PLANNING FOR LOGISTICS AND DISTRIBUTION FACILITIES IN THE HAMBURG REGION

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1 INTRODUCTION

A high demand for new logistics and distribution facilities (e.g. warehouses, distribution centres, transfer depots) can currently be observed in many German and other European regions (Cushmann & Wakefield 2006; Jones Lang Lasalle 2006a). This is caused by the ongoing globalisation of production, European integration as well as restructuring and outsourcing in the logistics market. The purpose of the paper, which is based on the PhD project of the author,[1] is to show how the development of new logistics facilities and sites can be integrated into urban, regional and transport planning, focusing on traffic impact assessment.

1.1 Development of new sites for logistics related land use

Logistics related land use is often perceived as space consuming, noisy and traffic intensive. While existing company plot sizes differ, new logistics facilities often tend to be space consuming. According to a study of Jones Lang Lasalle (2006b), the outsourcing of logistics activities to logistics service providers leads to a demand of new, optimized sites larger than 5 hectares. During the (re-)location of logistics companies, strong opposition from residents can usually be observed.

With the development of new, modern warehouses, where most of the goods handling is done inside, noise and emissions from goods handling generally declines. However, the impacts from the traffic generated by logistics facilities still need to be integrated into the environment. Locally, peaks of heavy vehicle traffic as well as trucks parked in the neighbourhood have to be dealt with. With extending operating hours, the night time impacts from moving vehicles and other activities also increase. On the regional level, the development of new sites for logistics centres results in regional traffic growth.

Being an important economic sector, logistics companies are increasingly coming into the focus of real estate developers and municipal business developers. Local and regional authorities often aim for job generation and value creation when promoting and developing sites for logistics related land use. Whereas possible regional economic gains of the logistic sector are currently of high political significance, careful integration of new sites into the urban and regional environment is generally neglected (Hesse 2006). Particularly traffic generation is not a major decision criterion for site selection and development. This is mainly due to two reasons. Firstly, in regions where space is scarce, finding feasible sites is difficult and traffic generation is perceived as a secondary problem. Secondly, there is very limited planning knowledge on trip generation of logistics related land uses and on how trip generation relates to the characteristics and size of logistics centres.

1.2 Case study: Logistics site development in the Hamburg region

The region under consideration in this study is the City of Hamburg and its surrounding area. Hosting Europe's second biggest seaport, Hamburg is a major transport hub. Container turnover in the port is expected to double up to the year 2015 (18 million TEU). At the same time, there is an estimated demand for logistics and distribution facilities of an additional 400 hectares from 2005 to 2015 (Bürgerschaft der Freien und Hansestadt Hamburg 2005). Some of these facilities will be directly related to the port, others will primarily serve goods distribution to the urban area.

In the City of Hamburg, land availability is limited and potential land use conflicts are high. As a consequence, hinterland communities more willing to accept the development of logistics areas are competing for company location, resulting in traffic intensive developments in hinterland areas. In the wider region of Hamburg, many sites are currently considered for the development of new logistics areas, some reaching sizes of up to 100 hectares. Because the region spans three federal states of Germany and 14 administrative districts, there is no coordinated regional planning for industrial and commercial areas.

Figure 1 gives an overview of the region, its main transport corridors and potential logistics development sites. In addition, the location of the industrial sites, where traffic was counted (see section 2), and the scenarios included in the traffic impact assessment (see section 3) are highlighted.

