EFORWOOD
Tools for Sustainability Impact Assessment

Assessment of logistics concept to sustainability: Development of a common approach to transport issues

Jean-Matthieu Monnet and Elisabeth Le Net

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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EFORWOOD
Sustainability Impact Assessment of the Forestry - Wood Chain

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EFORWOOD

Tools for Sustainability Impact Assessment

Instrument: IP

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Assessment of logistics concept to sustainability: Development of a common approach to transport issues

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WP 3.3 Transport systems

A technical report documenting the Eforwood approach of the transport and logistics sustainability.

Jean-Matthieu Monnet, Elisabeth Le Net (FCBA)

Executive Summary

The document aims to give an overview of the general context of sustainability of transport and logistics and to explain the choice made within EFORWOOD.

We highlight that (a) the existing studies on sustainability indicators are based more on transport dimension than on logistics (b) there are no specific indicators on logistics at national/sector level. Logistics is more oriented to enterprise level (decision and choice). To illustrate this statement, some existing sets of indicators relating to transport (economic, social and environmental dimensions) are presented. Finally, we explain why, in EFORWOOD, (1) the input data are more logistics oriented and (2) the "transport indicator" (output data) is integrated in political orientation of transport sustainability.

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1. General concepts

1.1. Sustainability

- *Definition*

The most commonly quoted definition of **sustainable development**: "*Economic and social development that meets the needs of the current generation without undermining the ability of future generations to meet their own needs*" dates back to the 1987 Bruntland report (WECD, 1987). The contribution of individual countries to sustainability as a global objective is still under discussion and it is all the more difficult to define which objectives should be assigned to each sector.

Transport is a crucial sector regarding sustainability as it supports others sectors, has a major role in social interactions and makes intensive use of non-renewable energies, consuming 70% of all petrol in the EU (ECORYS Nederland BV, 2008). Moreover transport has been identified as the major sector whose CO_2 emissions are forecast to increase over the next twenty years. Accordingly, consideration for the long-term effects of transportation activities should strongly influence policy decisions.

- *Sustainable transportation system*

The European Conference of Ministries of Transport has given a widely agreed definition of **sustainable transportation system** (ECMT 2004). It:

- "*Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.*
- *Is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development*
- *Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.*"

Economic and social development and ecological preservation commonly referred to as the three pillars of sustainable development are brought together in this definition, along with notions of public policies.

The overall objective of the EU regarding sustainable transportation is "*To ensure that our transport systems meet society's economic, social and environmental needs whilst minimising their undesirable impacts on the economy, society and the environment*" (Council of the EU, 2006). Its first operational target deals with the key issue of decoupling transport impacts from economic growth, i.e. fostering economic growth with an efficient transport system while reducing its negative impacts on the environment, human health and economy (see also Åhman, 2004 and McKinnon, 2006 for detailed analysis of the Swedish and United Kingdom cases).

There is a growing need for policy instruments to be designed to mitigate and control the side-effects of transport activities. Indicators are generally considered as valuable tools for assessment of transport sustainability performance.

1.2. Indicators

- *Definition*

An **indicator** is a tool measuring a situation or tendency in time or space, designed for evaluation, monitoring and help to decision-makers.
The European Environment Agency uses the following definition: "*an indicator is a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time*" (EEA, 2005).

- *Levels of analysis*

Evaluating such a complex concept as sustainability requires a set of indicators covering several levels, from decision-making process and transport, to physical impacts and their social, environmental and economic effects. Dobranskyte-Niskota *et al.* (2007) give a list of the different levels:

- "*Planning process – to assess planning and investment practices*
- *Options and incentives – to examine consumers' options and markets […]*
- *Physical impacts – to evaluate pollution emission and crash rates, land consumption, etc.*
- *Effects on people and the environment – to measure mortality, morbidity, environmental degradation, etc.*
- *Economic effects – to provide monetized estimates of economic costs, reduced productivity, property values etc.*
- *Performance targets – to establish a degree to which desired standards and targets are achieved.*"

