Sustainable Mobility in an Ecological Economics Perspective - some problems with relating sustainable development to transport.

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1. Introduction

"Sustainable mobility" has been suggested by the European Commission as an overall goal for a European transport policy. It was launched in the Green Paper on The environmental Impact of Transport and was given additional support in the Transport Policy White Paper itself.

The policy documents themselves do not suggest a clear definition, and the content of the documents does not offer much help. One is actually left with the impression, that nobody knows what they are talking about. This confusion is most regrettable, as the term already is becoming widely used.

Anyway, the commission has clearly confronted a vastly important problem, even though they may not have given the answers: Can transport or mobility be made compatible with the notion of sustainable development? In other words how should transport activity and transport policy be conducted to secure, that we serve the need of the present without compromizing the ability of future generations to meet their needs?

It would be clear to most people, that this is a problem. Current growth pattern of transport represents an important part of the environmental problems we have to face. Transport is responsible for more than 25% of CO_2-emissions in Western Europe and growing. It has an even greater share of oil consumption, and it is main contributor to problems such as acid rain, forest dieback and the formation of tropospheric ozone, not to mention the problem of health and quality of life in

urban areas, which are strongly affected by mobile sources.

Possibly a clearer notion of "sustainable mobility" could supply us with criteria for selecting goals, instruments and projects related to these problems. We have therefore set ourselves the task to work on the conceptual questions arising from confronting transport and mobility with sustainable development.

In doing so we have been searching for an analytical platform. Our point of departure has been the area of so-called ecological economics (EE). EE is a rapidly developing interdisciplinary research field, which by its proponents is labeled as "The science and management of sustainability." [Costanza 1991]. Main issues of EE is exactly to establish operational principles of sustainable development and to apply them to practical policy issues. However, the operational principles have so far mostly been applied to micro-scale case-studies within sectors like agriculture, forestry and fisheries, that is, sectors of primary production. To our knowledge, no one has yet tried to apply the sustainability ideas of EE to transport.

So, what we will do in this paper is to focus on some problems with relating an analytical concept of sustainable development to different notions of transport. We will:

1. Indicate what sustainable development means within EE
2. Describe the operational criteria they suggest.
3. Discuss what is to be sustained - is it the transport system, is it the mobility level, or what is it?
4. Apply the operational principles of sustainable development to the relevant notions of transport.
5. Conclude,
   a. Whether current mobility satisfies operational sustainability criteria of EE,
   b. Whether the approach of EE is sufficient to make operational principles of sustainable development, or if other approaches are needed.

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2. Sustainable development

The term sustainable development was launched as a policy goal in the Brundtland report. The emphasis was mainly on the ethical issue of justice within and between generations.

As an analytical concept sustainable development has been explored within economics as well as in ecology. It is associated with the stability and evolution of systems of production and consumption.

In ecological economics (EE), a considerable effort is conducted to make the concept of sustainable development operational, combining concepts and results from the two disciplines. EE puts the issue of preserving the life-supporting natural systems in the forefront of the research agenda, not for its own sake, but because of its importance for human production and consumption.
According to EE, there is a limit to the *scale* of the economy, which is set by the need to sustain the carrying capacity of the ecosystems and resources of the globe. The first research task is to define that scale. Secondly the fair *distribution* of resources and output from the economy within and among generations of humans should be settled. Only then we should concern ourselves with efficient *allocation* of resources, maximizing the net benefits, as is the issue in traditional econo-

mics.

However, EE is not satisfied with a division of labor between ecologists and economists. The aim is to integrate the concepts. One suggestion is to treat nature as a certain type of capital. The so called "Natural capital" is present in the forms of non-renewable resources such as minerals and renewable resources, which include the ecosystems. This natural capital is able to provide us with certain types of goods and services, much in the same manner as human capital (skills and knowledge) and manufactured capital (machinery, technology). Sustainable development requires that we preserve the natural capital base separately, or at least manage it in an intelligent manner. In this paper we use this term although we are aware, that it is not without conceptual problems.

The idea of natural capital shows an important distinction in the concept of sustainable development, namely a 'weak' and a 'strong' concept [Turner 1993].

Weak sustainability represents the idea held by many traditional neo-classical economists, that the capital base should remain intact to secure sustainable development, but natural resources can be substituted by man-made capital and vice versa if there is a demand for it. Normally the market will take care of the substitution rate. As certain ecosystem services are not traded in the market, however, other valuation techniques may be applied to support the market mechanism. This can give some trouble in assessing the long term opportunity values of 'natural capital'. We may even have to make a rule (known as the Hartwick rule [Common and Perrings 1992]) in order to secure that the rents from depleting non-reproducible capital are invested in reproducible capital. However, according to mainstream economists, these are mainly problems of methods, not problems for the theory itself.