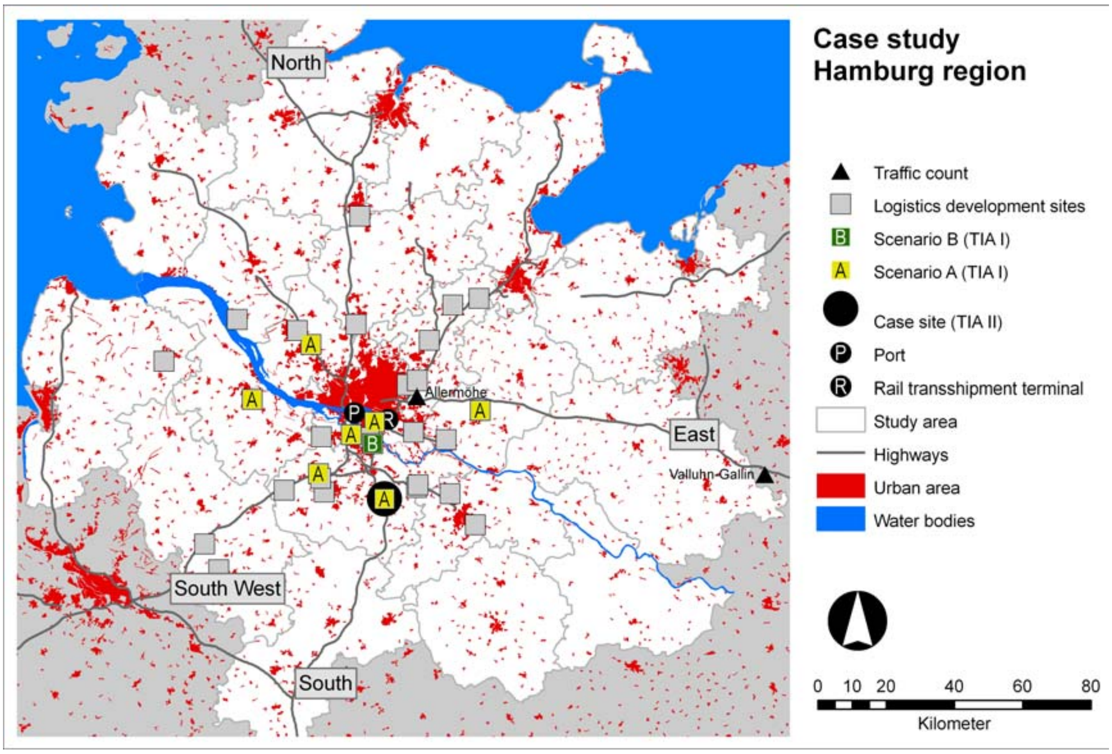


Fig. 1 Map of the case study Hamburg region

Source: Author based on Corine Land Cover 2000 and Esri

Applying the results of two surveys (see section 2) as input values for a traffic impact assessment, different logistics land use development scenarios are assessed in order to answer the following questions:

How much traffic is generated by new logistics areas?

Can a strategic location of logistics areas and functions reduce traffic (impacts)?

2 TAKING A CLOSER LOOK AT LOGISTICS AND DISTRIBUTION FACILITIES

Aiming at a deeper insight into the characteristics and trip generation of logistics related land uses, two surveys were conducted in the Hamburg region in 2007 and statistically evaluated regarding dependencies between trip generation and company characteristics. As a major result of these surveys, general trip generation rates could be calculated and different types of logistics related land use were identified and described (see Figure 2).

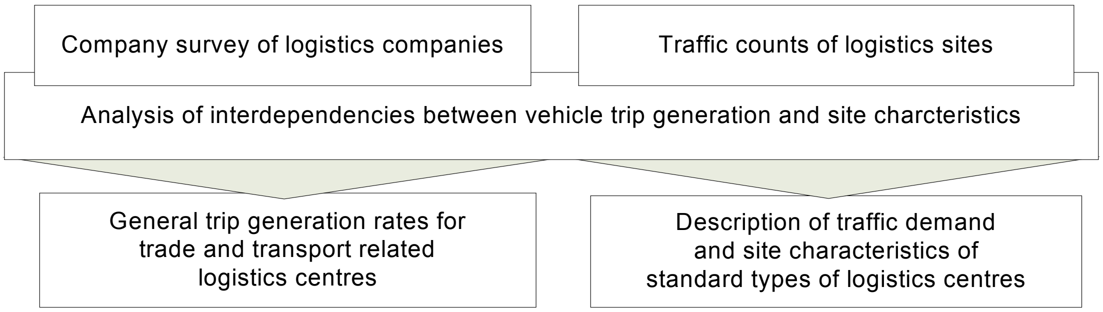


Fig. 2 Translating empirical analyses into planning parameters

Source: Author

2.1 Surveys and general findings

A company survey was carried out in order to find out which services are offered by logistics companies, what patterns of land use they show, how many truck trips they generate and how the trips are performed (vehicle type, time of the day, etc.). 860 companies of the transport and trade sector were contacted via e-mail or phone, 64 of which (i.e. 7.5%) participated in the survey.[2] Additionally, expert interviews were conducted in 20 large companies. Only companies of the trade and transport sector with more than 20, respectively 10, employees situated in industrial or commercial areas were included. Overall, it was found that a wide range of logistics companies exists and consequently there are highly varying requirements on space and infrastructure.[3]

In addition to the company survey, a traffic count was performed in two industrial areas (Hamburg Allermöhe and Valluhn-Gallin, see Figure 1) where many logistics facilities are located. It could be observed, that the traffic volume, its diurnal distribution and the use of different vehicle types are connected to location and company characteristics in the different areas.[4]

The trip generation of Hamburg Allermöhe, a densely developed industrial area close to Hamburg containing many regional transfer depots and regional and national trade distribution centres, is almost 90 daily truck trips per hectare of developed real estate. The trip generation of the industrial area Valluhn-Gallin located in a rather rural area containing some large distribution facilities is only 10 daily truck trips per hectare of developed real estate.