- *Selection criteria*

The selection of a given set of indicators has a significant influence on analysis results for it is based on underlying assumptions on main factors and their desirable direction of evolution. Marsden (2007) gives five **key principles** that should be observed when developing a sustainable indicator set:

a) *Headline indicators[1] should be outcome oriented*
b) *A direction of change should be specified*
c) *Policy targets should be included where relevant*
d) *Indicators should be disaggregated appropriately*
e) *Supporting intermediate outcomes should be specified*

It is essential to have an understanding of what changes in the transport system will drive changes in the key outcomes and to consider that indicator can have a different interest by mode.
Besides, the use of relative indicators, including reference units (measurement units normalized to facilitate comparisons, such as per-year, per-capita, per-mile, per-trip, per-vehicle-year and per dollar) reflects various perspectives from which different solutions may arise.
The quality and availability of data should be taken into account when defining a set of indicators. Indeed, data collection practices should provide accurate and comparable information at various geographical and time horizons.

[1] Headlines indicators are global indicators such as "transport indicator" in Eforwood which integrates sub-indicators dealing with transport intensity information such as t-km per transport mode.

- *Comprehensiveness*

Litman (2008) lists the impacts that a sustainable transportation indicator set should reflect:

Economic	Social	Environmental
Traffic congestion Infrastructure costs Consumer costs Mobility barriers Accident damages Depletion of non-renewable resources	Equity / Fairness Impacts on mobility disadvantaged Human health impacts Community cohesion Community livability Aesthetics	Air pollution Climate change Noise and water pollution Habitat loss Hydrologic impacts Depletion of non-renewable resources

1.3. Examples

- *Transport headline indicator of the EU*

The European Union has chosen the **energy consumption of transport,** defined as the ratio between the energy consumption of transport and gross domestic product at constant prices, as headline indicator. The decoupling of economic growth from transport demand (energy consumption is often used as a proxy) can be monitored at global level with the evolution of this indicator. However individual contribution of vehicle consumption reductions, modal shifts from road to rail and inland waterways will not be distinguished. This indicator is designed to monitor energy efficiency at global level but fails to account for changing factors.

- *Effect of reference units at truck-level*

At truck-level, the use of reference units has also major influence. Indeed, according to Larsson (2008) "*fuel economy is not the same as fuel efficiency :*

- *"liters / 100 km" is not a good fuel efficiency metric for trucks and cannot be generally applied as it requires same duty cycles and vehicles with identical specifications.*
- *measure of "fuel used" and "work done" is more relevant. It is easy to measure fuel used but measurement of work is complicated.*
- *"work" can be specified in "ton.km" which focus on the weight but as loading volume is becoming more import "m^3.km" is an option.*
- *the time required for the transport is also a factor as "time is money" and because it has impact on the number of trucks needed.*"

- *Various ratios reflect various levels of analysis*

McKinnon (2005) illustrates how the choice of ratios and reference units reflect different levels of analysis in transport.

Indicators	**Level of analysis**
Transport Intensity tonne-kms / total output	- logistics infrastructure - supply networks - scheduling of flows - managing transport resources - vehicle operation - vehicle design
Modal Split road tonne-kms / total tonne-kms	
Vehicle Utilisation vehicle-kms / tonne-kms	
Energy Efficiency energy consumed / vehicle-km	

1.4. Conclusion

Choosing an indicator is not neutral as it reflects the choice of a determined level of analysis (geographical, sector, temporal) and is often constrained by data availability. It is thus important to understand the assumptions and perspectives used to select and define sustainable transportation indicators.

2. Transport indicators

2.1. Economic indicators

Public policies are generally designed to maximise general welfare, which is not easy to measure. Indicators such as monetary income or productivity are usually used as economic indicators, even though they are unable to account for non-market activities and do not reflect wealth distribution.
The following table lists examples of economic indicators that could be used to assess transport sustainability in the wood-based sector.

