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SPATIAL EVALUATION APPROACH IN THE PLANNING PROCESS OF TRANSPORT LOGISTIC TERMINALS

ABSTRACT

The "state-of-the-art" of the present global European situation is in desperate need for a new approach to development of urban and rural environment with an interdisciplinary approach, when introducing the elements of transport infrastructure and transport infrastructure landscape into space and environment.

In order to reach a decision regarding the location of a certain transport logistic terminal some constraints (technical and technological as well as financial) should be considered. As part of the process trying to respond to these constraints, associated primarily with the traffic conditions at the appointed network locations, a careful evaluation in respect to cargo flows and infrastructure connections as well as spatial planning should be performed.

Morphological indicators, which directly and indirectly affect the structure and the form of the transport infrastructure elements – transport logistic terminals, are extracted and presented in the paper. At this point, the paper concludes that the laying down and the evaluation of transport infrastructure elements are based on two categories of morphological elements:

Constructed morphological elements (all constructions and their elements), and

Natural morphological elements (topography, climate, vegetation, etc.).

The presented spatial methodology deals with the interactions between the constructed and natural morphological elements - the quality and the characteristics of the design are added to both groups.

Findings and projections acquired on the basis of a spatial evaluation and transport logistic analysis constitute, together with financial-economic assumptions, the basis for elaborating a business plan – a significant element in the decision-making process regarding the development of a transport logistic terminal.

KEY WORDS

transport, transport logistics, intermodal transport, transport logistic terminal, spatial planning, spatial evaluation

1. INTRODUCTION

An intermodal transport system consists of the elements of a physical subsystem and a service subsystem. The infrastructure and the transport equipment form the physical subsystem. The infrastructure consists of the transport logistic terminals – nodes and transfer points (seaports, inland ports, airports, transfer stations, etc.) and links (railways, roads, waterways) which linked together present the physical intermodal transport network.

Reaching a decision on establishment of a transport logistic terminal and the choice of location is based on the results of preliminary analysis. Appropriate location of the transport logistic terminal is of great significance for its successful operation and further development. When placing transport logistic terminals in space, multidisciplinary approach proves indispensable and effective. Multidisciplinary approach consists of three essential parts: transport logistic analysis, thorough spatial-environmental evaluation and business-financial analysis. The paper presents in detail spatial-environmental evaluation methodology developed as tools in the planning process of the transport logistic terminal.

2. SPATIAL APPROACH - THE PRELIMINARY CRITICAL SPATIAL AND ENVIRONMENTAL IMPACT ASSESSMENT – PCSEIA

2.1. Methodology

When dealing with such an extensive and complex intervention, like the evaluation of space for the development of transport infrastructure elements –

transport logistic terminals (TLT), the determination of the stages of the pointers is only the first step of the method. Practically all the evaluation factors are reciprocally dependent on each other and the results value of the pointers will surely overlay in some cases. And thus, a composing part of each evaluation matrix part must be also an elimination factor-information about the relation the pointer has to the space / environment in view of the national/regional/local viewpoint, the relation to the regulations on a national/regional/local level and the degree of reliability of the information (A - high, C - low and sometime additional research necessary).

The method comprises information accessible freely also to the open public, so that the accession will always be transparent and undoubtedly financially up-to-date, giving the fact that the problem or idea is treated preliminary.

2.2. Study and analysis of the relevant information (documents) – pre-evaluation

A detailed research of the key spatial, environmental and transport documents allows a »pre-evaluation« or definition of the »national« relation and interest towards the proposed spatial installation of the regional transport logistic terminal. The matrix for the evaluation of the study of the relevant spatial, environmental and transport documents is represented in Table 1.

The key components that have to be taken into consideration in the preparation of the evaluation matrix are:

- influences on the international development,
- influences on the national development,
- influences on the regional development and settlement,
- influences on the natural environment, residential environment, cultural quality and use potentials,
- transport viewpoints,
- economy viewpoints, and
- structural and technical viewpoints.

The key considered criteria for the field of water, agriculture and settlement of rural population safeguard are:

- safeguard of water,
- preservation of the agricultural and settlement potentials,
- preservation of functional settlement areas and the improvement of the residential environment,
- consideration of the interests of the population, and
- the safety and economy of the realization.

