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Summary:

Indicators for environmentally friendly logistics

Development of indicators may contribute to the identification of problem areas and best practies, which in turn may lay the ground for improved measures targeted at environmental policy goals. We present a set of indicators for environmentally friendly logistics in general, and a set for environmentally friendly city logistics. A subset of the suggested indicators are quantified by use of statistics, both at the national level and the city level. The indicator set may be used for comparisons of cities or for studies of development over time, at the national level or the city level.

Introduction

The freight transport sector contributes to a range of environmental problems, including emissions of greenhouse gases, local emissions and noise. The need to reduce the environmental impacts of transport has been on the agenda of decision-makers and researchers for decades, but there is nevertheless an increasing need to design and implement measures that may reduce the environmental impacts of freight transport.

In order to properly develop useful measures it is necessary to obtain a good understanding of the freight transport sector. The development of *indicators* expressing important aspects of the transport activities may contribute to the identification of problem areas as well as good practices. Litman (2009) defines an indicator as "a variable selected and defined to measure progress towards an objective". Indicators have two major functions (OECD, 2003):

- They reduce the number of measurements and parameters required to give an accurate description of a situation
- They simplify the communcation of measurements to the users

To summarise, indicators are used to *simplify* and to *communicate*.

The aim of this report is to define a set of indicators for environmentally friendly logistics in general as well as indicators specific for logistics and freight transport at city level. The indicators should faciliate analysis of the environmental performance of Norwegian freight transport and logistics, and lay the ground for comparisons between cities and development over time. It is a goal that it should be possible to quantify the indicators from existing statistics or by reasonable extensions of existing statistics.

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The DPSIR model

The OECD and other institutions have organised indicators in accordance with cause-effect relationships, for instance by linking pressures, states and responses. The European Environmental Agency (EEA, 2003) organises environmental indicators according to the *DPSIR* model*:*

- Drivers
- Pressures (in our case transport)
- State (of the environment)
- Impact
- Response

Drivers represent economic and social trends, including demography and purchasing power. For freight transport, also industrial activity, foreign trade and logistic trends are important drivers.

The **transport** activities are affected by the drivers and are considered to represent **pressure** on the environmental status. This includes volumes transported, the organisation of the transport, vehicles used, etc.

The state of the environment includes environmental effects of the transport activities, including land use, energy use and emissions.

Impact refers to consequences and impacts that the environmental status has on humans and society. This includes health effects of noise and emissions, accidents and other external effects.

Response covers the measures that are applied to reduce the environmental impacts of the transport. The measures may be targeted towards the drivers giving a cyclic model, but measures may also be directed towards transport, the state of the environment or the environmental impacts of transport.

Indicators for environmentally friendly logistics

We present a suggested set of indicators for environmentally friendly logistics in Table S-I. The indicators are grouped in accordance with the DPSIR-model, and further by topic. For each indicator we indicate by "X" in the two last columns whether it is intended for use at city/municipality-level or for national analysis. Data avilability is indicated by use of a coloring scheme. Shaded cells in the two last columns indicate that data is available for quantification. Stripes indicate that it might be possible to quantify the indicator by calculations, in some occasions with significant uncertainty. White background in cells marked with "X" means that no known data sources are currently available. These indicators are nevertheless included due to their importance or because data coverage could be anticipated in the future.

Table S-I. Proposed indicators for environmentally friendly logistics.

	Topic		Indicator	Unit	City	Nat.
DRIVERS	Demography	1	Population	Number	X	X
	Economics	2	Personal income	NOK	X	X
		3	Gross Domestic Product	NOK		X
	Industrial activity	4	Employment in wholesale, retail and agency businesses, construction activities and hotels and restaurants	Number	X	X
		5	Turnover in retail trade	NOK /capita	X	X
		6	Area of buildings under construction	m2 / capita	X	X
	Logistics	7	Imports and exports	Tonnes (per capita)	X	X
		8	Freight rates (price of transport)	NOK/ tonne km		X
TRANSPORT	Size and extent	9	Modal split by group of goods	Tonne km		X
		10	Vehicle kms in road freight transport	Vehicle km	X	X
		11	Tonne kms per capita	Tonne km / capita	X	X
		12	Tonnes transported by mode	Tonnes (per capita)	X	
	Vehicles	13	Distances covered by vehicle age	Km		X
		14	Distances covered by Euro standard	%		X
	Performance	15	Transport efficiency	Tonne km / vehicle km	X	X
		16	Rate of empty kilometres	% of vehicle km	X	X
		17	Transport content	Vehicle km / tonne	X	X
		18	Trip distribution by day and time of the day	Time intervals	X	
		19	Delays for industrial transport	Index	X	
	Deliveries	20	Stop time for deliveries	Minutes	X	
ENVIRONMENT	Energy use	21	Energy use by mode	GWh / year	X	X
	Emissions	22	Total emissions (local emissions and green-house gas (GHG) emissions) by mode	Tonnes / year (and capita)	X	X
		23	Emissions (local and GHG) per tonne km and per vehicle km	Gramme / km	X	X
		24	Illegal discharges of oil at sea	Tonnes		X
	Land use	25	Size of land used for freight facilities	m2 / capita	X	X
IMPACTS	External effects	26	External costs of freight transport	NOK		X
	Health effects	*Health effects of noise and emissions are treated in Nenseth og Nielsen (2009)*				
	Accidents	27	Killed and injured persons in accidents involving freight vehicles	Number	X	X
		28	Killed and injured persons in accidents involving freight vessels	Number		X
RESPONSE	Planning	29	Strategies for city logistics	Yes/No	X	
		30	Formalised cooperation between authoirities and industry for planning of city logistics	Yes/No	X	
	Land use	31	Requirements for the design of freight loading/unloading facilities	Yes/No	X	X
	Financial measures	32	Congestion charging for improved traffic flows	Yes/No	X	
		33	Internalisation of external costs	%		X

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Testing of indicators

We have quantified a subset of the proposed indicators, both at national level and at city level. Most data are collected from Statistics Norway. At national level it seems that personal income (indicator 2) is the driver that is closest to following the development in road freight traffic. Road transport is the largest contributor to CO_2 emissions in Norwegian freight transport, while maritime transport is the major contributor to emissions of nitrogen oxides (NO_x).

In the comparison of cities it appears difficult to draw any clear conclusions on the degree of correlation between drivers and transport development, but it might seem that income and employment to some degree correlates with the development in transport at city level.

The purpose of the indicator testing has been to assess the relevance and usability of the indicators, and not to make a comprehensive evaluation of the environmental statues of the considered cities. A thorough comparison of the freight transport-related environmental status of Norwegian cities is left for future studies.

Recommendations for use

The indicators that are proposed in this report give a comprehensive overview of the environmental status of freight transport in cities or at national level. It may in some occasions be useful to use a subset of the indicators only. Direct comparison of cities based on the indicators might be difficult, in particular because industrial structure and settlement patterns strongly affect the outcome of a comparison. This represents an important perspective that stresses the need for treating results with care, but it may in some occasions be possible to correct for such differences. Moreover, indicators may also be used to study development over time.

There are different methodological approaches for combining information from a set of indicators, including multicriteria analysis and different evaluation frameworks. Such developments are outside the scope of this work, but should be considered in the future.