Strong sustainability represents the view of EE, which consider strong limits to substitution between natural capital and the other capital types. Costanza and Daly [1992] defines the relation between capital types as a complementary one and not a substitution relation. We can shift our dependence on natural capital from one type to another but we can't do without it. The idea of a "dematerialized" economy is thus a dangerous illusion. We must account for the natural capital separately. The problem of the market failing to reflect some environmental value is not (only) a methodological issue, it is a genuine limitation to traditional economic theory.

There are many positions between weak and strong sustainability. The main point is, that EE want us to put far more emphasis on the value of the natural systems.

3. Guiding Principles of Sustainable Development in Ecological Economics

In an attempt to operationalize sustainable development EE proponents Robert Costanza and Herman Daly have defined four guiding principles of sustainable development, based on the idea of strong sustainability. They are:

"(1) The main principle is to limit the human scale to a level which,_, is at least within the carrying capacity of the remaining natural capital and therefore sustainable
(2) Technological progress for sustainable development should be efficiency-increasing rather than throughput-increasing,
(3) RNC {renewable natural capital}, in both its source and sink functions should be exploited on a profit-maximizing, sustained-yield basis, and in general stocks, should not be driven into extinction since they will become ever more important as NNC {nonrenewable natural capital} runs out.

(4) NNC should be exploited, but at a rate equal to the creation of renewable substitutes." [Costanza and Daly 1992]

The first, third and fourth principles deal with natural capital. They seem mainly designed to apply to activities depending directly on natural capital, like agriculture and fisheries or to the natural capital of the economy as a whole.

The formulation of the second principle, concerning efficiency, differs from the others in two ways. First, it describes a desired direction, rather than a stability condition. Furthermore, it can be applied to any activity, including transport, since it is not specific for natural capital. The efficiency idea is inherited from traditional economics, but when applied this way it is a more 'natural science' criterion.

For us these four principles all seem relevant to an ecologically sustainable social system. What is remarkable is however, that the development part of sustainable development is hardly treated at all. The criteria's mainly reflect sustainability as a more or less static condition of stability, they do not give much guidance on how to deal with aspects related to improving the quality of life, changing society or developing other aspects of human conditions. Qualitative notions are lacking.

It is also worth noticing that Costanza/Dalys principles do not include anything about the distribution issue, although the three guidelines for EE are sustainable scale, equitable distribution and efficient allocation (cf previous chapter).

These omissions may be drawbacks for making the principles operational for a 'moving target' such as transport, which moreover involves many distribution issues. Before confronting the two issues we will however take closer look on transport.

4. Transport, Mobility and Access

If we want to sustain something, we must have a clear picture of exactly what it is we want to sustain [Tisdell 1991]. According to the EU commission, it is the mobility. But is mobility a goal in itself or is it something else we want? Can mobility be de-linked from the physical transport activity? In the following we will briefly discuss some relevant terms.

Transport and traffic

Transport is a physical unit measuring the movement of people and goods, mileage x individuals (or tonnes). Traffic measures things such as mileage or flow. As mere units transport and traffic can hardly be 'sustainable'.

Transport sector

The activity of the transport sector is the transport of people and goods. Can we have a sustainable transport sector? One might say, that the transport sector does not serve any natural purpose by itself. It mainly yields service to other economic activities, like some production process, which can increase its economic efficiency by spatially separating the processing. The transport sector does not support any natural capital buildup. On the contrary it consumes large amounts of natural capital (in the form of energy consumption and physical outputs such as pollution, noise, damaged land, etc.). The sector itself could therefore never satisfy strong sustainability criteria. It could only be justified in its relations to other sectors.

Transport system
Looking at the transport system is to take a broader view. A transport system includes the means and instruments of motion. The main functions are fuels, vehicles, infrastructure and the skills of the driver. The production of these functions involves parts of other sectors. All these functions would have to be provided and linked for the system to work and be sustained.

A transport systems perspective may be more easily related to notions of sustainability, at least at a conceptual level. It may even be tempting to compare transport systems with a 'modern' concept of ecosystems in order to get some guidance and policy lessons of sustainable systems in general.

According to Holling et al. [1994] ecosystems are very complex and do not follow any general laws. Some important characteristics of ecosystems are however:

i) change is not continuous and gradual, but episodic
ii) spatial attributes are not uniform or scale invariant
iii) ecosystems do not have single equilibria with functions controlled to remain near them
iv) policies and management that apply fixed rules for achieving constant yields, independent of scale, lead to systems that increasingly lack resilience i.e. to ones that suddenly break down in the face of disturbances that previously could be absorbed.