The different characteristics of the areas are also reflected in the distribution of trips to vehicle types. In both cases, the share of heavy goods vehicles of total traffic volumes was about 20 %. The share of smaller trucks and vans added up to almost 25 % in Hamburg Allermöhe and only 10 % in Valluhn-Gallin. The remaining traffic volumes were car traffic.

Overall, it could be shown, that both location and company characteristics influence the traffic demand of logistics related land use.

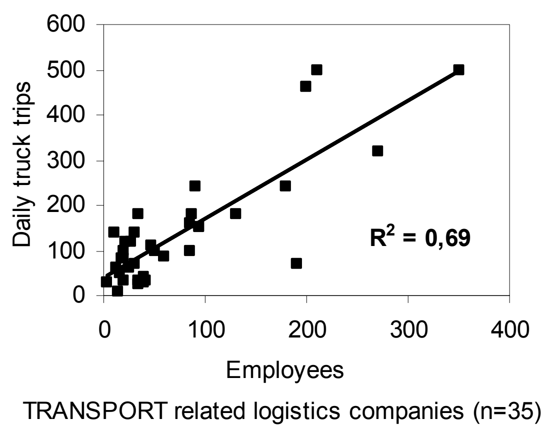
2.2 General trip generation rates

For using trip generation rates from empirical analyses to estimate traffic impacts from new site developments, Hooper gives several recommendations (refer to Hooper and Institute of Transportation Engineers 1998):

- Regression equations should be used, if the data plot contains more than 20 data points or the R^2 is at least 0.75 and the standard deviation is less than or equal to 110 % of the weighted average rate.
- Weighted average rates should be preferred, if at least three data points are available and the standard deviation is less than or equal to 110 % of the weighted average rate.

If only few data points are available (less than five) or land use types other than the ones provided are needed, it is recommended that local data is collected.

Figure 3 illustrates the data plots and R^2 of the correlation between truck trip generation and number of employees derived from the company survey. For both transport and trade related logistics service providers R^2 is below 0.75. Beside the number of employees, plot size, floor space and handling floor space were tested as independent variables, but produced a far lower R^2.



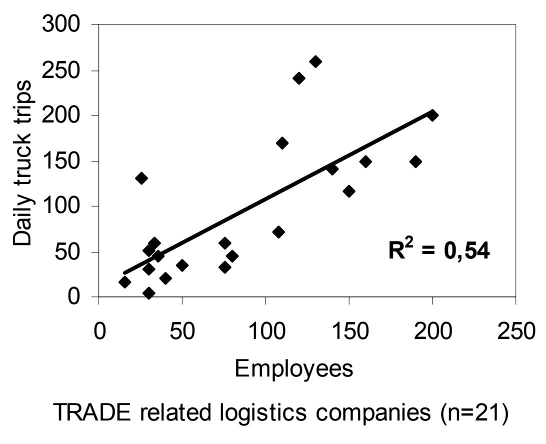


Fig. 3 Data plots of truck trip generation by number of employee

Source: Own analysis based on a company survey in the Hamburg region in 2007

Table 1 summarises the average rates, weighthed average rates and standard deviations of truck trips per employee and per plot size as well as employees per plot size. Interpreting and using these rates, it has to be considered that the land use type analysed here, namely trade and transport related logistics companies, are rather diverse, which is reflected in high standard deviations. The figures are based, however, on a representative mixture of logistics companies and thus the planning parameters are perceived as sufficiently exact for a rough estimation of traffic impacts at an early planning stage.

Tab. 1 Employee rates and truck trip generation rates of logistics companies

Planning parameter	Land use type, logistics companies related to…	Average	Weighted average	Standard deviation (% of weighted average)
Daily truck trips per employee	Transport (n=35)	2.9	1.8	2.8 (150%)
	Trade (n=22)	1.4	1.4	1.2 (89%)
Daily truck trips per plot size [ha]	Transport (n=31)	117	56	130 (231%)
	Trade (n=19)	63	40	56 (143%)
Employees per plot size [ha]	Transport (n=32)	54	31	48 (155%)
	Trade (n=20)	58	29	53 (183%)

Source: Own analysis based on a company survey in the Hamburg region in 2007

Furthermore, the comparison with other sources and the results of the traffic counts mentioned above shows that all derived trip generation rates are more or less in the same range. A direct comparison is, however, not possible due to differences in the reference land use. Bosserhoff (2000:43), whose work is the major German source for trip generation estimates, suggests 10 to 15 daily truck trips per hectare developed real estate for transport related land use and 40 to 90 daily truck trips per hectare developed real estate for land use dedicated to hauliers and logistics centres. As daily truck trip generation rates per employee, he suggests 2 to 4 for storage facilities and 2 to 9 for facilities of shippers.

