Environmental capacity in Dutch urban passenger transport

Assessment and application of the ecological footprint concept

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A general assumption is that the limits of growth of transport are reached. People are becoming more and more aware of the necessity to be cautious with the available resources, and the need to reduce emissions and wastes. Therefore environmental sustainable transport is the topic of research. How to integrate environmental sustainability into traffic and transport plans and into transport modelling are some of the most challenging questions.
This research makes a contribution to the theory of environmental capacity in urban passenger transport in order to supplement the discussion about an environmental sound transport system among transport and environmental specialists. In the past years many research has been carried out assuming there is an environmental capacity and what can be done to stay under or meet this limit. However, the question remains how environmental capacity can be defined, measured or applied at a local (geographical) scale?

The aim of this research is to: ‘Define and demystify the concept environmental capacity in urban passenger transport by (1) giving an overview of existing sustainability concepts from literature, (2) developing theory when gaps in literature come across, and (3) applying the results on an urban scale.’

Part one of this study is a literature survey in which the sustainability concepts are defined. This research is in search of a quantitative concept of environmental capacity, qualitative definitions are however used as starting-point.

These definitions are defined by developing a paradigm, which is presented in the text box.

- Product (short/medium term)
- Weak sustainability
- The Netherlands
- Cities and their surrounding areas
- No trade of emission rights
- Passenger transport
- Maintaining the quality of life
- Livability problems are not included
- Amenity values are set aside
- Neutral time preference

The focus of this research is on urban passenger transport in The Netherlands, urban is interpreted as cities and their surrounding areas. Furthermore does this research concentrate on the product sustainability instead of the process towards it, in other words the sustainability requirements. Intergenerational equity is an important issue in defining the sustainability concepts, a neutral time preference is assumed and amenity values are set aside, maintaining the quality of life is the condition. Livability problems are therefore not included in this research, since the focus is on sustainability problems which diminish the possibilities for future generations. It is however assumed that manufactured capital can take the place of natural capital, which is referred to as weak sustainability. Trade of emission rights is not expected to be sustainable in the long term.

Based on the paradigm, the definitions of several sustainability concepts are developed in part 1. The concept of particular interest: 'Environmental capacity in urban passenger transport' is defined as follows:

> The environmental capacity of urban passenger transport is the environmental passenger transport impact of a city at an environmental sustainable level.

And the definition of urban environmental sustainability is as follows (keeping in mind that passenger transport is among the great subsystems making up a city):

> An environmental sustainable city requires synergetic integration and co-evolution among the great subsystems making up a city (economic, social, physical and environmental), to ensure that, in collaboration with the surrounding areas, the limit of the ecological system is respected.

A conclusion of the literature study is that not much is actually known about our environment. There is no general accepted view on the current situation of the ecological system and many ecological processes are not yet understood.
As a result of the lack of information about the environment the definitions and approach of sustainability problems are mostly the outcome of a political process, not based on quantitative data, but a compromise between authorities. Although there is generally agreement on the sustainability definitions, major differences arise in interpretation an implementation of the concepts.

This research has found four approaches for implementation of environmental sustainability:

1. Reductions of all kinds of environmental burden, such as emissions and waste production;
2. As few as possible production of waste, use of resources and other causes of ecological damage;
3. Relying on technological progress, in combination with a fifty years time span;
4. Concepts which are all comparable to carrying capacity or the ecological footprint.

This research aims in particular at a quantitative, objective concept of environmental capacity. The first two approaches are subjective and not based on the limit of the ecological system. The third method does acknowledge the limit of the ecological system, but does not deal with intergenerational equity. Therefore this study looks further into the concepts of carrying capacity and ecological footprint.

The concept of carrying capacity, understood as the maximum population that can be supported indefinitely in a give habitat without permanently impairing the productivity of the ecosystem upon which the population is dependent *[Rees 1988 in: Wackernagel & Rees, 1996]* is a concept that depends on the size of the supporting territory, which is chosen subjectively and which changes according to the problems involved. It also depends on available technologies, scale economies, and types of activity carried out in the city.

The concept of ecological footprint is understood as the area of ecologically productive land (and water) in various classes – cropland, pasture, forests, etc. – that would be required on a continuous basis

1. to provide all the energy/material resources consumed, and
2. to absorb all the wastes discharged

by that population with prevailing technology, wherever on earth that land is located" *[Wackernagel & Rees, 1996]*.
The limit of the ecological system is in the concept of the ecological footprint not dependent on the available technologies, scale economies and types of activity carried out in a city. But the ecological footprint as limit of the ecological system is not constant either, it is dependent on the world population and the amount of ecologically productive land (and water). These two factors are easier to measure and to predict and therefore the footprint approach seems to be more suitable to quantify urban environmental sustainability.

The main difference between the two concepts is the conversion of units. The ecological footprint measures land area required per person (or population), in contrast to carrying capacity, which measures population per unit area. The simple inversion of the human carrying capacity is far more instructive than traditional carrying capacity in characterizing the sustainability dilemma.

The ecological footprint especially enables comparisons between the environmental sustainability of countries, cities, people and other consumers of the global ecological system.