Indicator	**Description**
User satisfaction	Overall transport system user satisfaction ratings, considering the following aspects of transport: - Cost; - Time (door-to-door transport time); - Loss (percentage of commercial value lost from damage, theft and accidents); - Frequency of service; - Reliability as percentage of deliveries at scheduled time; - Flexibility as the percentage of non-programmed shipments executed without undue delay.
Transport accessibility	Proximity of the nearest transport facilities: - highway; - railroad station; - maritime or inland waterways port.
Transported volumes	Total freight transported.
Modal split	Share of road, rail, inland waterways and sea shipping in transportation.
Transport cost efficiency	Transportation costs as a portion of the economic activity of the wood-based sector.
Employment	Total employment required for transport operations (full time equivalent)
Facility costs	Expenditures on infrastructures and traffic services.
Cost efficiency	Portion of infrastructure costs borne directly by users.
Traffic costs	Crash and congestion costs.
Planning quality	Comprehensiveness of the planning process: whether it considers all significant impacts and uses best current evaluation practices.

2.2. Social indicators

They should reflect transport impacts on equity, health, community livability and historic and cultural resources.

Indicator	Description
Work equity	Part of female employment in transport full time equivalent.
Safety	Accident related disabilities and fatalities.
Health	Disease caused by transport side effects (pollution, noise….).
Community livability	Contribution of transport to employment and activity in rural areas.

There are no specific measures of safety and health impacts[2] of wood-sector related transport and such indicators have to be estimated with ratios on national data, even though roundwood transportation impacts are mainly located in rural areas where issues are quite different from urban areas.

2.3. Environmental indicators

They measure impacts at local and global level such as noise, habitat destruction, water pollution, air pollution and contribution to climate change.
Same remarks as for social indicators apply.

Indicator	Description
Climate change	Fuel consumption, CO_2 and other greenhouse gas emissions.
Air pollution	Emissions of air pollutants (NOx, CO, volatile organic compound, particulates)
Noise pollution	Population exposed to high levels of traffic noise.
Water pollution	Vehicle fluid losses (leaks)
Land use impact	Land devoted to transport facilities.
Habitat protection	Preservation of habitats.
Resource efficiency	Non-renewable resources consumption in the production and use of vehicles and transport facilities.

3. Indicators in the Eforwood project

3.1. Overview

Due to the drastic increase of the price of gas (economic indicators) and the necessity to reduce CO_2 emission caused by the global climate warming (environmental indicators) logistic concepts and transport issues are becoming particularly important. Transportation is a major contributor to the energy and GWP (Global Warming Potential) profile of components. The long distance transportations make sometimes the highest CO_2 emission step of the wood products life cycle (Bucket E., Deroubaix G., 2004).

3.2. Eforwood approach to transport/logistics

Some data about transport are available at European and national level. It is easy (but not always relevant[3]) to derive transport indicators of the wood-based sector by applying ratio on national data. However specific transport conditions in the wood-based sector should be taken

[2] On population in general (not direct information concerning drivers).
[3] For instance, in PD332, we have shown that employment calculated from Eurostat overestimates the indicator in comparison with terrain and direct information (the wood transport is less labour intensive than transport of "all commodities" in general).

into account as they differ significantly from the general case, especially for roundwood transport:

- truck weight (payload depending on technical gross weight and regulation)
- back haulage possibilities;
- road use in rural areas.

For these specific situations it is necessary to combine both top-down and a bottom-up approaches, i.e. deriving wood-based sector transport indicators from global data and using terrain information to calculate indicators.

In Eforwood, the transport indicator or "**transport intensity and modal indicator (14)"**, gives quantitative information of the transport by mode (t-km and v-km) for a chain and qualitative information (modal split: percentage share of each mode of transport in total transport expressed in tonne-kilometres[4]). This indicator is more relevant at a global level and monitors "*the objective of the 2006 renewed sustainable development strategy to achieving a balanced shift towards environmentally friendly transport modes to bring about a sustainable transport and mobility system*" in the EU (Eurostat, 2007).

To do so, input data are:

1. Distance by mode (road, railways, inland waterways, maritime, air) (km)
    - loaded (km)
    - unloaded (for road mode only) (km)
2. Load capacity of vehicles per movement by mode (tons/vehicle) (by mode)