For the preservation of the quality of the cultural region, clear liability and possibility of improving the transport infrastructure, also the visual experience and aesthetic criteria have to be considered.

3. FORMATION OF INDICATORS

The subject of the evaluation is the Critical Spatial Analysis of the existing situation on regional or local level and spatial simulation of the transport logistic terminal development.

The six natural morphologic elements are determined: geology, climate, topography, hydrology, pedology, florae and fauna – being obtained by the analysis of interaction between natural cycles and physical environment.

The methodology relates to the gathering of information from various sources such as: spatial policies on a national local level and abroad, recommendations of various official bodies, recommendations of various foreign authors and recommendations of published studies. However, not all issues are covered, but efforts should be made to be most comprehensive in

Table 1 – Study and analysis of the relevant documents – the pre-evaluation model

Pointer	Possible intervention	Partially possible intervention (terms)	Not possible intervention	Not relevant
	1	3	5	
Spatial (transport) documents – international level				
Spatial (transport) documents – national level				
Spatial (transport) documents – local level				
Spatial environmental documents on national, regional and local level: – Atmosphere – Natural and cultural heritage – Forestry, agriculture, soil – Water – Noise				

this point of view. It should be also mentioned that the preparation of evaluation matrix is a dynamic work, as the latter continuous to be upgraded and improved in accordance with the new studies.

The interactions among indicators, classified according to groups of natural and built morphological elements and design qualities shall form the frame of the valuation method in introducing infrastructure transport elements into the open space by means of AHP (Analytical Hierarchy Process) Methodology and through the Three-Dimensional Matrix Model.

3.1. Indicators – evaluation frame

The indicators, classified according to the typology and morphologic elements constitute the very basis for this model – Method of element valuation in transport infrastructure (see Table 2).

Table 2 – Draft of evaluation frame

Morphological Element	Indicator	Indicator Criteria
Geology	»Natural« pollution	Emissions of methane, metals and acids (min-max)
	Foundation conditions	Bearing capacity – compaction (min-max)
	Occurrences of scientific and educational value	Presence(description min-max)
	Minerals	Presence (description, min-max)
Climate and air	Wind exposure	Wind power (low-high)
	Sun exposure	Inclination and orientation of slope (poor-good)
	Air circulation	Topographic sample (poor-good)
	Air quality – human	Emission presence in (min-max)
	Air quality - nature	Green stocking (poor-good)
Topography	Soil configuration	Inclination (small-big)
	Landscape aesthetic value	Description (small-big)
Hydrology	Surface water source	Zones of protected sources (protection, min-max)
	Fresh water quality	Water quality classification (poor -good)
	Tendency to flooding and erosion	Frequency (small-big) and Risk assessment (small-big)
Pedology	Agricultural area quality	Agricultural value (poor-good)
	Carbon presence in soil	Density (poor-good)
Florae and Fauna	Animal and plant habitat	Quality (poor-good)
	Forest coverage	Coverage percentage (min-max)
	Rare species	Rarity (big-small)
Disposal of Space	Density, size and location of urban areas	Human habitation density (persons per hectare, min-max)
		Number of inhabitants in urban area (person per hectare, min-max)
		Settlement in remote rural area(description, poor-good)
		Settlement in populated (urbane) country areas- transport, public utility infrastructure and energy (description, poor-good)
	Affordability	Construction, maintenance, employment (bad-good)
	Availability of possible locations in traffic infrastructure elements	Size of locations and various possible uses– description (min-max)
	Adequacy of possible locations in traffic infrastructure elements	Interdisciplinarity, taking account of various aspects description (bad-good)

