Urban sustainable development: indicators for a co-evolution of the economy, the community and the environment

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1. Conventional Economic Approaches to Sustainability

In dealing with (urban) sustainability, it may be useful to start with a review of conventional economic thinking on environmental externalities.

Traditionally, Gross National Product (GNP) has been considered as the best performance indicator for measuring national economy and welfare. But if resource depletion and degradation are factored into economic trends, what emerges is a radically different picture from that depicted by conventional methods.

Is our traditional analytical framework able to incorporate conflicting issues caused by social and environmental costs?

From an epistemological point of view, economists belonging to the **Neo-Classical school** take inspiration from Newton's mechanics, as they tend to believe in value neutrality and objectivity and regard their arguments and statements as "scientific". Rational decisions are connected with the existence of optimal solutions based on calculations in *monetary* or other *unidimensional* terms. Central premises of this economic paradigm are [Klaassen & Opschoor, 1991]:

- the maximisation premise
- the weighting premise
- the fixed content premise.

The *maximisation premise* on behaviour states that "economic men" (individuals and groups) try to maximise their objective function (especially welfare for individuals and profit for enterprises) and individual welfare judgements are the ultimate criterion. According to this assumption, politicians are assumed to maximise their votes and

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bureaucrats their financial budget or power position in other respects. Egoistic motives are assumed to dominate. The economic value of marketable commodities, unpriced environmental goods and services, or sympathy for future generations, is determined according to the amount of personal utility yielded. The preferences of individuals are revealed by the decisions they make and *efficiency and consistency* of decisions reflect rational behaviour. The preference structure is assumed to hold only the *preference* and the *indifference* relations.

The weighting premise on evaluation states that all relevant changes as a consequence of economic decisions can be expressed in a welfare-related, one-dimensional entity, so that costs and benefits of all alternatives can be reduced to neat (ordinal) balance figures that can be ranked so as to identify optimal states of an economic system.

The *fixed content premise* states that a range of parameters are assumed to be static or given, including: institutional arrangements (especially the economic system), preferences and needs, the state of technology and the state and functioning of the environment. Conventional economic frameworks are essentially based on a *closed* economic system consisting of a set of production functions, cost functions, and final demand functions, in which resources, commodities and services can in principle be generated in any combination within the system concerned. Furthermore, perfect information availability to all actors is assumed. Given these assumptions, the existence of a static equilibrium and different extensions to the dynamic case have been demonstrated in the economic literature [Arrow & Debreu, 1954; Solow, 1974].

Finally, we can synthesise the position of standard economic theory towards sustainable development in the following propositions: production is the result of the combination of capital, labour, and natural resources with pollution as an externality. Growth of consumption can be sustained even if production and consumption deplete a natural resource faster than it regenerates if:

- the resource can continuously be substituted for capital, or
- if there is exogenous resource-saving technical progress.

Pearce and Turner [1990], although they are inside the framework of conventional economics, have a different position in approaching environmental problems. They devote their attention to the **desirability and meaning of maintaining the natural capital stock** as a condition for sustainable development. Maintaining the natural capital stock is considered *desirable* for the following main reasons:

1) Complete substitution between natural capital and man-made capital is impossible.
2) There is no guarantee that new technology is necessarily less polluting.
3) The role which natural environments play in supporting and sustaining economic systems is covered by scientific uncertainty. Since *uncertainty* exists on the way in which environments function, either internally or in terms of their interactions with the economy, a trade-off of the benefits of substituting man-made capital for natural capital is not a serious one. Moreover, most environmental decisions are characterised by irreversibility; if a mistake is made, it is not possible to correct it afterwards (it is quite difficult to create again a tropical forest). Thus the presence of *uncertainty and irreversibility* together should make human beings more circumspect about giving up natural capital.

But what does a constant capital stock *mean?* Measurements of natural capital stock made exclusively in physical terms are problematic because of the difficulty in adding up different physical quantities expressed in different units. For this reason the total value of the natural resource stocks should remain constant in real terms. By valuing each resource stock in money terms, the total value of natural capital can be measured.

One obvious problem here is that many natural resources (e.g., air, water, wilderness) do not have observable prices. Thus one would need to find implicit or shadow prices in some way. Even those prices that do exist may not be useful; they may be affected by market imperfections and taxes, and they may exclude externalities involved with the production and use of the resource. "There are additional problems in using market prices to value the aggregate stock of natural capital. Resource prices or net prices reflect conditions at the margin and to use these to value entire stocks can give perverse results. For example, it is possible for the real price or net price of a resource to rise over time at the same rate as (or faster than) the rate of decrease in the physical stock of the resource..... This possibility is of more than theoretical interest. If price or net price rises as resource quantity is declining, the value of resource stocks as an indicator of sustainability can give precisely the wrong policy signal to government. As long as the value of the stock remains constant or rises, the government, through this indicator, will not perceive a problem even though the flow of resource is becoming increasingly valuable (as measured by price) and the physical stock is declining [Victor, 1991, p. 204]".