To get an impression of the truck traffic intensity of logistics related land use, it can be compared to truck trip generation rates of other land use types. Bosserhoff (2000:42) states that an industrial park generates 0.6 to 0.8 daily truck trips per employee or 10 to 12 daily truck trips per hectare developed real estate. Commercial land uses - except for wholesalers - generate up to 2 daily truck trips per employee. Office-type land uses have a low truck trip generation rate of 0.1 daily truck trips per employee.

2.3 Standard types of logistics centres

For a more precise traffic impact assessment that considers a higher variety of logistics related land uses, standard types of logistics centres were defined based on the surveys, expert interviews and existing research. The structuring of the logistics related land uses for planning purposes considers the following principles:

- The standard types defined have similar site and traffic demand patterns and are applicable for regional and transport planning issues.

- The standard types are relevant for new site developments.

The description of the standard types in a fact sheet includes a general qualitative description of the site and traffic demand patterns and provides quantitative planning parameters based on individual examples. Because of the high diversity of the logistics sector, there are overlaps between the types and variations within the types. An overview and short description of the standard types is provided in Table 2.

Tab. 2 Overview of the standard types

Type	Sub-type and short description
Trade related logistics centres	*Regional distribution centres of retail chains* that supply the stores of a region (e.g. supermarket chains).
	National or international distribution centres of retailers that supply the regional distribution centres or directly supply large stores (e.g. DIY stores).
	Warehouses of wholesalers that distribute on a regional or national level depending on their service area. They often supply regional distribution centres of retail chains or industries depending on the material or product they trade in.
Industry related logistics centres	*Warehouses dedicated to the supply of a particular factory* are usually located close to that factory. Different suppliers deliver their resources and parts to the warehouse. From the warehouse, the factory can be supplied just in time or just in sequence.
	Warehouses dedicated to the distribution of products of a particular factory can be located close to the factory or close to the market areas served. They usually deliver into distribution centres of retailers or wholesalers in the national and international market.
Logistics centres for the transport of packaged goods /courier services	*Regional transfer depots* that bundle and unbundle packaged goods from or dedicated to a region. The regional transfer depots are connected overnight with other regional transfer depots directly or via the national network hub. During daytime, the packaged goods are distributed into and collected from the region.
	National hubs of packaged goods networks connecting the regional transfer depots. Their peak of operation is at night and they are usually located in the geographic centre of a country.
	Consolidation hubs at the interface of national road networks and international transport networks. They are usually located at seaports or airports.
Logistics centres of shippers and freight carriers	*Warehouses of (regional) freight carriers* that offer a broad range of logistics and transport services focusing on full container / trailer loads or part loads.
	Facilities of shippers that focus on container based import and export of goods and offer services that cover the whole supply chain.
	Facilities of freight carriers that focus on special transport tasks like heavy goods or dangerous goods.
Basic logistics services	*Dedicated or multi-user warehouses* that often serve for temporary or long term storage.
	Company sites of trucking companies that actually operate transport services. They are often subcontractors of other logistics service providers that do not operate their own vehicle fleet.

Source: Author

For eight standard types, a detailed type fact sheet was developed based on the results of the company survey and expert interviews. As an example, the fact sheet for regional trade distribution centres (retail) is shown in Table 3.

Tab. 3 Fact sheet of the standard type regional distribution centre (retail)

Trade related logistics centres — Regional distribution centre (retail)

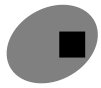
Regional distribution centres (retail) serve the stores of retail chains in the food or non-food sector. Depending on the perishability of the goods the stores are served on a daily to weekly basis. The delivery tours are operated by company owned vehicles or subcontactors. Regional distribution centres usually operate 24 hours a day.

Characteristic services and integration into the wider network

Stocks are usually deliverd to the regional distribution centre directly from suppliers or from national distribution centres of the retailer. Products are unpacked, checked, labeled and transfered to the storage area. Storage times range from a few hours up to several weeks. Based on store orders products are picked, assembled, packed into resusable transport units and boxes and shipped. Usually, the delivery trucks collect the garbage and empty transport units from the stores, because they are centrally handled in the regional distribution centres.