Space and communication	Space arrangement in urbane area and landscape	Legibility (bad -good)
	Way of travelling	In respect of various transport means in %
	Visibility	Physical elements of readability
	Transparency of public spaces	In respect of accesses to convex spaces and use of space
	Legibility of public spaces	In respect of metal image and number of axial steps towards the settlement centre
	Visual experience in space definition	Space impression, description (bad-good)
Plans and planning	Intended function	Scope (min-max)
Buildings Characteristics	Fitness for uses	Volume, height and object identity in transport infrastructure availability- (min-max)
	Supply and removal of construction material	Distance in km (min - max)
	Objects of cultural importance	Value of existing objects (bad – good)
	Engineering, construction and architecture elements	Description (quality – non-quality)
Noise	Day and night noise levels	Area category due to the legislation (IV-I in Slovenia)
Traffic infrastructure	– Passengers transported by mode of transport – Cargo conveyed by mode of transport – Length of transport infrastructure by individual subsystems	Adopted (national, regional, local level)
Railways or	– Length of railway lines (all, renewed, electrified) – Passengers transported – Passenger kilometres – Cargo transported – Newly constructed railway lines – Railway lines upgraded	Adopted (national, regional, local level)
Roads or	– Length of roads – Newly constructed sections of road network – length of cycle path in km	Adopted (national, regional, local level)
Motorways or	– Length of motorways – Newly constructed sections of motorway network	Adopted (national, regional, local level)
Airports and heliports or	– Passengers transported – Passenger kilometres – Transported goods	Adopted (national, regional, local level)
Ports or	– Transported goods – Tons kilometres – Passenger transported – Passenger kilometres	Adopted (national, regional, local level)
Urban traffic or	– Public passenger transport (Centres of statistic regions)	Adopted (national, regional, local level)
Multimodal traffic or	– Passenger transport terminals – Cargo transport terminal	Adopted (national, regional, local level)
Intelligent transport systems	– New information and navigation services(VMS, RDS-TMS, DAB, GSM, GPS, GNSS)	Adopted (national, regional, local level)

In every morphologic element the most important relevant indicators were selected. For example, in the element *climate and air*, the exposure to strong wind seemed to be of major importance. This increases both the possible damages in the object and endangers human safety (expansion, flexibility), by affecting the use of the object surroundings (infrastructure *(transport)* landscape) as well as energy losses in objects (speaking of transport infrastructure elements where such losses are essential). Speed and wind frequency criteria are specified as well as the five-level grading scale. A source is also supplemented by selected indicator grades (see Table 3).

3.2. Evaluation Matrix

In preparing the evaluation matrix base, the first step is to define a group of index grades on a scale from one to five, where one means very good and five means a very poor rate of application or quality or behaviour (various in respect of context). In order to facilitate the application of a frame in decision making, we have decided that the security rate shall be index rate four in all factors i. e. the rate not to be exceeded if we do not want to risk an irreversible damage or danger.

The evaluation frame was developed to provide that the values of morphologic elements and their possible changes are as rational and accurate as possible.

The priority of such access is to offer the most accurate list for which the process of decision making is more comprehensive and more transparent and much better and authentic as such. During the planning and estimating the disputable themes may arise in various areas that can be solved on-line.

In some cases, the minimal, yet acceptable, indicator values will be determined. Whereas the danger of any environment pollution may be high, it is better to set a higher limit in the environment protection criterion, as these limits may be reduced later on, while the damage in the environment is minimal during this period of time. Waiting for a scientific proof on the environment problematic may cause serious consequences which can be avoided by taking actions on time. Many times the preventive actions may prevent expensive and irreversible damages. Where these safety steps are known, they are shown on a scale as the fourth grade in all indicators.

For some indicators there are many scientific and technical studies, and in some cases the security limits have been already defined by the European, national and local authorities. In such cases these rates are used in the corresponding elements. However, in other areas the research is not comprehensive enough, therefore we cannot determine with certain security limits and indicator rates. In such cases, the best information is used, while in the text and matrix a note is written that this area needs to be additionally researched. For the same reason the details related to indicators might not be equally represented in the evaluation frame.

Types or indicator rates may vary according to the discussed level. The *air quality* and *air circulation* would have, for the *climate* element, a different criterion in the regional level, where smooth air circulation for cleaning of the whole area in urban areas and outside - in the country, should be taken into account. When ensuring the self-cleaning of urban areas, landscape and locations for the local and location level, the stocking and configuration of soil should be considered. In some cases, the indicator cannot be determined quantitatively, so the criteria are qualitative or descriptive.

The importance of each factor is changed according to the situation dealt with. However, this is why it may not be assumed that all factors have an equal value.