These problems are unlikely to be overcome easily. Indeed the problem of measuring capital has been one of the fundamental sources of criticism on conventional economics raised by the Post-Keynesian school. The so-called *"Cambridge Controversy"* [Harcourt, 1972] deals with the problem of measurability of capital. Capital here is referred to man-made capital, but the results can easily be extended to natural capital. The *quantity of capital* depends on its value (price), *its value* depends on the rate of interest (the maximum price that a buyer will pay for a capital good is the present value derived from the increase in output over time that is made possible by the acquisition of the capital good, such a present value depends on the interest rate), and the *rate of interest* (price of capital which is determined on the capital market) depends on the *quantity of capital!* The difficulties involved in finding theoretically sound, robust measures of the stock of natural capital may be even greater than those identified by the Post-Keynesians for manufactured capital.

Although the idea of a constant capital stock is quite important and desirable (maintaining the natural capital seems to be an important prerequisite for sustainability), one should admit that the above considerations demonstrate that the development of relevant indicators of sustainable development connected to this idea is quite difficult.

2. Operationalizing Sustainable Development at a Meso and Local Level: the Problem of "Incommensurability"

After our discussion of macro aspects of sustainable development, we will now turn to meso and local dimensions. At a meso scale, the concept of evaluation plays an important role. The traditional evaluation methods, as cost-benefit analysis (CBA) are monetary in nature.

In classical welfare economics, prices resulting from a competitive equilibrium can be considered to be a measure of social opportunity costs. Deviations from the neo-classical model originate from the so-called *"market failures"*. Market distortions such as monopoly, taxes, price regulations and disequilibria often play an important role in the economy. As a result, prices may be bad indicators of the real scarcities and pertaining social evaluations in the economy. Some set of prices, called *shadow or accounting prices*, which reflect the true social opportunity cost of using resources in a given project, need to be computed. In general, we would expect the marginal cost of a final good to indicate society's valuation of that good, since the marginal cost reflects consumers' willingness to use resources in that situation. As a first approximation, shadow prices are assumed to reflect marginal costs. Clearly, if market prices are to be corrected so that they reflect marginal costs, there is a *practical* problem of estimating marginal costs and a *conceptual* problem of justifying the procedure in the face of the second best theorem. Furthermore, marginal private cost will still not fulfil the role of a proper shadow price if private and social cost diverge. An important cause of divergence is the presence of an important category of market failures contributing to environmental degradation, viz. *externalities* . In order to deal with the problem of consequences that are not priced at all on a market, neo-classical economists use the concept of externalities. Pollution can then be considered as an external diseconomy. The necessity of operationalizing the externalities concept in environmental management has led to the following typology of theoretical responses to externalities:

(1) optimisation
(2) compensation
(3) internalisation.

As noted by Verhoef [1993], consensus on the exact definitions and interpretation of these concepts seems to be lacking in literature. However, the following definitions seem to be relevant [Verhoef, 1993, p. 6]:

- an externality is *optimised* when its level is consistent with Pareto efficiency according to the Kaldor-Hicks criterion;
- an externality is *compensated* when a (financial) transaction takes place between the supplier and the receptor of the effect, which compensates for the welfare effects due to the externality;
- an externality is *internalised* if a market for the effect comes into being.

Optimisation is an efficiency related concept, whereas compensation is an equity related concept[1]. Generally it is said that cost-benefit analysis focuses on *efficiency* criteria. But, any policy decision affects the welfare positions of individuals, regions or groups in different ways; consequently, the public support for a certain policy decision will very much depend on the *distribution effects* of such a decision. Given that society is unlikely to be indifferent between various distribution of

1) The compensation principle is very important in the measurement of social costs: if utility is regarded solely as an ordinal concept, how - even in principle - can the disutility imposed on different members of society be aggregated? The solution which has been most commonly adopted is the so called *"compensation principle"* usually associated with the names of Hicks [1939] and Kaldor [1939]. By this, the social cost of a given output is defined as the sum of money which is just adequate when paid as compensation to restore to their previous level of utility all who lose as a result of production of the output in question. In other words, the Kaldor-Hicks principle declares a social state y "socially preferable" to an existing social state x if those who gain from the move to y can compensate those who lose and still have some gains left over. Such a situation is consistent with a Pareto improvement since we have x indifferent to y for the losers (once they are compensated) and y preferred to x for the gainers (if they can over-compensate). It is just this principle which underlies cost-benefit analysis. If the monetary value of benefits exceeds the monetary value of costs, then the gainers can hypothetically compensate the losers and still have some gain left over. The excess of gains over required compensation is equal to the net benefits of the project.