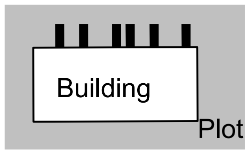
Location

Regional distribution centres are usually located at the edge of an urban area and service the urban area and the surrounding region. Between 100 and 300 stores are served by one centre (refer to TradeDimensions 2007).



Typical site and building characteristics

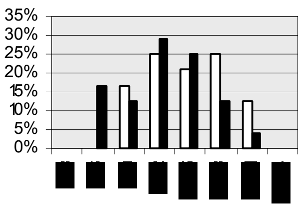
The buildings of regional distribution centres are usually large with many truck docking gates on one or two frontages. Separate areas are provided for incoming and outgoing goods. Perishable goods like fruit and vegetables are often stored at ground-level, whereas dry goods or cosmetics can be stored in high-rise racks. Typical land requirements range from 2 to 5 hectares. The ratio of floor space to plot size is between 30 and 60 % with floor space ranging from 5,000 to 20,000 square meter. The number of employees amounts to 100 to 200. Very large distribution centres of supermarket chains can take up to 15 hectares of land and 80,000 square meters of floor space.



Truck trip generation

Daily truck trip generation of average regional distribution centres is high with 150 to 250 incoming and outgoing trucks and can reach up to 1000 trips at very large facilities. The share of regional traffic (delivery tours) amounts to 50 to 75 %. Delivery of incoming stocks is usually performed with heavy trucks from morning to noon. Diurnal distribution of delivery tours depends on the assortment of goods and the delivery time slot of the stores. Also depending on the assortment of goods, different delivery vehicles are appointed. Up to 20 stores can be served in a single delivery tour. From regional distribution centres of supermarket chains around 5 stores are served.

Diurnal tuck trip distribution of a regional distribution centre for a drugstore chain.



Outgoing trucks = white
Incoming trucks= black

Company	Company parameters	Truck trip generation
Regional distribution centre of a drugstore chain in Hamburg Allermöhe	5 ha plot size 14,000 m² floor space High-rise stack 120 employees	240 daily truck trips Long haul: 25 % Delivery tours: 75 %
Regional distribution centre of a supermarket chain in the Hamburg region	15 ha plot size 50,000 m² floor space Partly high-rise stack 160 employees	720 daily truck trips Long haul: 45 % Delivery tours: 55 %

Source: Author

3 ASSESSING TRAFFIC IMPACTS OF LOGISTICS SITE DEVELOPEMENT

The planning parameters presented in section 2 are a prerequisite for the traffic impact assessment (TIA) of new site developments for logistics. Based on the general trip generation rates, different spatial logistics site development options in the Hamburg region were evaluated (TIA I). Based on the standard types different sectoral development paths of a specific site were assessed (TIA II). This section presents the general methodology and the results of the traffic impact assessment.

3.1 General methodology and assumptions

Starting point for the traffic impact assessment is the definition of the project or development paths considered and the estimation of the expected number of employees.

For TIA I, two spatial options (scenarios) for the development of 210 hectares of new logistics space are evaluated. Scenario A defines the more realistic option, where several potential sites close to the major highways in the hinterland of Hamburg are developed. Scenario B bundles the 210 hectares in a centrally and well connected freight village with an integrated rail transshipment terminal. This opens up the possibility of reducing trip generation by shifting goods traffic from road to rail, reducing goods traffic through the cooperation of logistics companies and shifting commuter traffic from road to public transport. Since the trip reduction potential of freight villages is only of a theoretical nature, two sub scenarios are looked at: Trip reduction is achieved (scenario B^+) or not achieved respectively (scenario B^-).

For TIA II, three sectoral development options (standard types) of one potential logistics site, which offers 30 hectares of land, are evaluated. The following standard types are considered: regional transfer depot (Type A), regional distribution centre (Type B) and multi-user warehouse (Type C). They were chosen to demonstrate the possible range of traffic impacts, if only one specific type of logistics related land use takes up a whole site.

Based on the number of employees, daily truck trips and their split between long and short haul and according to vehicle types can be estimated. Commuter trips can also be calculated based on assumptions regarding the share of personal motorized travel (60 to 100 %), which depends on the site accessibility for non-motorized and public transport.

In order to estimate vehicle kilometres travelled, a study area that covers an area of less then 100 km distance to the Hamburg city centre and respective traffic zones were defined. The total amount of trips is then distributed according to origin-destination matrices derived from the company survey as well as commuter statistics and multiplied with distance matrices generated with the network analyst of ArcGIS 9.2. In this step of the calculation, it has to be considered that not every incoming and outgoing trip actually carries goods. Sometimes, empty trucks enter or leave the logistics centres. This is done by applying a factor for loaded trucks and assigning a constant distance of 30 km to empty truck trips.