The majority of indicators related to the natural morphologic elements are space indicators and ensure assistance in the two-dimensional mapping. By mapping scales of indicator criteria, the evaluation sample is made to provide for the determination of value related to various land areas. The drawing of such maps in the transparent form ensures overlapping of various indicators and use of simple "sieve" technique in searching the area with the highest or lowest indicator rate. Later on, as part of the planning and making up the Location Permit, this technique may be used for an exact implication determination of various development possibilities and provision of transparent changes among various possibilities. Such a *"refined sieve technique"* was first applied by McHarg [14]. Other indicators may also be expressed, both in the form of a map, where morphological analyses may be used (physical plans on a local level), and in table form as in the evaluation matrix. Also, where the factor mapping is used, the evaluation matrix may be used as a summary of indicator values being present at any location.

Table 3 presents a whole evaluation frame that is focused, both on the local and state level. Under each morphologic element there is shown an indicator, indicator criterion, scale of five indicator grades, level where they should be taken into account, sources of indicator rates, measuring techniques and data reliability rate.

4. CONCLUSION

The present paper merges the theoretical deliberations of thinkers and experts in the fields of engineering, architecture, transport, economy and science, as

Table 3 – The exact spatial evaluation frame

Morphologic element	Indicator	Evaluation criteria	Indicator rates					Level			Source of selected indicator levels	Measuring technique
			1	2	3	4	5	Country	Location	Location		
Geology	Areas disposed to "natural" pollution	Imissions of methane, metals and acids (min - max)	No presence	No presence (mg/kg dry soil)	Limit value (mg/kg dry soil)	Warning value (mg/kg dry soil)	Warning critical values (mg/kg dry soil)		x	x	Official Gazette of RS No. 68-3722/1996	Local Environment Studies
	Foundation conditions	Compaction KN/m² (min - max)	Low compaction soil	Low compaction soil	Less compaction soil	Medium compaction soil	Very and extreme compaction soil	x	x	x	Construction 1982	Data from geologic filed studies, soil studies
	Occurrences of scientific and educational value	Presence (min - max)	No presence	Area VI (IUCN)	Area IV. (IUCN)	Area II (IUCN)	Area I IUCN)	x	x	x	IUCN/UNEP/WWF, 1991	Provisions of government bodies
	Minerals	Presence (min - max)	No presence	No presence	Minerals of local value	Minerals of regional value	Minerals of regional value	x	x	x	Geological Institute of Slovenia – Data from Geological Studies	Geological studies
Climate and Air	Wind exposure	Wind speed m/sec (low-high)	Less than 2 m/s	2 - 4 m/s	4 - 10 m/s	10 - 15 m/s	Above 15 m/s	x	x	x	Beer (1990), Lynch & hack (1984), Penwarden (1974)	Meteorological data; land studies
	Sun exposure	Inclination and slope orientation	1:5 - S, SW, SE 1:10 - N	1:5 - E, W 1:10 - E, W, SW, SE	Levelled	1:5 - NW, NE 1:10 - NW, NE	1:5 - N 1:10 – N		x	x	Roaf & Hancock (1992); Turrent, Doggart, Ferraro, et al (1980)	Land analyses
	Air circulation	Topographic and settlement sample on a local level	Close to large water surfaces	Hilly areas	Flat surfaces	Flat surfaces	Basins and hollows ("islands of city heat")	x			Morbert & Kirshgeary (1984)	Land analyses
	Air quality-human	Total average 24/h emission concentration in air	Min. (concentration of emissions is insignificant)	Emission concentration is acceptable	Emission concentration is hardly sufficient	Limit emission values are taken into account	Max. (emission concentration is inadmissible)				Official Gazette of RS, No. 73/94	Air analyses
	Air quality-nature	Air quality (good-poor)	Very poor	Poor	Acceptable	Good	Very good		x	x	Analyses of forest coverage and air quality analyses at the regional level	Air analyses
Topography	Slope	Slope (small – high)	1.100 –1:40	1:40 – 1:25	1:25 – 1:10	1.10 –1:2	More than 1:2		x	x	McHarg (1969); Lynch (1972); Simpson (1983)	Land analyses
	Landscape with cultural and aesthetical value	Presence (small - high)	No presence	Local natural features	Natural features of regional importance	Protected areas; areas of cultural and aesthetic values	National Parks, regions under UNESCO protection		x	x	Provisions of government bodies and expert services at the government at local, regional and government level	Background documents