So far, some ecological footprint analysis has been carried out on a global and local level, but much vagueness remains around the used methods and usefulness of the results. This vagueness around the used methods becomes especially visible when the ecological footprint is applied on an urban scale. Surrounding areas should be considered in respect to the limit of the ecological system and therefore the scale of the city should be very carefully chosen to make fair comparisons. This problem of scale is currently not addressed in urban ecological footprint studies. The subsystem passenger transport has not yet been the main subject of an ecological footprint study, although it is assumed a vital subsystem with a serious impact on the environment.

Hence, the second part of the research looks further into the ecological footprint concept applied in Dutch urban passenger transport.

The mean ecological footprint per citizen due to passenger transport of 51 medium-sized cities and the four largest cities in The Netherlands is calculated in part 2 of this study, using the approach and parameters developed by the Van Hall Institute. Their parameters are part of a software programme to calculate your individual ecological footprint online. The objective of this software is to give individuals a first impression about their footprint and was therefore rather simplistic. Although the approach to the ecological footprint of the Van Hall Institute does fit this study's paradigm, their parameters appear not very suitable for further ecological footprint research.
The trip behaviour of citizen is input for this urban ecological footprint calculation and is coming from the Dutch mobility survey of 1995 (OVG).

The mean ecological footprint due to passenger transport of citizen of 51 medium-sized cities turns out to be very small, with a small variation. Individual differences between trip behaviour of citizens disappear in the aggregation to urban scale. Therefore the used parameters do not influence the results that much, other than not giving a fair estimation of the size of the urban ecological footprint by passenger transport.

The footprints vary from 0.18 gha (Kerkrade) to 0.32 gha (Heerenveen). The mean ecological footprint of citizen is 0.25 gha, with a standard deviation of 0.03. This is smaller than the 0.34 gha that the Van Hall Institute and Best Foot Forward calculated with their calculations of the ecological footprint of urban passenger transport. These institutes used national figures on trip behaviour and that causes probably a difference with this study. This analysis uses an individual mobility survey for trip data, which is raised to obtain the required data. Mobility surveys mostly underestimate the number of trips and trip kilometres, because respondents are not always complete in their diaries. Another main cause is that the production, maintenance and disposal of the car is not included in this study, other studies do incorporate these aspects in some way.

The share of the subsystem passenger transport is low compared to the total Dutch individual ecological footprint of 4.6-4.7 gha. It is even low compared with the fair earth share of each world inhabitant, which is around 1.5-1.7 gha.

Hence, according to this ecological footprint analysis, urban passenger transport appears to be not one of most environmental damaging subsystems.

Analysis shows that the ecological footprint of urban passenger transport is not a direct conversion of the trip behaviour of citizen, although the total number of kilometres is highly determinative. The small differences in mean ecological footprint among Dutch cities are therefore mainly caused by differences in the total number of travelled kilometres, and modal split differences have a minor influence.

This analysis only has found urban scale as an influencing factor of the ecological footprint due to passenger transport, no other spatial characteristics are found to be significant. It is however observed that the four largest cities in The Netherlands have a smaller mean ecological footprint than the selected 51 medium-sized cities.

According to the analysis, spatial characteristics do not determine the total number of travelled kilometres of citizen or the urban modal split. The influence factors of the urban ecological footprint can be sought for in other urban characteristics, such as demographic or economic variables.

Analysis of the influence of urban scale on the ecological footprint is performed by identifying three rings around the city centre that reflect the distance to the city centre. The results show a larger ecological footprint of citizen in the outer rings for the 51 medium-sized cities as well as for the four largest cities.
Urban scale influencing the mean urban ecological footprint of citizen due to passenger transport complicates the application of the concept in urban passenger transport. The understanding and definition of a city and the urban subsystem passenger transport become even more important if one wants to be able to make a fair estimation of the ecological footprint as well as make comparisons between cities and ecological footprints calculated at a different scale.

A conclusion so far is that the ecological footprint is for sure a strong metaphor, with an enormous communicative power. Hectares that reflect the individual burden on the environment and the direct link with the available land on earth are far more alive than concentrations CO_2 or resource harvest rates.
However, the method of ecological footprinting is still under construction and various interpretations circulate. The methods so far are still simplistic for academic use and leave several aspects out of consideration, the estimates of the ecological footprints are therefore an underestimation.

The aim of the second part of the research is to find out if further research into this ecological footprint concept is justified.
The development of the ecological footprint methods needs to be kept an eye on, since the method has certainly the potential to grow into a respected method of assessing the state of environmental sustainability. In the long run the ecological footprint concept could offer possibilities to be added as a restriction concerning environmental sustainability into urban transport models.
A thorough understanding and definition of the subsystem transport in a city and its overlap with other subsystems of a city is therefore needed. A clear-cut definition of the geographical scale of an urban passenger transport system, as well as grounded transport parameters need to be developed also. Life Cycle Analysis will be needed to attain the firmly based parameters.
Application of the concept as a restriction in urban transport planning also implies a choice about the size of the ecological footprint spent on the subsystem passenger transport, which is mainly a political decision.

Concluding, it can be said that the ecological footprint concept does offer possibilities for incorporating environmental capacity into urban transport planning, although existing methods are not sufficient. The ecological footprint concept first needs to be strengthened, the ecological footprint method needs a lot more deepening and standardization, and the subsystem passenger transport requires a more exact demarcation. Further research into the ecological footprint is therefore justified.