TØI report 686/2003
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Oslo 2003, 39 pages, Norwegian language

Summary:

Appraisal in integrated land use and transport planning with sustainability objectives

Sustainability has emerged as the overarching objective of urban land use/transport planning. In the words of the Brundtland Commission (1987), sustainable development is '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs'*. It is possible to subsume all the objectives of urban land use/transport planning under this objective, and the main objective of the present report is to show how this can be achieved in a consistent way.

The PROSPECTS approach to land use and transport planning

The PROSPECTS project, funded by the European Commission under its Fifth Framework Programme, has produced three guidebooks on urban land use and transport planning with sustainability objectives. *The Decision-Makers' Guidebook* is aimed at politicians and other stakeholders and introduces a structured approach to such planning. *The Methodological Guidebook* is concerned with the technical methods. It is aimed at planners and builds on the same logical structure as the Decision-Makers' Guidebook. *The Policy Guidebook* is a manual for picking policy instruments and composing strategies. A preliminary version is to be found on http://www.transportconnect.net/konsult/index.html. Other documents from the projects, including the guidebooks, are found on http://www-ivv.tuwien.ac.at/projects/prospects.html.

Transport, land use and the environment are linked together, and planning needs to take this into account. On the other hand, the links to other markets and activities in the city may be so much weaker that we can ignore them and treat the volume of production, the income level etc. as exogenously given. With this, we have defined the system that we are planning for. We consider it meaningful to talk about a sustainable land use and transport system, without considering other consumption and production in the city.

Of course, the planning takes place within a certain given context, consisting of the institutional framework, demographic forecasts and assumptions about income growth, national policy such as car and fuel taxation, available technologies, given constraints on land use etc. This context, as it develops over time, is called a *scenario*. Within this, or across different scenarios, *strategies* consisting of a set of available policy instruments are tested by implementing them in a model system. The policy instruments include pricing instruments, infrastructure provision, public transport policies, restrictions etc. *Barriers* on the use of the policy instruments and on available finance will have to be considered.

To be able to select or recommend a best strategy, rank strategies, discard useless and unacceptable strategies or select a set for further study, an appraisal framework must be devised. How are we to appraise the sustainability of strategies?

Our starting point is to define a sustainable land use and transport system. The PROSPECTS' definition is:

A sustainable urban transport and land use system

- *provides access to goods and services in an efficient way for all inhabitants of the urban area*
- *protects the environment, cultural heritage and ecosystems for the present generation, and*
- *does not endanger the opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage.*

From this definition we derived the following six objectives, all of which belong as aspects of the overarching objective of urban sustainability[1]:

1 *economic efficiency*
2 *liveable streets and neighbourhoods*
3 *protection of the environment*
4 *equity and social inclusion*
5 *safety; and*
6 *contribution to economic growth.*

To take account of these objectives in a way that brings about sustainability, however, we need an objective that does not concern any single year. Rather, it concerns how we trade off the achievements in the various years against each other. So we require

7 *intergenerational equity.*

Standard cost-benefit analysis[2] will be a good indicator for the level of goal achievement with respect to objectives 1, 3 and 5, and to a certain extent also with respect to objective no. 6. For objectives 2 and 4, PROSPECTS developed own indicators. The indicators that were developed for objectives 1 – 6 could be combined to form an objective function or be used separately to set targets. (Targets are defined as the level of the indicators that is necessary to bring about a sustainable urban land use and transport system). A third possibility is to combine some of the indicators to form the objective function, while keeping others separate and set targets for them. Note that indicators will have to be computable from model output, since we are engaged in planning for the future, not in measuring present progress.

Our problem is now how to define the objective function, and how to take account of objective no. 7 in it?