Morphologic element	Indicator	Evaluation criteria	Indicator rates					Level			Source of selected indicator levels	Measuring technique
			1	2	3	4	5	Country	Location	Location		
Hydrology	Surface water	Zones of protected sources -sinking	Area where sinking in not possible	Area where sinking is partly possible	Area where sinking of rain water is possible	Area where intensive sinking of pure and cleaned rain water	Area where sinking of pure and cleaned rain water is obligatory	x	x	x	Water Act, 2000	Background documents and spatial analyses at the local level
	Fresh water quality	Classification of water quality (good poor)	Very poor	A3 poor	A2 satisfactory	Good A1	Good	x	x		Regulation on quality of surface water taken for drinking water supply Official Gazette of RS, No. 125/00	Water analyses
	Flood tendency	Frequency (low-high)	Under 1x in 50 years	1x in 50 years - 1x in 25 years	1x in 25 years - 1x in 5 years	Less tan 1x in 5 years	More than 1x in 5 years	x	x	x	Water Act, 2000; Open Space Plan of RS,	Flood determination map
Pedology	Classification of agricultural areas	Quality (poor - good)	Inadequate or conditionally adequate	Adequate and less adequate	Very adequate	The most adequate	Exceptional	x	x	x	MAFF, 1988 Prem, 1999	Classification of agricultural surfaces
Flora and fauna	Natural animal and plant habitats	Life conditions (poor-good)	Poor	Moderate	Good	Very good	Excellent	x	x	x	Guidelines and EU legislation	EU provisions; land studies
	Tree and forest coat	% of land	No forests and no trees	No –forest- individual groups of trees	The existing tree coat is maintained	Min. addition of tree coat	Max. addition of free coat is needed	x	x	x	Evans, 1996	Background documents, Examination maps
	Rare animal and plant species	Frequency (high - low)	Not known	Smaller local interest	Higher local interest	National interest	International convention on animal and plant species protection	x	x	x	Environment protection act of RS, Guidelines and EU provisions	Field studies, examination maps
Disposal of space	Density of habitation	Number of persons /Ha	above 50 persons./Ha	50-40 persons./Ha	40-30 persons./Ha	30-20 persons./Ha	Less than 20 persons./Ha	x	x		Newman in Kenworthy, 1989	Local studies
	Location of settlement and density of habitation on a remote rural space	Use	Mixed use of spaces in a circle of 400m	Mixed use of space in a circle of 1km	High density Separate use of space in a circle of 400m	Low density Separate use of space in a circle of 400 m from the centre	Low density Separate use of space in a circle above 400 m		x		Blovers, 1993	Background documents, local analyses
	Accessibility in respect of distance	Distance among homes and employment, service activities etc.	Under 400m	400 - 800 m	800 - 1200m	1.2 -1.6 km	Over 1.6 km				Ecotec, 1993	Background documents, local analyses
	Accessibility and route quality in respect of local needs	Accessibility and quality	Very good	Good	Acceptable	Poor	Unacceptable		x		Ecotec, 1993	Background documents, local analyses
	Availability of possible TLT locations	For energy, transport and public utility infrastructure systems	Good	Good	Acceptable	Poor	Unacceptable		x	x	PUP- Open Space Arrangement Conditions	Spatial analyses at local level
	Adequacy of possible TLT locations	Expert-interdisciplinary assessment	Good	Good	Acceptable	Poor	Unacceptable		x	x	PUP – Open Space Arrangement Conditions	Expert analyses and assessment