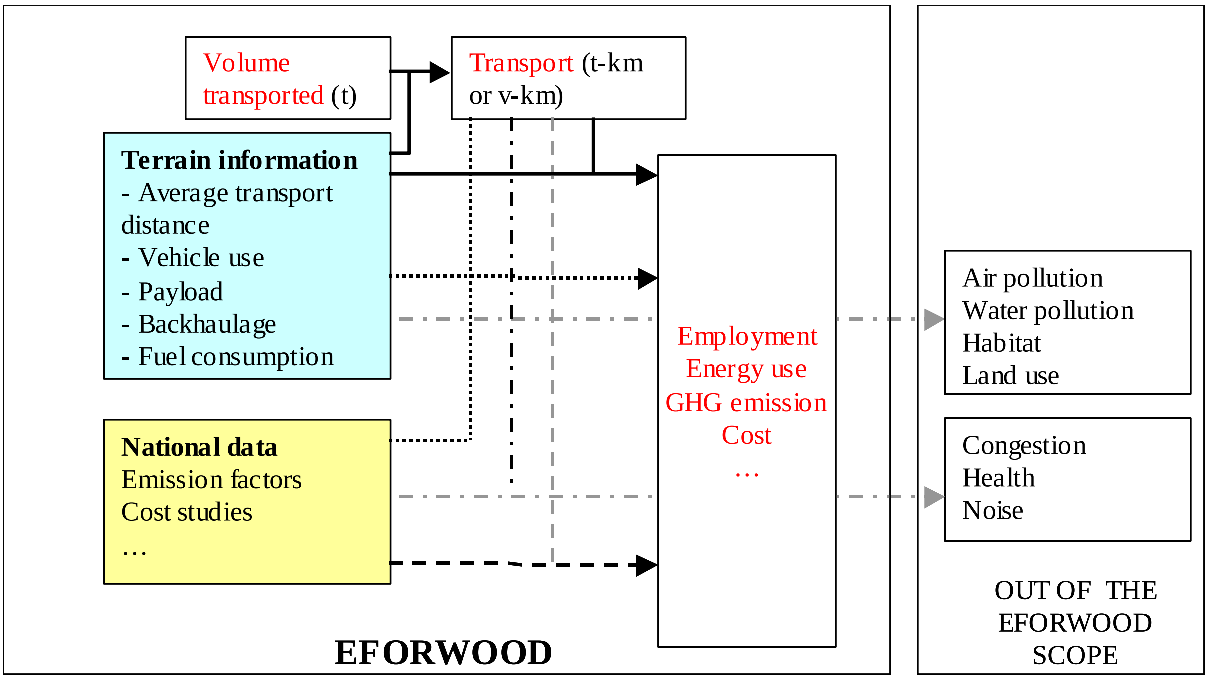
By combining terrain information and national databases (see Project Deliverable PD3.3.2 "Identification of existing transport methods and alternative methods or new approaches with data about costs, labour input and energy consumption"), it is also possible to calculate various economic, social and environmental[5] indicators, as shown in the following diagram.

[4] It is important to remember that the definition of modal split is specific to Eforwood:

- Eurostat: percentage share of each mode of transport in total **inland** transport expressed in tonne-kilometres.
- Eforwood: the percentage share of each mode of transport in total movements of the **FWC boundaries** expressed in tonne-kilometres. It includes transport by road, rail, inland waterways and maritime movements. For case studies, the movements are: the movements on national territory plus the movements to the extra-European import/export harbour and extra-European borders.

[5] For example, emissions of green house gases are regulated by the United Nations Framework Convention on Climate Change and the Kyoto Protocol, which bends the EU to reduce its emissions by 8 % in the period 1990 to 2008/2012.

Figure 1 – The Eforwood approach to transport/logistics



For instance, national data about roundwood transported or consumed volumes are available. By combining this information with terrain knowledge on logistic practices such as average transport distance, the transport indicator "volume in t-km" can be calculated. Other logistic figures concerning vehicle use (payload, empty backhaulage) allow the calculation of the transport sub-indicator giving information on transport intensity ("t-km" or "v-km"). By combining these indicators with national data on emissions factors (e.g. in gCO_2 per t-km or v-km) or terrain information on fuel consumption (L[6]/v-km) we obtain indicators on GHG emissions or energy use. Similar approaches (general data on "transport" as an activity, cf. NACE data), can yield other indicators such as employment, pollution and social impacts (some of them out of the scope of the Eforwood project).

3.3. Logistics concepts and transport issues

Transport can be defined as the movement of people and goods from one place to another. It is a basic operation characterized by parameters such as distance, duration, transport mode and material used.