Since the compensation principle was formulated, it has been attacked from several sides. Amongst the most important contributions to the debate are those of Scitowsky [1941] who first noted the possibility that the undertaking of a project without the payment of compensation may redistribute income in such a way that an ex post application of the compensation test yields a different answer from an ex ante one, and Little [1950] who stressed the value content of the approach and the need to take distributional factors into account.

The Kaldor-Hicks test requires only that gainers be able to compensate losers, it does not require actual payment to be made. Scitovsky demonstrated that in absence of compensation, it is possible for circumstances to exist such that once the change has come about, a move back to the status quo can also be judged socially desirable. In essence what happens is that the change is desirable when valued at the new set of prices that emerge from the new distribution of income resulting from the policy change. Since, in general, no mechanism exists for the transfer of funds from beneficiaries to losers, the Scitovsky paradox rises considerable doubts upon the usefulness of the Kaldor-Hicks formula, and ergo upon this aspect of the welfare foundations of cost-benefit evaluation [Johansson, 1987].

Many decisions will lead to widespread price changes, resulting in some consumers paying more for goods they purchase, and others less. Scitovsky [1954] has termed such effects *pecuniary externalities*. Price changes themselves redistribute income; for every consumer who pays more, a producer receives more, and vice versa. Therefore, if we are adopting the compensation principle, such changes are to be ignored. Once again, it is necessary to stress the lack of concern for distributional questions embodied in this way of measuring social costs.

income, some ways of integrating the distributional aspects into the analysis have to be found. For instance, cost-benefit analysis tries to include distribution values directly in the analysis by using different weights for different social groups [Helmers, 1979]. The main limit of this approach is that it is not clear how to derive such weights and who should attach these ones. In any case, if weights are used, it has to be recognised that no completely objective analysis is possible, and therefore no optimal solution exists. Finally, it has to be noted that failures to use any weighting system implies making the value judgements that the existing distribution of income is optimal. If, and only if one is happy with such a value judgement, it is reasonably possible to use unweighted market valuations to measure costs and benefits. Therefore, there is no escape from value judgements.

The internalisation model can be regarded as a crucial tool in conventional economics, because only in this way one may assign an amount of money to environmental decay. However, it has to be noted that such a model does not aim at achieving a better environmental quality, but only at incorporating the environmental impacts in the traditional price and market system (after internalisation, market forces will take over, and thus no room for political intervention exists).

Finally, one should note that since externalities are characterised by the absence of markets, there will also be an absence of observable prices. Many external effect problems therefore reduce the issue of valuing "intangibles": in order to be consistent with the objective of maximising social welfare, it is necessary that the prices attached to the physical benefits and costs reflect society's valuations of the final goods and resource involved. Then a question immediately arises: if markets do not exist, how are surrogate prices to be derived which, in turn, reflect social valuations?

The basic idea behind *implicit markets* is that there are links between the consumption of ordinary goods sold on markets and the consumption of non-marketed goods, including environmental values. Thus, changes in environmental quality are also reflected in prices of ordinary goods, such as land and houses. But sometimes it is not possible to make inferences from actual behaviour; thus one may have to measure consumer preferences in hypothetical situations or by creating *artificial markets*. This approach is often called contingent valuation.

The aim of contingent valuation is to elicit valuations (or "bids") which are close to those that would be revealed if an actual market existed. Respondents say that they would be willing to pay or willing to accept if a market existed for the good in question. In order to determine the value of environmental goods and services, economists try to identify how much people would be willing to pay (*willingness to pay"* (WTP)) for these goods in artificial markets. Alternatively, the respondents could be asked to express their *"willingness to accept"* (WTA) compensation. The respondents must be familiar with the good in question and with the hypothetical means of payment (payment vehicle). The limitations inherent in this method have been well formulated by Costanza and Perrings [1990]: "the quality of results in this method depends on how well informed people are; and does not adequately incorporate long-term goals since it excludes future generations from bidding in the markets. Furthermore, the problem with these techniques is that respondents may answer "strategically". For example, if they think their response may increase the probability of implementing a project they desire, they may state a value higher than their true value (free rider problem)".

One has to note that willingness to pay measures can be criticised from both the intratemporal and intertemporal points of view. As we have noted before, WTP depends upon the ability to pay, thus projects which benefit higher income groups are generally considered to be the best. Furthermore, society as a whole, may have values that deviate from aggregated individual values. Society has a much longer life expectancy than individuals; thus the value society attaches to natural resources and the environment is likely to deviate from individual values, since the simple summation of individual preferences may imply the extinction of species and ecosystems. This implies that environmental policy cannot merely be based upon the aggregation of individual values, and estimation of willingness to pay at any particular point of time [Klaassen & Opschoor, 1991].