Chichilnisky's theorems

According to Chichilnisky (1996), sustainability implies that planning should take account of problems that may appear in the very distant future. Global warming, nuclear waste and biodiversity are examples that come to mind. Based on this, she formulates two requirements on an objective function that is going to be used to assess policies with long-term effects: It should neither be a dictatorship of the future nor a dictatorship of the present. A dictatorship of the future is an objective function where the interests of those living now – or any given number of years from now – carry no weight. The objective function only cares about benefits and cost as time goes to infinity. A dictatorship of the present is an objective function where what happens after a certain point in time – closer or more distant, and regardless of the consequences it may entail – is of no importance for policy selection. When these concepts are made mathematically precise, she is able to show that a standard cost-benefit analysis is a dictatorship of the present, regardless of the discount rate chosen. She is also able to show that a weighted sum (a linear combination) of a standard cost-benefit analysis and the undiscounted annual net benefit as time goes to infinity is the only possible mathematical form of an objective function that is neither a dictatorship of the future nor a dictatorship of the present.
Thus there are strong theoretical grounds for adopting this mathematical form for an objective function that is meant to reflect intergenerational equity.
Applying this insight to land use and transport planning poses certain problems. It does not make sense to use an integrated land use and transport model to make forecasts very far into the future. 30 years seem to be a maximum. So how to handle long-term effects then?

Appraisal in PROSPECTS

In PROSPECTS we used an objective function that was a linear combination of a standard cost benefit analysis and the undiscounted net benefits of year 30. For this to make sense, conditions in year 30 will have to be a good indicator of the long-term (i.e. sustainable) conditions. For instance, green areas built down in year 30 could be considered lost forever. In addition, we will have to try to make year 30 as "sustainable" as possible. So we require targets to be met in year 30 with respect to for instance CO_2-emmissions, intragenerational equity, traffic accidents, and conservation of green areas. A deficit in government account should not be allowed for year 30, since such deficits cannot be carried on indefinitely.

Thus we discard strategies that do not achieve targets for selected indicators in year 30, and rank the remaining strategies according to their objective function value. This way, the appraisal framework takes account of all objectives belonging under sustainability:

[1] Some of the objectives represent groups of sub-objectives rather than single objectives. This is particularly true for objectives 3 and 4.
[2] As performed in Norway, i.e. including costs of emission.

- The objective function covers the efficiency and intergenerational equity objectives as well as aspects of the environmental, accident and growth objectives.
- Other objectives, including more ambitious long-term accidents and emission objectives than those implied by the CBA values, are covered by setting targets for year 30.

It might not be optimal to force the path towards sustainability to take only 30 years, and so some compromises may have to be made in setting the targets. Nevertheless, if we cannot predict more than 30 years ahead, then if we want to apply the Chichilnisky objective function at all, we have to identify benefits as time goes to infinity with the year 30 benefits.

Under the assumption that sustainability is reached in year 30, we might as well assume that all years after that are identical. Thus we can let the CBA element of the objective function run from year 0 to infinity. This makes the objective function formally identical to Chichilnisky's function and solves some problems of discontinuity and scrap values at year 30.[3]

The approach requires the participation of decision-makers at various points in the planning process: defining objectives and their priorities, choosing possible policy instruments, setting targets and possibly using the results to reconsider priorities and targets.

Optimal strategies

The PROSPECTS appraisal framework may be applied to test selected strategies or to find the best possible strategy, given the available policy instruments (optimisation). Algorithms have been developed to find the strategy that maximises the objective function subject to other indicators reaching their target levels. These algorithms consists in repeated runs of the model system, charging the strategy from run to run according to some rule. To a certain extent we are able to optimise dynamic strategies, where the levels of the policy instruments may change over time. For use in optimisation, the model system should be relatively simple, while still reflecting the whole range of behavioural responses and environmental impacts. PROSPECTS case studies made the first experiments to optimise with dynamical strategies, and it seems this might produce new insights.

Even if we are not prepared immediately to accept the "optimal" strategy, the optimisation procedure is useful. It is able to produce strategies previously not thought of and to produce new knowledge about the complex ways policy instruments interact.

[3] This idea was suggested to us by Lars-Göran Mattsson. It is not in the Methodological Guidebook.