Logistics is the management of the flow of goods, information and other resources, including energy and people, between the point of origin and the point of consumption in order to meet the requirements of consumers. Logistics involve the integration of information, transportation, inventory, warehousing, material-handling, and packaging[7].

Transport, as a relatively basic operation, can be monitored using indicators such as those presented above. Transport modes or situations in different countries seem to be easily

[6] Diesel litres for trucks for instance.

[7] Logistics costs include not only transport costs, but also inventory, sorting, packing and production costs. Therefore, a reduction in transport costs will not necessarily lead to a reduction in total logistics costs. Even in the relationship between logistics costs and services, transport services include various factors (time-designated delivery, missed delivery, delay and re-delivery, etc.), which affect inventory costs (OECD, Benchmarking Intermodal Freight Transport, 2002).

comparable, but at sector / product level (cf. PD332), it can be difficult to compare things on a reliable basis.

Considering those indicators, the first suggestions to improve transport sustainability might propose solutions such as reducing the size of procurement areas or improving resource efficiency (fuel consumption, average payload).

However, perspectives should not be restricted to what is easy to measure and comprehensive solutions may arise from a logistical point of view. For example, it is possible to improve transport sustainability at mill-level by synchronising incoming and outgoing freight when origin and destination are close and transported materials compatible, so that empty backhaulage is reduced.

- *Logistics' contribution to sustainability*

The main source of negative impacts in logistics is of course the transport function. However by adopting a broad-base logistical perspective is it possible to assess the opportunities for reorganising the transport function as well as the operational constraints.

Indeed, indicators often reflect global transport impacts (e.g. total transport in t-km) or transport mode performance (g CO_2/t-km for each mode). They fail to account for the way logistics practices combine transport possibilities. This is the concept of "**co-modality**": the efficient use of different modes on their own and in combination, will result in an optimal and sustainable utilisation of resources (EC 2006).

Data at global level, such as transport volumes, is easily available and allows the monitoring of freight evolution at a high level. "Bottom" information such as vehicle performance (e.g. fuel consumption) is also easy to obtain and effects of legal constraints can be observed (e.g. Euro emission limits for trucks).
On the contrary, how transport demand meets transport capacity, i.e. how logistics organises complex and sometimes multimodal transport operations is difficult to monitor.
Among the several deficiencies in data availability concerning freight transport pointed out by McKinnon (2008), many deals with logistics issues:

- "*Vehicle utilisation data for all modes;*
- *Volumetric and deck area measures of freight;*
- *All statistics relating to the movement of freight in vans;*
- *Differentiation of freight movements, energy and emissions by supply chain link;*
- *Door-to-door energy consumption / emissions for intermodal services.*"

However, understanding the way logistics meets enterprises needs and trying to integrate sustainability concerns is a major way of improving transportation sustainability, and requires the design of indicators dedicated to evaluate performance and trends in logistics practices. Such indicators are difficult to define at national level where practices are complex but might be relevant if centred on a single sector such as the wood sector.

- *Examples of logistics best practices*

Trucks and CO_2 efficiency
In a study based on a survey of German haulage companies, Léonardi and Baumgartner (2004) have thus shown that "*if any enhancement of the CO_2 efficiency is observed in road freight traffic, it can be partly explained by an increased efficiency of vehicle usage, which can be measured by the newly introduced indicator t-km/m-km. The indicator is calculated*

analogue to the indicator tonne-kilometre, but also includes the mass of the empty vehicle and therefore does not neglect the vehicle kilometres travelled empty […]." The integration of information and communication technologies in logistics practices can improve transport efficiency by reducing empty-running distances and increasing payloads.

Logistic synchronisation at mill level
In France, a specific team often manages wood procurement, including transport. Cases studies (Afocel, 2006) have shown that truck empty running could be significantly reduced by generalising the use of common trucks and synchronising the input (wood and other raw materials) and output flows (pulp/paper and wastes).

Wood swapping between Scandinavian pulp mills
Swapping roundwood between mills and better optimisation of truck journey cut transport costs and externalities. Possibilities of reducing empty running are all the more important as numerous mills are involved. Some mills in Scandinavia even out-sourced the wood transport to a common logistic agency.