The concept of a shadow project is of fundamental importance to answer the question whether CBA is consistent with a goal of sustainable development. If the Pearce and Turner definition of sustainable development is accepted, the answer is yes. This is providing that the government receives sufficient shadow projects to offset environmental damages, so that across a portfolio of public investments, net environmental damage is zero. However, besides the aggregation problems inherent in this definition of sustainability already extensively discussed, there are problems here, both in measuring environmental impacts and in designing shadow projects which fully compensate. The idea is that the costs of deterioration of a natural area or of a historical building can be assessed from the costs of creating an equivalent project elsewhere (a so-called "shadow project"). The shadow project need not necessarily be actually implemented; it has only significance as an indirect step to gauge the costs of intangible losses of the original project. It is clear that a basic problem of the shadow concept is the definition of an equivalent project. Certain projects are unique as a result of a long historical, cultural or ecological development, so that the *time dimension* plays a crucial and sometimes prohibitive role in the definition of a shadow project. In addition, the *spatial dimension* must not be neglected, because the value of a certain project is co-determined by its accessibility. If the shadow project has a different accessibility, the compensating costs must be corrected for travel time differences. One should be aware of the fact that a shadow project has only a concrete meaning if its site is known. The creation of a shadow project at a different place affects in turn the land use at that place; thus here again, a second shadow project would have to be defined in order to calculate the intangible losses due to the shadow project. In this way, a whole chain of shadow projects might be defined, which probably would lead to an indeterminate solution.

Finally, one has to note that a frequent ethical criticism of valuation methods is that natural resources, human life and health are not economic assets and hence cannot be valued in economic terms. We do not maintain that a human life has infinite value; for example, a reduction in road accidents can be secured at some cost, but society is unlikely to devote the whole of the national income to this end. Logically, any intangible has a value, but *in practice* the derivation of this value may be impossible; *intangible and incommensurable* effects are very hard to incorporate in a conventional economic analysis. Therefore, the conclusion is justified that any attempt to transform a priori heterogeneous and unpriced impacts into a single dimension runs the risk of failure.

3. A New Economic Paradigm for Sustainability: Ecological Economics

The linkages between ecosystems and economic systems are the focus of **ecological economics** [Costanza, 1991; Martinez Alier, 1987]; and therefore this third main stream will now be discussed.

The "fixed content premise" is replaced by one of circular interdependence incorporating the major processes in the environment and taking into account essential biophysical laws (e. g. the laws of thermodynamics). There is a constant and active *interaction* of the organisms with their environment. Organisms are not simply the results but they are also the causes of their own environments. The concept of *evolution* is a guiding notion for both ecology and ecological economics. Evolution is the process of change in complex systems through selection of transmittable traits. The evolution of such systems is neither entirely deterministic nor entirely stochastic, but a subtle mixture of both. Economic development can be viewed as a process of adaptation to a changing environment while itself being a source of environmental change. However, evolution does not imply change in a particular direction (i.e., progress). The interrelations between ecosystems and economic systems concern the dynamic structure, function, and performance of compartments in both systems and the flows and feed-backs between these compartments [Norgaard, 1988, 1994].

These compartments include also significant institutional, political, cultural, and social factors through which action is carried out. Thus instead of the "maximisation premise" and the "weighting premise", a *holistic or inclusionist* approach to economic and policy-making is emphasised [Myrdal, 1973, 1978; S'derbaum, 1992]. Concerning environmental issues, *conflicts* between interests and interested parties are the normal state of affairs. The previous discussion points in the direction of disaggregated approaches to decision making and resource management rather than aggregated ones. Impacts of different kinds should be kept separate; impacts related to different interests or interested parties should be kept separate, as should impacts referring to different periods or points in time [Söderbaum, 1992], thus the problem of incommensurability is explicitely recognised..

Environmental management is essentially conflict analysis characterised by technical, socio-economic, environmental and political value judgements. Therefore, in an environmental planning process it is very difficult to arrive at straightforward and unambiguous solutions. This implies that such a multi-related planning process will always be characterised by the search for acceptable compromise solutions, an activity which requires an adequate evaluation methodology. Multiple criteria evaluation techniques aim at providing such a set of tools. Multicriteria methods provide a flexible way of dealing with qualitative *multidimensional and incommensurable* environmental effects of decisions.

From an ecological economic perspective, the expansion of the economic subsystem is limited by the size of the overall finite global ecosystem, by its dependence on the life support sustained by intricate ecological connections which are more easily disrupted as the scale of the economic subsystem grows relative to the overall system. Since the human expansion, with the associated exploitation and disposal of waste and pollutants, not only affects the natural environment as such, but also the level and composition of environmentally produced goods and services required to sustain society, the economic subsystem will be limited by the impacts of its own actions on the environment [Folke, 1991]. A central issue then is: does any *optimal scale* exist for the economy? This point has especially been tackled by Daly.