Morphologic element	Indicator	Evaluation criteria	Indicator rates					Level			Source of selected indicator levels	Measuring technique
			1	2	3	4	5	Country	Location	Location		
Space and communic.	Space arrangement in settlement and landscape	Mental image – space legibility	Good	Good	Acceptable	Poor	Unacceptable		x	x	Linch, 1974	PUP - Spatial Arrangement Conditions Local analyses
	Visibility	Physical elements of visibility	Integrated sample of elements –individual elements of settlement are visible	Integrated sample of elements – –Visible outline of settlement	Visible roads with some milestones	Roads poorly defined, no milestones, unclear edges and areas	Roads poorly defined, no milestones, unclear edges and areas		x	x	Relph, 1976	Background documents and spatial analyses a t local level
	Visual experience in space definition	Impression of local population	Very good	Good	Acceptable	Poor	Unacceptable		x	x	Local Population Survey	Local population survey
Plans and Planning	Plans and planning	Scope and quality of equipment	Very good	Good	Acceptable	Poor	Unacceptable	x	x	x	PUP - Spatial Arrangement Conditions, PIN – Spatial Implementation Plan, urban and landscape concept, building plans individual projects	Expert assessment
Buildings charact.	Cultural objects of importance	State of existing objects	Renewed object of local and national value	Renewed object of local value	Object of local value	Damaged objects of local value	Demolished objects of local value				Evans, 1996	Background documents, Register of cultural heritage, Spatial Arrangement Conditions - PUP
	Engineering-construction elements	Quality	Very good	Good	Acceptable	Still acceptable	Unacceptable		x	x	Expert opinions, analyses and research	Expert opinions and analyses
Noise	Day and night noise levels in respect of area sensitivity	Area category	IV	III	III	II	I	x	x	x	Noise regulation on roads and railways, expert analyses and research	Expert opinions and analyses

well as cases of good practices or the presentation of application possibilities which have their source in the theoretical background.

The main advantage of the presented methodology is without doubt the parallel multidisciplinary approach which combines spatial and environmental evaluation with a set of relevant indicators which directly or indirectly influence the spatial placing of transport infrastructure elements – transport logistic terminals and the transport logistic approach.

The key to understanding multidisciplinary problems such as the development of regional transport logistic terminals is above all the interlaced observance of various viewpoints of the transport problem from the global-international to regional-local level.

Local (in most European countries regional) authorities have to take into consideration all the mentioned inputs of relevant documents on international, national, regional and local level. The authorities also have to define indefensible components and criteria of spatial evaluation.

The results of the methodology presented in the paper show that the choice of indicators is suitable and efficient in all respects. The Analytic Hierarchy Process method correctly enables users subsequent adding and removing of criteria (indicators), sub-criteria, alternatives, depending on the individual evaluation case.

Based on Analytic Hierarchy Process - AHP method, the authorities may present the results of evaluation of the transport logistic terminal location to potential developers or investors. The authorities can also use this method to define and design the spatial development guidelines for themselves.

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PRISTOP K PROSTORSKEMU VREDNOTENJU V PROCESU NAČRTOVANJA TRANSPORTNO LOGISTIČNIH TERMINALOV

POVZETEK

Trenutno stanje vsesplošne globalizacije v Evropi in v svetu nujno potrebuje nov interdisciplinarni pristop k prostorskem umeščanju elementov prometne infrastrukture in prometne infrastrukturne krajine v razvoju urbanega in podeželskega okolja.

Pri odločanju o lokaciji transportno logističnega terminala morajo biti upoštevane določene tehnične, tehnološke in finančne omejitve. Pri tem je potrebno analizirati blagovne tokove in infrastrukturne povezave ter opraviti okoljsko ovrednotenje.

V prispevku je dan poudarek prostorsko-okoljskemu vrednotenju, zato so predstavljeni vsi morfološki kazalniki, ki neposredno in posredno vplivajo na strukturo in podobo elementov prometne infrastrukture – prometno logističnih terminalov. Članek se v tem delu sklene z ugotovitvijo, da sta pri oblikovanju in vrednotenju elementov prometne infrastrukture in prometne infrastrukturne krajine prisotni dve kategoriji morfoloških elementov:

grajeni morfološki elementi (vsi objekti in njihovi elementi) in

naravni morfološki elementi (topografija, klima, vegetacija itd.).

Predstavljena metodologija prostorsko-okoljskega vrednotenja se ukvarja z interakcijami med grajenimi in naravnimi morfološkimi elementi - oblikovne kakovosti in karakteristike so dodane obema skupinama.

Izsledki in projekcije, pridobljene na podlagi prostorske in transportno logistične študije, predstavljajo, skupaj s finančno-ekonomskimi predpostavkami, osnovo za pripravo poslovnega načrta – pomembnega elementa pri sprejemanju odločitev o izgradnji transportno-logističnega terminala.

KLJUČNE BESEDE

promet, logistika, intermodalni transport, transportno logistnični terminali, prostorsko planiranje, prostorsko vrednotenje

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