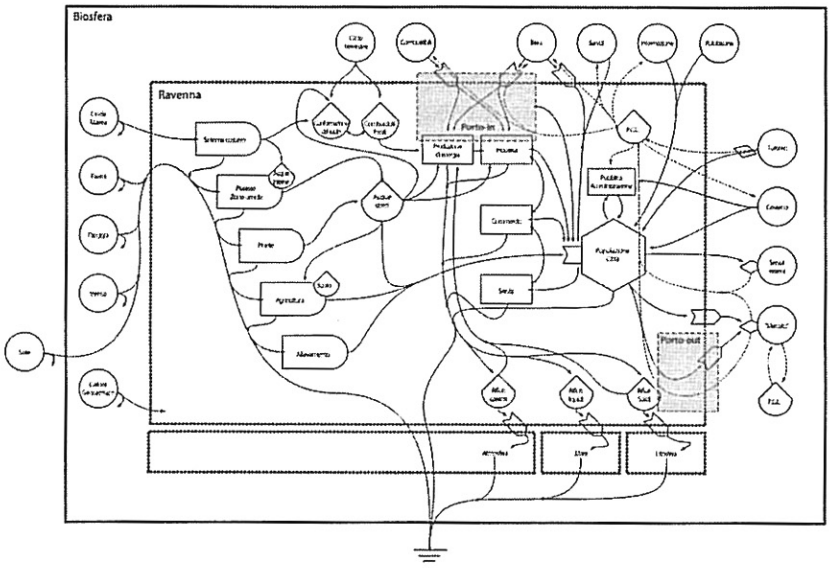

Figure 1: Diagram of the territorial system of Ravenna.

So, the diagram is a schematic description of the flows of resources and transformation processes within and through specific boundaries and it gives a synthetic idea of the relationships between elements and processes in form of fluxes of energy and matter. The emergetic diagram uses the "energy storage symbols" as they were introduced by Howard Odum.

To apply the methodology it is required a deep research of statistical data dealing, on one hand, with the anthropic activities taking place in the territory (productions, consumptions, inputs, outputs, market, etc.), and, on the other hand, with its physical and geo-morphologic features (solar energy, rain, soil erosion, mineral sinks, water, etc.).

The case study is focussed on the municipality of Ravenna. The collected data are referred to a solar year, the 2003. The analysis is based on a sequence of steps, from drawing the energetic diagram, collecting data and processing, finally to assessing outcomes in form of synthetic indicators ordered in a series of tables, graphics and finally in form of maps. The interpretation of the results is the last step of the analysis and it is definitively involved in the practices of the SEA.

Furthermore, the data collecting and also the outcomes of the analysis fallow the frame adopted in the GIS of the municipal urban office that provides maps of the territory organized into 22 Land Units.

In conclusion, the outcomes concern a huge sight on the whole system enhanced also by a detailed view on each Land Unit. For this reason the results are particularly useful in providing information for shaping urban strategies in any local area. Moreover, the interpretation about reciprocal roles played by the

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different Local Units inside the municipality is the essential point for the discussion on targets and actions within the plan.

3 Outcomes

The outcomes of the emergy flows analysis are numbers obtained by an addition or a ratio. The assessment of flows through the transformity represents an environmental value based on the effective resource consumptions occurring during the process. These values are not relevant on their own but the most significant information comes from their reciprocal comparison.

This future of the analysis is the point to understand this methodology. The whole process, besides the final outcomes, allows a deep knowledge of the municipality and each Land Unit. The data collection and their organization into tables, their processing by applying the transformity and their aggregation and classification in flows of emergy, are all single steps that simultaneously collide into the final interpretation of the outcomes.

This section of the paper will not issue extended information about the lot of outcomes obtained in this case study, if not in form of few graphics and maps. Otherwise, it seeks to explain how the results of the emergy analysis provide information about the environment to be applied within the process of SEA for the Plan. In fact, they constitute the background and the mainframe for the appraisal of any proposal for strategic choices. The outcomes of the analysis concerns different levels of information according to the reference scale: that one of the whole municipality and those ones of the 22 Land Units. The results obtained for the whole system Ravenna give information about the exploitation of resources in the territory according to their emergy value. The total flux of emergy calculated in Ravenna is a high value (2,80x1022 sej) that depends on the variety of activities and dynamics occurring within the municipality. Several activities of transformation industry, commerce, services, tourism, beside the density of people, let the value increase. A high percentage (83%) of the all resources are inputs coming from the outside that means there is a presence in Ravenna of many overlocal services managing resources for a huger context. Only the 17% of resources are locally available and, moreover, the analysis also highlights the renewable ones are a small range of less than 1%. The assessment of the renewable resources (solar energy, wind, rain and earth's heat) takes into account the physical dimensions of the local system that means the natural availability of renewable resources within the system despite their real exploitation. So, the low level of the renewable resources depends, on one hand, on the narrow boundaries of the system and, on the other hand, on the low value of their transformity exactly because they come directly from the environment.