The term scale is shorthand for "the physical scale or size of the human presence in the ecosystem, as measured by population times per capita resource use [Daly, 1991, p. 35]". Traditionally, the theoretical focus of economics is on prices and the issue is to internalise external environmental costs to arrive at prices that reflect full social marginal opportunity costs. In this way, in theory the problem of *efficient allocation* can be solved. Under ideal conditions the market can find an optimal allocation in the sense of Pareto. Another problem is the *just distribution*; the market's criterion for distributing income is to provide an incentive for efficient allocation, not to attain justice. These two values can conflict, and the market does not automatically resolve this conflict. Generally there is agreement that it is better to let prices serve efficiency, and to serve equity with income distribution policy. But the market cannot find an optimal scale any more than it can find an optimal distribution. The latter requires the addition of *ethical criteria*, the former requires the addition of *ecological criteria* thus a multidimensional paradigm is needed.

Thus the standard economics point of view about economic growth seems quite optimistic. But as an economy grows, it increases in scale. Scale has a maximum limit defined either by the regenerative or absorptive capacity of the ecosystem, therefore "until the surface of the earth begins to grow at a rate equal to the rate of interest, one should not take this answer too seriously [Daly, 1991, p. 40]".

In conclusion, we can identify three main conflictual values of economics, allocation (efficiency), distribution (equity), and scale (sustainability). While an optimal allocation in theory could result from the individualistic marketplace, the attainment of an optimal scale (or at least of any scale that is not above the maximum carrying capacity) requires *collective action by the community on a regional, national or international level according to the problems faced.*

4. Sustainable Development at a Urban Level

We will now address in more detail the notion of sustainable development in a spatial context. Sustainable development has of course a global dimension, but it is also increasing recognised that there is close mutual interactions between local and global processes. In particular, cities are open systems impacting on all other areas and on the earth as a whole. Therefore, an urban scale for analysing sustainability is certainly warranted.

Especially in the European context, the reinforced focus on the city seems warranted, as the European countries are facing a stage of dramatic restructuring and transition as a consequence of the move towards the completion of the internal market. However, the aim to make Europe more competitive in economic terms may be at odds with its environmental sustainability. In the long history of Europe numerous cities with an extremely valuable and vulnerable socio-cultural heritage have emerged which deserve strict protection in the interest of current and future generations. Therefore, what we are facing here is a problem of ecologically sustainable urban development. This is now more important, as some 80 percent of European people lives in cities.

Sustainable development is not a predetermined end state, but a *balanced and adaptive evolutionary process.* Sustainability in an urban setting describes the potential of a city to reach qualitatively a new level of socio-economic, demographic and technologic output which in the long run reinforces the foundations of the urban system. The urban sustainability ensures a long-term continuity of the urban system. In summary sustainable cities are cities where socio-economic interests are brought together in harmony (co-evolution) with environmental and energy concerns in order to ensure continuity in change.

Most cities exhibit drastic changes patterns, varying from rapid decline to rapid growth. Though urban development is a complex and multidimensional phenomenon, it is increasingly realised that, in addition to demographic, social, environmental and residential quality aspects, also technology and innovations may be regarded as a major driving force behind urban economic dynamics. In addition, it is also recognised that a favourable urban structure may stimulate new activities in the city [Nijkamp. 1991].

Despite changes in roles and despite stages of relative decline and progress, an indigenous feature of an urban system is its struggle for life, in the sense that its final aim will be to survive. However, the aim of continuity is not a random phenomenon, but is to be based on competitive market. Total demand on this broad market is more or less given, and hence the only possibility of an urban system to attract a maximum share of this market is to be as competitive as possible. In many cases this may require a complete restructuring of the economic, environmental, industrial and technological base of the city. Thus, continuity or survivoship does by no means imply a stable evolution.

One may argue that sustainability, as a social science interpretation of the continuity objective of a species, may be conceived of as a plausible development objective of a city in a competitive environment with other cities.

Urban sprawl rests on a trade-off of agglomeration economies (notably economies of scale and scope including higher wages) versus diseconomies (e.g. population density and environmental decay). It is likely that environmental quality problems may become more severe with urban size, however factors as the land use, the transportation system and the spatial layout of a city are also critical factors for determining the *"urban environmental carrying capacity"*.

A necessary condition for implementing an effective planning system for urban environmental management is the development of a system of suitable urban environmental indicators. Such indicators which should represent a balance between the necessary quality of information and the costs involved, would have to be related to economic, social, spatial and cultural dimensions of the city. Thus a multicriteria framework is relevant here.

For example, urban development means the creation of new assets in terms of physical, social and economic structures, but it is at the same time recognised that each development process often also destroys traditional physical, social and cultural assets derived from our common heritage. Clearly, although not always immediately computable, all cultural assets represent an economic value which has to be considered in any urban transformation process. Unfortunately, the inclusion of such assets in the planning process often cannot be left to the market mechanism, as most urban historico-cultural assets represent "unpriced goods" characterised by external effects which are not included in the conventional "measuring rod of money" [Nijkamp, 1988].