Based on trips and vehicle kilometres generated within the study area, regional traffic impacts are calculated from standardised cost values (taken from Arnold 2004:834 for truck operation costs; from Maibach, Schreyer et al. 2007:57;84 for air pollution and climate change) and local traffic impacts are discussed.

The different spatial scenarios and the study area are depicted in Figure 1 (see section 1.2). The planning parameters used and assumptions made regarding trip distribution are summarized in Tab. 4.

Tab. 4 Planning parameters and assumptions for the traffic impact assessment

	Comparison of regional spatial development paths				**Comparison of sectoral development options of a specific development site**					
Site characteristics										
Area considered	210 hectares				30 hectares					
Logistics related land use and its share on site development	Sector 1 (50%)		Sector 2 (50%)		Type 1 (100%)		Type 2 (100%)		Type 3 (100%)	
Short description of sector / type	Transport related		Trade related		Regional transfer depot		Regional DC (retail)		Multi-user warehouse	
Plot size (type) [ha]	-		-		2,5		15		1	
Employees (type)	-		-		225		200		15	
Daily truck trips (type)	-		-		450		700		60	
Employees per hectare	31		29		90		13		15	
Daily trip generation										
Truck trips per employee	1,8		1,4		2,0		3,5		4,0	
	LHT[I]	RT[II]	LHT	RT	LHT	RT	LHT	RT	LHT	RT
Share of LHT / RT [%]	45	55	50	50	40	60	40	60	25	75
Reduction modal shift [%]*	10	-	10	-	-	-	-	-	-	-
Reduction cooperation [%]*	-	10	20	-	-	-	-	-	-	-
Vehicle type: Heavy truck [%]	-	-	-	-	100	60	100	80	100	70
Vehicle type: Light truck [%]	-	-	-	-	-	30	-	20	-	20
Vehicle type: Van [%]	-	-	-	-	-	10	-	-	-	10
Factor for loaded trucks	1,5	1,5	1,5	1,5	1,5	1,2	2	1	2	2
Commuter trips per employee**	2,5									
Presence [%of employees]**	80									
Share of personal MT[III] [%]**	60 - 100				100					
Persons per car**	1,1									
Truck trip distribution (aggregated level)										
Hamburg City [%]	-	25	-	39	-	45	-	30	-	30
Hamburg City – Port [%]	3	15	2	4	3	10	2	-	3	50
Hamburg City – RTT[IV] [%]	-	3	-	3	-	-	-	-	-	10
Metropolitan Area [%]	-	42	-	44	-	45	-	70	-	10
North [%]	19	5	25	4	19	-	25	-	19	-
East [%]	20	3	20	4	20	-	20	-	20	-
South West [%]	19	3	18	1	19	-	18	-	19	-
South [%]	39	4	35	1	39	-	35	-	39	-
Abbreviations and Sources										
[I] LHT = Long haul traffic					** Sonntag und Meimbresse (1999)*					
[II] RT = Regional traffic					*** Bosserhoff (2000)*					
[III] MT = Motorized traffic					*Others: Author*					
[IV] RTT = Rail transshipment terminal										

Source: Given references and author

3.2 TIA I: Regional land use development paths

Depending on the development path, 210 hectares new logistics related land use generate 8,900 to 10,100 truck trips and 6,900 to 10,600 car trips per day. Within the study area 485,000 to 658,000 truck kilometres and 185,000 to 329,000 car kilometres are generated per day. This leads to 4,100 to 5,700 Euros additional external cost from air pollution and 900 to 1,200 Euros additional external costs from climate change per day.

The comparative illustration of the results in Figure 4 shows, that scenario B^- produces less regional traffic impacts and truck operation costs than scenario A due to the good location of the freight village. Further reduction can be achieved, if modal shift of long haul goods traffic from road to rail, a reduction of truck trips through company cooperation and modal shift of commuter traffic through the provision of good public transport access is actually realized in the freight village (scenario B^+). However, whereas regional traffic impacts can be reduced through bundling of all logistics service providers in a suitably located freight village, local traffic impacts from incoming and outgoing trucks are extremely high due to their spatial concentration.