3.4. Conclusion and perspectives

The Eforwood "transport" indicator aims to combine transport information and logistics:

	Transport (indicator)	**Logistics information (input)**
Tons given	T-km V-km Modal split	Km by mode (input) Unloaded km for road (input) Loaded capacity (t/v) (input)
Not integrated in Eforwood (but important in other works)	Noise Health External costs…	Time dimension (and congestion) Reliability Warehousing systems…

Note: V = vehicle ; choosing a loaded capacity, i.e. tonnes per vehicle can grasp information on regulation (for truck: 60 tonnes in Sweden vs. 40 tonnes in Southern Europe) and type of equipment for a specific commodity (bulk, container, etc). that have an influence non only on intensity (vehicle-km) but also on other indicators related to transport impact.

The availability and relevance of logistics possibilities highly depends on local transport opportunities (infrastructures, origin/destination matrices) and wood-sector organization and habits (carriers, shippers). For example it is possible to reduce total transport by swapping roundwood between pulp mills so that transport distances are minimized as done in some Scandinavian countries. On the contrary, it can be more environmental friendly[8] to transport roundwood on longer distance with rail than on shorter distances by road.

Promising ways of improving transport sustainability should be identified for each case study regarding local context. When simple indicators such as those proposed are unable to measure the efficiency of global solutions, specific indicators should be designed for efficient monitoring.

[8] Less global warming potential emissions which is one aspect of "environmental friendliness".

Abbreviations

EC	European Commission
ECMT	European Conference of Ministries of Transport
EEA	European Environmental Agency
EU	European Union
EUROSTAT	the Statistical Office of the European Communities
WECD	World Commission on Environment and Development

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Addendum to Deliverable D3.3.3
Transport indicator: input and output data and how ToSIA makes calculation

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WP 3.3 Transport systems

A technical report documenting the EFORWOOD approach of the transport and logistics sustainability.

Elisabeth Le Net (FCBA)

Executive Summary

The document aims to give detailed information concerning transport indicator and the relationship between input and output data.

This document is an addendum to D333 "Assessment of logistics concept to sustainability: development of a common approach to transport issues"

Table of contents

1. Transport and logistics within EFORWOOD: input and output data

1.1. Input data

“Transport indicator” will be calculated by ToSIA. To do so, the data collected are:
I. Distance by mode (km)
  I.1. Loaded (all modes) (km)
  I.2. Unloaded for road mode only (km)[1]
II. Freight volume through load capacity of vehicles (by mode) (ton/vehicle)

For case studies, the data client is therefore:

	DATA CLIENT	Unit	COMMENTS
14010	14.1.1.1 - Distance by mode - road transport – loaded	km	
14020	14.1.1.2 - Distance by mode - rail transport - loaded	km	
14030	14.1.1.3 - Distance by mode - water transport (inland waterways) - loaded	km	
14040	14.1.1.4 - Distance by mode - water transport (maritime - sea-going ships) - loaded	km	
14050	14.1.1.5 - Distance by mode - air transport - loaded	km	
14060	14.1.2.1 - Distance by mode - road transport - unloaded	km	Reflects logistics
14070	14.2.1.1 - Freight volume - road transport - loaded capacity	tons / vehicle	Different regulations can exist between countries and for specific products (ex. specific regulation for roundwood in France). Volume/mass is another dimension.
14080	14.2.1.2 - Freight volume - rail transport - loaded capacity	tons / vehicle	Depends on the volume/mass by product
14090	14.2.1.3 - Freight volume - water transport (inland waterways) - loaded capacity	tons / vehicle	Depends on the volume/mass and the type of equipments used (ex. small vessel such as 250 tonnes to large ones such as 4 000 tonnes). Cf. DCP annexes (15th of January 2008 version)
14100	14.2.1.4 - Freight volume - water transport (maritime - sea-going ships) - loaded capacity	tons / vehicle	Depends on the volume/mass question and the type of equipments used (ex. small vessel such as 250 tonnes to large ones such as 4 000 tonnes). Cf. DCP annexes (15th of January 2008 version)
14110	14.2.1.5 - Freight volume - air transport - loaded capacity	tons / vehicle	Not so important (in tonnages) so general information can be enough