These and others groups in which resources have been classified, are provided for the whole system and for each one of the Land Units, always presenting results in form of synthetic indicators (ratios between values related to different groups of resources).

The following maps and graphics represent for each Land Unit the values of the total flow of emergy trough the system, of the renewable resources flow, of

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the non renewable ones and of the emergy flow concerning the only imported resources.

Only a deep investigation on all the values, ratios and indicators, besides the first collection of data, allow to understand the real behaviour of each Unit and its role within the system. Each single indicator cannot provide any useful information about a certain area and, otherwise, it can provide significant information about the same area. That is why the all steps of the process and the several outcomes collide into the final practice of interpretation of the information.

Finally the maps of sustainability give a immediate sight on the whole system with its Land Units. They are a very simple graphical synthesis of the outcomes, conceived as a visual interface. They provide a simple description of the territory and the reciprocal role of the areas suggesting their potential future development in pursuing the future sustainability.

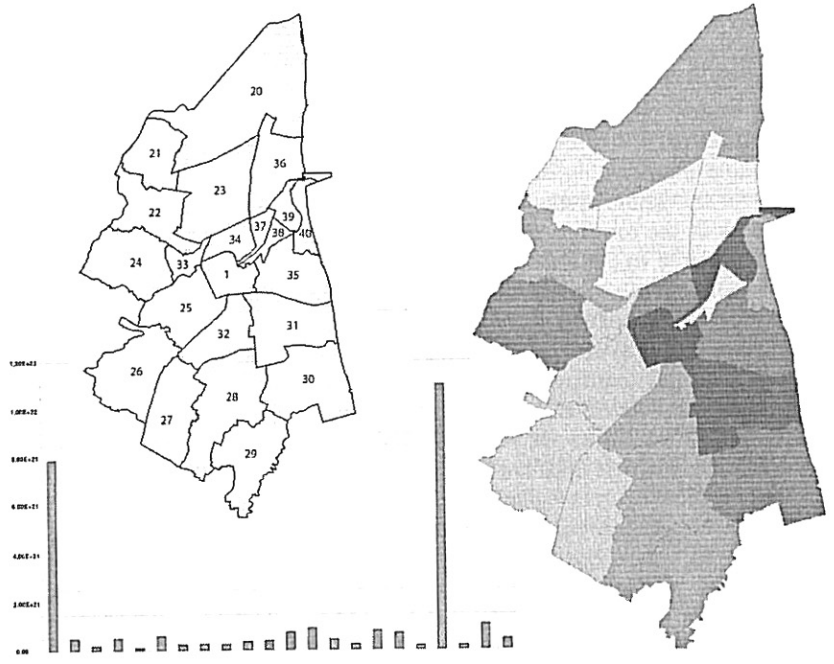

Figure 2: Graphic and Map of the total flow of emergy trough the system for each Local Unit within the Municipality of Ravenna.

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Figure 3: Maps of flows of emergy trough the system referring to renewable resources, non renewable resources and imported resources within the municipality of Ravenna.

4 Conclusions

The main aim of the SEA for the Structural Plan of Ravenna is the investigation of the local dimension of sustainability through the emergy analysis and its outcomes in form of synthetic indicators. According to the information so provided, it has to direct the future strategic choices in order to enhance the welfare of the local community meanwhile decreasing the consumptions of resources and the emissions of pollutants. The theory of thermodynamics and the principles of sustainability and ecological economics, joint with the emergy methodology and sustainable indicators, allow to provide both a background of knowledge and targets to pursue. According to these background and targets, it allows to appraise the state of the system and to verify the possible strategies toward the future development. The best solutions are obviously those ones that let decrease the value of the emergy flows that means decreasing the consumptions of energies and matters within the local human settlement.

In conclusion, the process of SEA will take into account those strategies pursuing the decrease of thermal waste optimizing the exploitation of resources and, in general, improving the exploitation of local renewable resources. It seeks to investigate and perceive all the potentialities of a process represented by an emergy flux and to avoid the exhaustion of that flux without exploiting at all the potential goods provided by the process.

The real application of the emergy analysis during the planning practices concerns practical choices even interacting with other actors, urban planners, stakeholders and policy makers. This paper seeks to give the main principles on

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which is based this work. The planning practices on the structural plan of Ravenna are still happening and this paper gives the general framework on which the SEA is based. The authors will provide detailed information about the interaction with other actors and the effective evaluation of practical choices in future works.

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