Monuments represent part of the historical, architectural, and cultural heritage of a country or city, and do not usually offer a direct productive contribution to the economy. Clearly, tourist revenues sometimes may reflect part of the interest of society in monument conservation and/or restoration, but in many cases this implies a biased and incomplete measure, so that monument policy can hardly be based on tourist value. On the contrary, in various place one may observe a situation in which large-scale tourism does affect the quality of a cultural heritage (e.g. Venice). Thus, the socioeconomic and historical artistic value of a cultural good is a multidimensional indicator or *"complex social value"* [Fusco Girard, 1986]

Another example can be found in energy-environmental planning strategies. In particular, at the urban level it is an extremely important activity in the framework of sustainable urban development for some reasons.

First, there is the obvious reason that most production, consumption and transportation activities in a country take place in urban areas.

Second, decentralisation of energy and related environmental policy has become a major device in current policy-making in most Western countries. The city is a natural institutional decision unit in this context, as it covers a well focused study area without running the risk of a heterogeneous policy structure with many horizontally organised planning agencies.

Finally, in terms of efficiency of data gathering and of availability, the city is usually a more suitable statistical entry providing systematic data sets on environmental, energy and socio-economic indicators.

It is noteworthy that energy plays a critical role in sustainable city policy.

There are various ways of saving energy in the urban environment. House-hold activities and consumption, industrial and commercial activities, and transportation are, in addition to electricity production, the main sources of energy use. Many European experiences have shown that considerable savings are still possible.

In general, urban energy planning may comprise a whole set of different and complementary energy policy strategies such as industrial cogeneration, district heating, combined heat and power (CHP) generation (using steam turbines, internal combustion engines, gas turbines or combined cycle gas turbines), combined urban waste management and energy production, load management, and institutional reforms in the structure of utilities.

At a more integrated and intermediate level of urban energy planning, various possibilities are offered by central heat distribution, by recycling of energy from heat, by combined heat and power either in district heating or in cogeneration, or by using urban/industrial waste as fuel for geneating plants. The evaluation of all these different alternatives can be done in a multicriteria framework too.

5. Multicriteria Evaluation in Urban Sustainable Development Planning

We have seen that efficiency, equity and sustainability are the three main objectives of economics. We have also seen that multidimensionality and incommensurability are a normal feature of sustainability problems at any spatial scale. In this section, we will discuss the possibility of operationalising efficiency, equity and sustainability in an urban planning context.

To tackle efficiency and sustainability objectives, economic-environmental integration is needed. Models aiming at structuring these cross-boundary problems of an economic and environmental nature are usually called *"economic-environmental"* or *"economic-ecological" models* [Braat & van Lierop, 1987; Hafkamp, 1984]. It is clear that in policy-relevant economic-environmental evaluation models, socio-economic and nature conservation objectives are to be considered simultaneously. Consequently, multicriteria methods are in principle, an appropriate modelling tool for combined economic-environmental evaluation issues.

In urban policy-making the following two main types of policy objectives may be distinguished:
(1) Efficiency: spatial-economic competition
(2) Sustainability: carrying capacity and conservation.

In the context of conflicting interests, it is noteworthy that in environmental management there is often an interference from local, regional or national government agencies, while there is at the same time a high degree of diverging public interests and conflicts among groups in society. At an *intrarurban level* many conflicting objectives may exist between different actors (consumers, firms, institutions, etc.), which can formally be represented as multiple objective problems and which have a clear impact on the spatial organisation of a certain area (e.g. industrialisation, housing construction, road infrastructure construction). At a *multi-city level* various spatial linkages exist which affect through spatial interaction and spillover effects a whole spatial system (e.g. diffusion of environmental pollution, spatial price discrimination) and which in a formal sense can be described by means of a multiple objective programming framework. At a *supra-city level* various hierarchical conflicts may emerge (e.g with the regional or central government).

Conflictual interests are connected to any planning problem. Two basic situations can be distinguished:

(1) *Broad Commonalty of Goals*, i.e., differences among parties are revealed through various trade-offs which they perceive to be most in their interest.

(2) *Direct Conflict of Goals*, i.e., a case where public policy involves an explicit division of resources among different sectors of the society or where attitudes have led to unreconcilable strong differences (e.g. environmentalists versus industrialists).

From an operational point of view, the major strength of multicriteria methods is their ability to address problems marked by various conflicting interests. Multicriteria evaluation techniques cannot solve all these conflicts, but they can help to provide more insight into the nature of these conflicts by providing systematic information into ways to arrive at political compromises in case of divergent preferences in a multi-group or committee system by making the trade-offs in a complex situation more transparent to decision-makers.

In multicriteria evaluation equity issues can be considered in three different ways:

1) by weighting the criteria (but this is always difficult);
2) by introducing a set of ethical criteria (but this could lead to an excessive number of criteria);
3) in Munda [1993b] it has been proposed to integrate multicriteria evaluation with conflict analysis procedures. In particular, equity issues are taken into consideration by means of a fuzzy conflict analysis procedure. Starting with a matrix showing the impacts of different courses of action on each different interest/income group, a fuzzy clustering procedure aimed at indicating the interest groups whose interests are closer in comparison with the other ones is used.