1.2. Output data and ToSIA calculation

From ToSIA calculation, transport indicator (result) gives information on two major dimensions:

1. Transport intensity, that is declining in tonne-km and vehicle-movement:
   1.1. Loaded (t-km)
   1.2 Total (t-km) = loaded (all modes) + unloaded (for road)
   1.3 Vehicle-movement (v-km)
2. Modal split (or share)[2]
   2.1. for loaded t-km in %
   2.2 for total t-km in %

Therefore,
- for data collector, the transport indicator name is **“distance and volume (load) indicator”**
- for EFORWOOD and ToSIA, the indicator name is **“transport intensity and modal indicator”**

[1] For more information concerning the interest of such data, cf. D333.
[2] Having 2.1 and 2.2. aims to make comparison possible with other chains than FWC, because usually empty backhaulage is not integrating.

2. ToSIA calculation to convert input data to output data

2.1. General information concerning output data

Full name of indicator (including subclasses):	Transport intensity and modal indicator
Name of subclass	**1. Transport intensity by mode** (road, railways, inland waterways, maritime, air) 1.1. Loaded (t-km) 1.2 Total (t-km) 1.3 Vehicle-movement (v-km) **2. Modal split** 2.1. for t-km in % 2.2 for total t-km in %
Purpose of the indicator	1.1 and 1.2 tells about the intensity of the transportation in terms of ton-km 1.3. tells about the intensity of the transportation in terms of vehicle-km 2 tells about the share of each transport mode (the road share in particular)
Collected information	I. transport distance by mode (km) I.1. Loaded distance (all modes) (km) I.2. Unloaded distance for road mode only (km) II. Load capacity by vehicles (by mode) (ton/vehicle)
How ToSIA calculates the result indicator	1.1. ToSIA multiplies the collected loaded distance (km) with the mass of the material flow calculated internally by ToSIA material (ton), this results in the loaded transport intensity (t.km). 1.2 ToSIA multiplies the collected unloaded distance (km) with the mass of the transferred material (ton) and sum this result with 1.1. to get the Total transport intensity. 1.3 ToSIA calculates the vehicle-movement intensity by using the result of loaded transport intensity (1.1 loaded ton km) dividing it by the collected loaded capacity (tons/vehicle). This results in the transport intensity information on vehicle movements (vehicle-km). Note: the information is available for "full equivalent ship". *Example:* Transportation of chairs (density 0.3 tons/m^3) by a 60 tons truck, loading volume 100 m^3. Loaded capacity with this low-density product is limited by the volume of the truck, it is thus 100 m^3 * 0,3 tons/m^3 = 30 tons. Then ToSIA divides the flow of tons of product (chairs) by the loaded capacity (30 tons/vehicle) to get the transport intensity in terms of vehicle km.
Measurement units of collected information:	I.1. km I.2. km II. ton/vehicle

2.2. How it works?

				Calculation	Calculation	Calculation	Calculation		Calculation
	Given	**Input**	**Input**	**Output**	**Output**	**Output**	**Output**	**Input**	**Result**
	Tons	Loaded km	Unloaded Km	Tons* loaded km	Tons * total km	Modal share in loaded tonnes-km	Modal share in total tonnes-km	Load capacity by vehicle	loaded transport intensity*load capacity (by vehicle)
	a	b	c	d	e	g	h	i	j
Road		Data	Data (or % to b)	a*b	a*(b+c)	d / Σ d	e / Σ e	Data HDV LDV Vans	d/i
Rail		Data	Idem b	a*b	a*b	d / Σ d	e / Σ e	Data	d/i
Inland		Data	Idem b	a*b	a*b	d / Σ d	e / Σ e	Data	d/i
Maritime		Data	Idem b	a*b	a*b	d / Σ d	e / Σ e	Data	d/i
Air		Data	Idem b	a*b	a*b	d / Σ d	e / Σ e	Data	d/i
TOTAL		Total loaded km	Total km	Loaded transport intensity	Total transport intensity	100 %	100 %	-	Vehicle movement intensity
Indicator		I.1	I.2	1.1	1.2	2.1	2.2	II	1.3

Note: violet = input data; black= ToSIA calculation