These characteristics seem applicable for transport systems, if the intention is to maintain their structure and functions to society. Episodic changes are for instance seen, when traffic suddenly is breaking down over large areas of the network. A new equilibrium may have to be established not by fixed rules but, e.g., by changing the supply of public transport through subsidies or by introducing entirely new types of systems like suburban trains. One should probably apply different policies for breakdowns at a local and an international scale. There are not sufficient 'functions' to secure that the system equilibrium does not deplete the natural capital base of the system.

But the analogies should not be taken to far. Important differences between ecosystems and transport systems are that the demand pattern for transport is rapidly developing and human decisions making are required, when there is a structural crisis or breakdown. These decisions are not a part of the system itself.

Mobility
Mobility is a difficult term with various interpretations. On the one hand it might be seen as a measure of the potential for people and goods to be moved, and thereby satisfy various demands. The more social or economic functions we (can) reach by moving about and the easier we can reach them, the higher is our mobility. In this sense mobility is a problematic term for sustainability, as it indicate increasing capacity to exploit still more remote resources, increasing detachment from the local physical surroundings, increasing distances and/or speeds, and no reflection on the impact from moving about.

On the other hand mobility could be a general term encompassing every aspect of transport activity, including the physical transport systems, our travel behaviour, the structural causes of mobility, and the qualities and values attached to moving about and the negative impact from it. If we include all this as aspects of mobility we would at least be able to discuss more or less sustainable levels and modes of mobility.

In neither case there is any guarantee, that current mobility levels can be maintained without heavy

net consumption of natural capital. 'Mobility' is a modern social concept, which may deceive us to think that we can move about without physical impact.

Accessibility
Accessibility is sometimes regarded as the ultimate purpose behind transport and mobility. The deception of the mobility concept may tempt us instead to define some basic needs or demands, which everybody should have access to. Sustainable access could then be considered the (physical) kind of access to serve these demands, which demand the lowest level of mobility.

This idea would inevitably involve very problematic assumptions about what are basic needs and what are not. Moreover it suggests, that mobility is the least sustainable way to acquire the necessary access, and this may not always be the case. This depends entirely on the physical means of mobility. We therefore reject the notion of defining some absolute access as criteria for 'sustainable mobility.' But access would be an important criterion when comparing for instance telecommunication based services with physical mobility based services.

Summing up
We have not identified an absolute term, which we want to sustain as the most important. Transport systems must be available, but not necessarily in the current structural form. Mobility should be considered as only one way among others to gain access to what is in demand, and the mobility notion should incorporate all the elements of natural capital that are prerequisites and consequences of moving around. Access must be secured, but we could hardly define a comprehensive set of demands when measuring the relevence of mobility.

One may rather use the terms in a relative manner to compare various more or less mobile and more or less consumptive ways to organize production and consumption of society. For instance the 'sustainable mobility' strategy of the EU Commission seems to be access to more functions with increasing mobility, increasing transport, increasing traffic but less direct environmental impact. Clearly other strategies are conceivable that probably were more compatible with sustainable development.

5. Discussion of sustainable mobility criteria

We now return to Costanza/Dalys four principles from chapter three, using the different concepts of sustainability and the different terms of transport. What problems do we find?

(1) Scale
Costanza/Dalys' first principle is about the scale of economic activity, related to natural capital in both its resource and sink functions. Could a proper scale of transport, mobility or access be established?

The first step would be to establish the proper overall scale of the entire economy, referring to ecological carrying capacity and the investment rule for non-renewable capital. Then we should seek for criteria to decide how large a share transport be allowed to "consume" within this overall frame. As the natural capital is to be preserved, increased environmental loads from transport would only be allowed, if other sectors compensate for this by reducing their contribution to the depletion of the natural capital.

However to define these partial shares of each subsystem would be difficult, as each subsystem has entirely different impact on the environment. As long as there is not one measuring unit of natural

capital, this would be a difficult task. We need to operate on many scales at the same time. Within EE some have suggested thermodynamic units to measure the productive potential of natural capital, but we will not go into this. If one measure could be established, than the partial shares of each subsystem could be defined from the distribution and efficiency criteria.

(2) Efficiency
Technology should increase efficiency not throughput is the second principle.

This is a critical issue for transport, because increased efficiency of transport systems usually leads to increased throughput. In fact, the usual efficiency criterion for transport relates exactly to its ability to increase the throughput. Increased amounts of people, goods and traffic through the system are often the result, when for instance a new motorway, a new traffic-light algorithm or a new logistics principle like just-in-time, is applied. We often see, that increasing throughput AND increasing resource use walk hand in hand, under a cover of efficiency improvements.

We therefore need a more comprehensive approach to justify increasing efficiency in the transport sector. The efficiency that must increase is the throughput per unit of resource use. In traffic, this could for instance mean that the fuel efficiency must increase more than the amount of vehicle kilometers. This is exemplified with the target that the sector must not increase its CO2-emissions. But we would have to consider the consumption of natural capital of the transport system as a whole. It might be no use to have cars that consume less oil, if the composition of materials in the cars becomes more energy intensive. In any case, the efficiency of transport (consumption of natural pr unit of mileage, mobility, economic contribution, access etc.) would be important to monitor and control.