A major problem is whether a cardinal metric system is an appropriate tool for multicriteria evaluation. This will be further discussed in the next section.

6. Qualitative Multicriteria Evaluation

The presence of incommensurable and intangible effects, creates the general problem of handling qualitative information. For the sake of simplicity, we will refer here to *qualitative information* as information measured on a nominal or ordinal scale, and to *quantitative information* as information measured on an interval or ratio scale (this last type of information is also called *crisp* information).

Another problem related to the available information concerns the uncertainty contained in this information. Ideally, the information should be precise, certain, exhaustive and unequivocal. But in reality, it is often necessary to use information which does not have those characteristics, so that one has to face the uncertainty of a stochastic and/or fuzzy nature present in the data. If it is impossible to establish exactly the future state of the problem faced, a **stochastic uncertainty** is created; this type of uncertainty is well known it has been thoroughly studied in probability theory and statistics. Another type of uncertainty derives from the ambiguity of this information, since in the majority of the particularly complex problems involving men, much of the information is expressed in linguistic terms, so that it is essential to come to grips with the fuzziness that is either intrinsic or informational typical of all natural languages. Therefore, a combination of the different levels of measurement with the different types of uncertainty has to be taken into consideration.

Fuzzy uncertainty does not concern the occurrence of an event but the event itself, in the sense that it cannot be described unambiguously. This situation is very common in human systems. Spatial-environmental systems in particular, are complex systems characterised by subjectivity, incompleteness and imprecision (e.g., ecological processes are quite uncertain and little is known about their sensitivity to stress factors such as various types of pollution). Zadeh [1965] writes: "as the complexity of a system increases, our ability to make a precise and yet significant statement about its behaviour diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics" (*incompatibility principle*). Therefore, in these situations statements as "the quality of the environment is good", "the unemployment rate is low" are quite common. Fuzzy set theory is a mathematical theory for modelling situations, in which traditional modelling languages which are dichotomous in character and unambiguous in their description cannot be used. Human judgements, especially in linguistic form, appear to be plausible and natural representations of cognitive observations. We can explain this phenomenon by *cognitive distance*. A linguistic representation of an observation may require a less complicated transformation than a numerical representation, and therefore less distortion may be introduced in the former than in the latter.

In traditional mathematics, variables are assumed to be precise, but when we are dealing with our daily language, imprecision usually prevails. Intrinsically, daily languages cannot be precisely characterised on either the syntactic or semantic level. Therefore, a word in our daily language can technically be regarded as a fuzzy set. Fuzzy sets as formulated by Zadeh are based on the simple idea of introducing a degree of membership of an element with respect to some sets. The physical meaning is that a gradual instead of an abrupt transition from membership to non-membership is taken into account.

Given the assumption of a second best world, multicriteria evaluation may be considered an appropriate tool to operationalize efficiency, equity and sustainability criteria, multicriteria methods able to deal with mixed information can be considered particularly useful [Munda et al., 1994].

Multicriteria methods provide a flexible way of dealing with qualitative multidimensional effects of decisions. However, this does not mean that multicriteria evaluation is a panacea which can be used in all circumstances without difficulties; it has its own problems. A discussion on the principles of multicriteria decision aid (*mcda*) can be found in Munda [1993a].

An example of a multicriteria method that may use mixed information (ordinal/cardinal) is the so-called *regime* method; this method is based on pairwise comparison operations; from this point of view it has something in common with outranking methods. However, it is based on a weighted linear additive model, thus it may be classified as a utility based method [Nijkamp et al., 1990].

Another interesting method able to tackle mixed information is the *evamix* method [Voogd, 1983]. The *evamix* approach concerns the construction of two measures: one only dealing with the ordinal criteria and the other one dealing with the quantitative criteria. By making various assumptions about standardisation and aggregation, several methods can be defined by which an appraisal score for each alternative can be calculated.

A problem, connected to all multicriteria methods that try to take mixed information into account, but that is particular evident in the *evamix* approach is the problem of equivalence of the used procedures in order to standardise the various evaluations of the performance of alternatives according to different criteria.

A new multicriteria method, based on some aspects of the partial comparability axiom, called *naiade* (Novel Approach to Imprecise Assessment and Decision Environments) has recently been developed [Munda, 1993b]. It is a discrete multicriteria method whose impact (or evaluation) matrix may include either *crisp, stochastic or fuzzy measurements* of the performance of an alternative a_n with respect to a judgement criterion g_m, thus it is very flexible for real-world applications. From an empirical point of view, this model is particularly suitable for economic-ecological modelling incorporating various degrees of precision of the variables taken into consideration. From a methodological point of view, two main issues are then faced:

- the problem of equivalence of the procedures used in order to standardise the various evaluations (of a mixed type) of the performance of alternatives according to different criteria;
- the problem of comparison of fuzzy numbers typical of all fuzzy multicriteria methods.