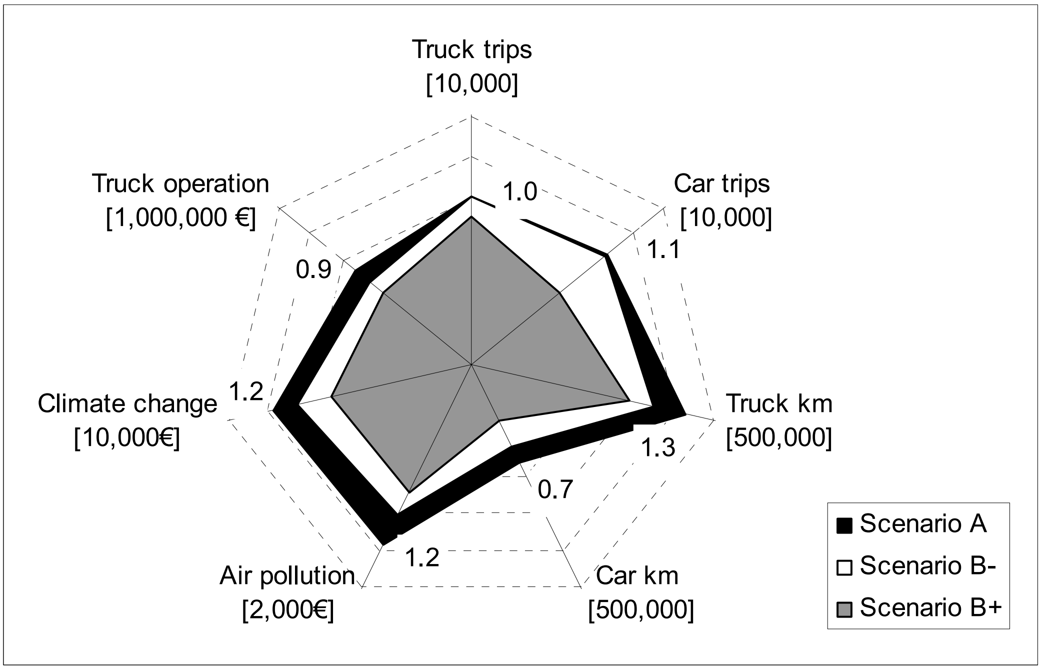


Fig. 4 Daily traffic impacts of the development of 210 ha logistics related land use

Source: Author

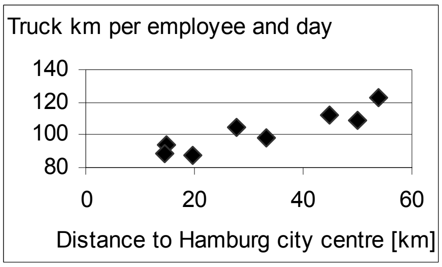


Fig. 5 Truck km depending on site location Source: Author

As Figure 5 illustrates, location plays an important role for the amount of truck kilometres generated. However, it has to be stated that this is only valid, if a consistent mixture of logistics related land use types is looked at (by applying the average truck trip generation rate). A comparison of specific types (sectoral variation) results in different findings, because trip distribution is variable.

3.3 TIA II: Local site development paths

Depending on the type of logistics related land use that locate on the potential 30 hectares sized logistics site analyzed, traffic impacts vary a lot (see Figure 6). The highest number of 5,400 truck trips and 4,900 car trips, and thus the highest local traffic impact, is generated by 12 regional transfer depots of packaged goods carriers. 30 multi-user warehouses and 2 large regional distribution centres serving retail chains both produce only one third of the truck trips and 15 % of the car trips.

The difference between the standard types is even bigger looking at the vehicle kilometres generated within the study area. Whereas 12 regional transfer depots generate 272,000 truck kilometres, 2 regional distribution centres (retail) generate 89,000 truck kilometres and 30 multi-user warehouses generate 43,000 thousand truck kilometres. These relations are also reflected in the external costs and the truck operation costs.