(3) Renewable natural capital
Renewable natural capital, should be utilized in a sustainable way (non-declining income from "harvest") as the third principle.

As it is today, this does not seem much of an issue within transport because transport is supported almost entirely by non-renewables. The lack of any active natural capital stock to maintain, could in itself be seen as an indication of 'unsustainability' of transport. It is completely dependent on outside supply. The only renewable capital type used by transport is the consumption of ecosystem services due to damage from various kinds of pollution.

There are no physical but only economical reasons, that renewable resources do not have a place in transport today. Transport was only some hundreds of years ago almost completely supported (and restricted) by renewable natural resources (wood, wind, manpower, etc.). Again, in the future there is potential for introducing renewable resource bases for transport, which could yield the same technical performance as todays non-renewables, for instance biomass fuels or electricity based on renewable sources.

However, increasing the use of renewable natural resources in transport is clearly not a sustainability criterion in itself. It is equally important how the resources are managed, accpording to Costanza/Dalys' third principle. We have not studied, whether this is the case of current projects of biofuels for mobile sources. Moreover it is dubious, if the current energy use for transport can be substituted by biofuels [Höyer and Selstad 1993].

(4) Non-renewable natural capital

Non-renewable natural capital, NNC, should be exploited, but at a rate equal to the creation of renewable substitutes.

As already indicated, this process has not taken place at all, as transport has become increasingly dependent on non-renewables such as oil, metals and plastics. The rents from the use of these are not to our knowledge being directed to investment in renewable alternatives. Then, even considering a weak position, transport is unsustainable, as not even the Hartwick rule of weak sustainability is currently respected. On the contrary, transport has been increasingly delinked from renewable resources, as we have seen above. The only reverse trend seems to be the increasing tendency to produce transport material like cars, which are designed for recycling. We have not investigated, what the real net outcome of this will be for preserving natural capital.

6. Concluding discussion

As far as we can see, current mobility levels and systems are far from satisfying the EE operational sustainability criteria governing preservation of natural capital. In fact all four criteria are violated:

- the sustainable scale of resources and sinks are not respected, as transport contributes to exceedence of critical loads and levels of pollutants

- technology is not (only) used to increase efficiency, but (also) to increase physical throughput as volume of traffic is growing, partly due to more powerful cars and more infrastructure being built,

- the non-renewable natural capital-base is being rapidly depleted, and rents are not reinvested in renewable alternatives,

The criterion that concerns renewables is the only one that for an immediate view does not seem to be violated. But this is only because renewables are used so sparsely for productive purposes in transport, which may actually be a sign of its vulnerability. And even worse, transport is a heavy contributor to the destructive pressure on renewable ecosystem, and may thereby violate this criterion also.

We thereby think that the EE principles can give some guidance on assessing or monitoring sustainable development of transport, when combined with the different notions of transport, mobility etc.

Having said this, we don't think the 'operational' principles of EE are sufficient or operational enough to assess the potential to make transport comply with sustainable deveopment. Some main drawbacks of the principles are:

- the principles omit the development part of sustainable development. We look upon sustainable development as a concept that combines survival of humanity (sustainable) with quality of survival (development). The conflict between long-term survival and short-term quality of life must be made clear.

- the concept of a certain scale of transport or mobility defined by natural limits to carrying capacity is problematic as transport is so integrated with other activities. Instead of defining a 'sustainable mobility level', the system boundaries (the ecological limits) for it must be defined.

- the EE principles does not tell us, how large a share of the overall limits, mobility can be allowed to take up. One might ask to what extent the "unsustainability" of transport could be compensated by investing in natural capital or improving quality-of-life in other sectors. We need some common measure of 'natural capital' if the term is to give any guidance on how to approach different subsystems.

- distribution issues have not been made operational. Should we advocate even distribution of mobility among individuals, among nations or among generations? Clearly this would not allow for maintaining the level currently enjoyed by the high-income male population in western countries. This only goes to show, that the distribution issue has some important implications to be considered even after the scale issues have been settled.

We have not found anyone who has succeeded in defining sustainable development for transport. We take this as a proof that no generally accepted definition exists. In the best case, political statements about sustainable mobility express intents to do something about the environmental problems. In the worst case, they are just statements telling that the overall goal for transport policy is maximized mobility.

Finally, we suggest that the following four topics should be addressed in a definition of sustainable development for transport:

* What is to be sustained? The transport system, the mobility or the access?
* Sustainability criteria, for example as suggested by Costanza/Daly1992
* Development criteria, concerning quality of life e.g in terms of health, safety, equity
* The transport activities' share of, and influence on, the overall economic activity.

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