7. A Short Illustrative Example

This case study concerns the city of Enkhuizen (in the province of North-Holland in the Netherlands). The city houses an interesting musuem on the history of the interior lake of the Netherlands. The construction and opening of a new exterior part of this musuem requires sufficient parking facilities for private cars.

The city itself is an extremely interesting old place characterised by an impressive architectural and historico-cultural heritage which deserves strict protection, so that parking policy in this city does not only have a *transport* aspect but also a *conservation* aspect. The city is also a centre of *tourism*, with a strong orientation towards water sports.

In view of many conflicting issues, an exploration of all possible relevant locations for a sufficiently large parking lot, which woulf favour visits to the musuem and the old city without being in conflict with the historical value of the place itself, can be made by using multicriteria analysis.

Seven alternative locations can be taken into consideration:

(1) a location near a former cement factory in the city
(2) a location on a camping site next to the museum
(3) a location on a camping site in a recreation area
(4) a more distant location next to a cemetery
(5) an extra-urban location
(6) a semi-extra urban location
(7) a location near the sluices of a new dike (annex provincial road).

A major problem is not only formed by the land use and the location of the parking lot, but also by various routes that can be chosen by tourists to reach a particular parking lot. This may vary for each distinct alternative, so that a given location can be subdivided into some variants. The total number of meaningful choice options appears to be 15 in this case.

Eight evaluation criteria can be used:

(1) a maximum number of visitors, arriving by cars and buses, to the museum should use the parking lot
(2) the parking lot should be as close as possible to the museum
(3) the parking lot should have a good accessibility
(4) the construction costs of the parking facilities should be as low as possible
(5) there should be a minimal disturbance of the quality of life
(6) the architecture land and the historical character of the city should be strictly protected
(7) recreational functions should not be disturbed by the parking facilities
(8) the loss of the remaining functions of the area to be used for parking should be minimised.

Clearly these criteria are qualitative and quantitative in nature. The qualitative criterion scores, e.g. accessibility, disturbance of life, etc, can be represented by both ordinal numbers or linguistic variables, thus the aplication of one of the above described qualitative multicriteria methods is meaningful.

It should benoted that the city has chosen as the best compromise solution alternative 7. This alternative results to be almost dominant by using ordinal criterion scores (only criterion 1 conflicts); however, by using the *regime* method, such an alternative results to be the best even in the extreme case in which a very high weight is given to criterion 1.

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Abstract

This paper will deal with the notion of sustainable development starting from a general *meta-level* of analysis and arriving to an *operational level*.

Central premises of conventional economics are: the maximisation premise, the weighting premise and the fixed content premise. The maximisation and the weighting premises lead to the use of monetary evaluation methods, thus assuming complete commensurability between different viewpoints. The fixed content premise leads to the well known optimistic attitude towards economic growth.

The Pearce and Turner approach in order to be operationalised, also needs a valuation of resource stocks in money terms. Ecological economics explicitely recognises that incommensurabilitiy and multidimensionality are normal features of economic-environmental processes. Thus instead of the "maximisation premise" and the "weighting premise", a *holistic or inclusionist* approach to economic and policy-making is emphasised, going in the direction of disaggregated approaches to decision making and resource management rather than aggregated ones. Thus an "economic axiomatization" of multicriteria evaluation methods can be found in the framework of ecological economics.

The "fixed content premise" is replaced by one of circular interdependence incorporating the major processes in the environment and taking into account essential biophysical laws (e. g. the laws of thermodynamics). The concept of *evolution* is a guiding notion for both ecology and ecological economics. Economic development can be viewed as a process of adaptation to a changing environment while itself being a source of environmental change (co-evolution).

Then the concept of sustainable development at a urban level is examined. It is shown that concepts as co-evolution and carrying capacity are very important at a urben level too. Thus a co-evolutionary development will depend on a balance between efficiency, equity and environment. Is it possible to operationalize these issues in a urban planning context?

The operationalization of efficiency, equity and sustainability objectives in a urban planning framework is examined by taking into consideration multicriteria evaluation. Particular emphasis is given to the role of information precision and uncertainty, and a brief survey of some relevant multicriteria methods is also given. Finally, an application to the locations of parking facilities in a historical town is presented as an illustration of urban sustainability policy analysis.

There aren't abstracts in italian language and in french language because they aren't furnished by the Author; so we are sorry.
Il n'y a pas les résumés en italien et françaíse pas evoyés par l'A.; nous Vous prions de nous excuser.
Mancano i sommari in lingua italiana e in lingua francese non forniti dall'autore; ci scusiamo vivamente di ciò.