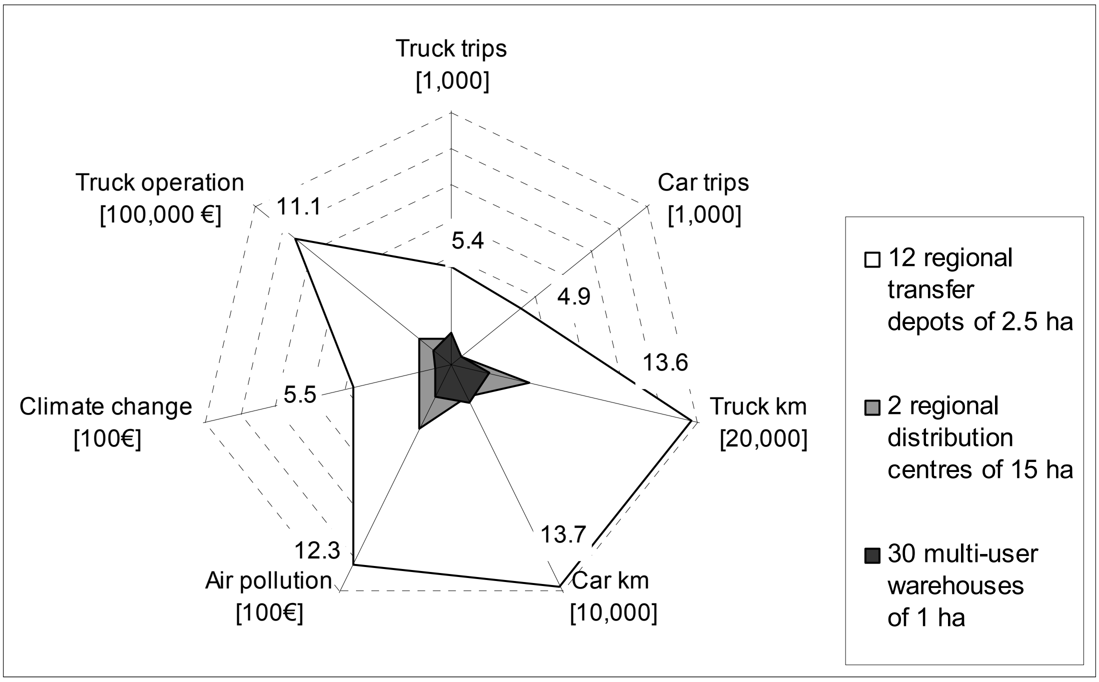


Fig. 6 Daily traffic impact of a 30 ha logistics development

Source: Author

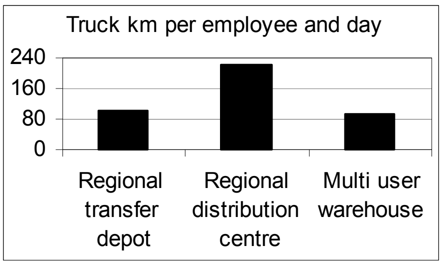


Fig. 7 Truck km depending on standard type of logistics land use Source: Author

Figure 7 illustrates daily truck kilometres generated per employee. Both, regional transfer depots and multi-user warehouses generate around 100 truck kilometres per employee and day. Regional distribution centres (retail) generate 220 truck kilometres per employee and day, that is more than twice as many. When costs and benefits of a site development are evaluated on a regional basis this might be a relevant decision criterion.

4 CONCLUSION

In growth regions like Hamburg land availability is limited and potential land use conflicts are high. As a consequence, demand for new logistics areas is often satisfied in hinterland communities. This form of development leads to further sprawl and complicates traffic and space efficiencies.

Both, location and type of logistics related land use of new site developments determine their traffic impacts, which are high compared to other land uses. In order to better integrate logistics site developments into urban and regional planning, site characteristics and traffic patterns of logistics related land uses were investigated in the Hamburg region. From the empirical analyses, average trip generation rates are derived for transport and trade related logistics companies and standard types of logistics related site uses are defined and described. Such planning parameters can be used as input values for comparative traffic impact assessment. However, because of the high diversity of logistics companies, further surveys on a larger scale are recommended. A methodological improvement could be the integration of trip generation and trip distribution estimation into regional land use and transport models. This will, however, not be straightforward, because the level of detail of modelled land use types usually is not sufficient enough to include different types of logistics related land use. In addition, no such models are maintained in most regions.

Traffic impact assessment provides a planning tool for communities to estimate local impacts of different sectoral site developments and a decision support tool for regional authorities aiming at spatial / sectoral development that reduces regional traffic impact. Since traffic impact is only one decision factor for site selection and development, the integration of traffic impact assessment as presented here into a broader cost benefit analysis will provide a more holistic decision support tool.

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NOTES

[1] The PhD research results will be published in 2009.
[2] The companies were chosen based on the economic sector they belong to according to the NACE classification. The relevant sectors for logistics services are: *Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods* and *transport, storage and communication.* The following sub groups according to the NACE code were selected:

51.2	Wholesale of agricultural raw materials and live animals
51.3	Wholesale of food, beverages and tobacco
51.4	Wholesale of household goods
51.5	Wholesale of non-agricultural intermediate products, waste and scrap
51.8	Wholesale of machinery, equipment and supplies
51.9	Other wholesale
60.1	Transport via railways
60.24	Freight transport by road
61	Water transport
62	Air transport
63.1	Cargo handling and storage
63.4	Activities of other transport agencies
64.1	Post and courier activities

The selection of economic sectors is based on Wrobel (2004). Additionally, some distribution centres of retailers were included in the survey.
[3] For a detailed description of the company survey refer to Wagner (2008a)
[4] For a detailed description of the traffic counts refer to Wagner (2008b)