Paper 189 - Inland navigation and Land use Planning: A multi-criteria approach

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ABSTRACT: The present structure of harbours in the Walloon region hardly fits the needs of present logistic developments. Considering the challenges for the development of fluvial transport, the Walloon public authorities decided in 2010 to indentify potential harbour development sites along its 440 kms of waterways. A three steps approach (selection, ranking and documentation) was designed for this purpose. This paper broaches the methodology and the results of this approach. The area of sites and their availability, which were considered as most debatable during the research, are specifically discussed.

1 INTRODUCTION

Land use planning appears to be a key requisite for the long-term development of waterways. This is especially the case in North-West Europe given the pressure on land exerted by housing, economic estates and natural conservation demands along waterways. At the same time dominant maritime harbours, like Antwerp or Rotterdam, are in search of larger inland harbours (more than 50 hectares) so as to deploy complimentary logistic projects in their hinterland in the view of facing expected congestion issues. This obviously requires an adequate land provision policy in the short, medium and long term. Finally, in a strongly urbanised context, land use planning has increasingly to address the concerns of local populations in order to minimize expected impacts (noise, dust, carriage) and offer adequate compensation for facilitating the integration of harbour sites in their local environment.

2 INLAND HARBOUR IN WALLONIA

2.1 Documentation of the current public offer

The territory of Wallonia counts 440 kms of fluvial waterways and is situated in between three main international connections: Anvers by the Albert canal, Rotterdam via the Juliana canal and Paris-Dunkerque via the Seine-Nord Europe canal (still in project). Four public operators are responsible for managing the public offer of harbour lands along waterways: the Port of Liège (PAL), the Port of Charleroi (PAC), the Port of Namur (PAN) and the PACO. Their competences are territorially established. Due to their independent character and lack of well-established reporting procedures, the regional authorities have no clear view on their policies of land allocation and management and on transport flows at aggregated and desaggregated level. A preliminary step of our research consists in establishing a central register of the existing sites. This register lists a series of 60 specifications and the exact localization for each site. Data were obtained by fieldwork and exploiting existing disaggregated databases. Table 1 compiled some results.

<table>
<thead>
<tr>
<th></th>
<th>PAL</th>
<th>PAN</th>
<th>PAC</th>
<th>PACO</th>
<th>Wal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of sites</td>
<td>33</td>
<td>31</td>
<td>28</td>
<td>45</td>
<td>137</td>
</tr>
<tr>
<td>Tot. area (ha)</td>
<td>369</td>
<td>157</td>
<td>356</td>
<td>29</td>
<td>911</td>
</tr>
<tr>
<td>Available (ha)</td>
<td>47</td>
<td>8</td>
<td>18</td>
<td>3</td>
<td>76</td>
</tr>
<tr>
<td>Mean area (ha)</td>
<td>11.2</td>
<td>5.6</td>
<td>13.2</td>
<td>0.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Largest site (ha)</td>
<td>97.9</td>
<td>47.5</td>
<td>54.6</td>
<td>5.1</td>
<td>97.9</td>
</tr>
</tbody>
</table>

Table 1: Main facts about existing sites.

If data was available, transport flows have also been registered and commented. We observed especially that IN/OUT flows ratios are characteristic of diverging conditions between the different ports, somehow related to the local industrial tissue. Figure 1 shows the global transport flows for the four ports and at the Walloon level.
2.3 SWOT Analysis

Considering collected data and intermediate observations, we proposed a SWOT (strengths, weaknesses, opportunities and threats) analysis relative to four competitiveness components of the Walloon structure: fluvial transport and logistics, infrastructures, harbour management, and urban planning. The main elements are outlined in the following tables 2 and 3.

<table>
<thead>
<tr>
<th>Component</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructures</td>
<td>Maintenance of waterways. Level of existing equipments.</td>
<td>Limitation due to locks. Connections with rail.</td>
</tr>
<tr>
<td>Harbour management</td>
<td>Diversification strategy Knowledge of economic tissue.</td>
<td>Site fragmentation and activity level. Commercialisation strategy. Monitoring and foresight planning.</td>
</tr>
<tr>
<td>Urban planning</td>
<td>Economic concentration along waterways. Cost of land.</td>
<td>NIMBY. Transaction costs.</td>
</tr>
</tbody>
</table>

Table 2: SWOT Analysis (part 1)  
Source: Teller et al. (2010)

<table>
<thead>
<tr>
<th>Influence Element</th>
<th>Positive influence</th>
<th>Negative influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Economic activity area with 0 to 5% of occupied surface.</td>
<td>Housing area. Natural conservation area. Slope &gt; 6%. High flood hazard or risks of landslides or karst constraints.</td>
</tr>
<tr>
<td>Weak</td>
<td>Economic activity area with 5 to 15% of occupied surface.</td>
<td>Green spaces zone. Slope 3%&lt;=x&lt;=6%. Medium flood hazard or risks of landslides or karst constraints.</td>
</tr>
<tr>
<td>Low</td>
<td>Economic activity area with 15 to 90% occupied surface.</td>
<td>Low flood hazard or risks of landslides or karst constraints.</td>
</tr>
</tbody>
</table>

Table 3: SWOT Analysis (part 2)  
Source: Teller et al. (2010).

3 IDENTIFICATION OF POTENTIAL SITES

3.1 A 3 steps approach

Considering these challenges, the Walloon Region decided in 2010 to identify potential harbour development sites. A three steps approach was designed for this purpose. The first step consists in the selection of relevant sites. The second step uses PROMETHEE II methodology to establish a ranking of the selected sites. The third step is the documentation of the final range of sites.

3.2 Selection of relevant sites

The first part of the selection consists in mapping the adequacy of land situated in a 1 km buffer along waterways for harbour development. For this, we use a six levels quantitative scale: negative (strong, weak, low) and positive (strong, weak, low) adequation. This scale is based on the existing land and enviromental planning documents, including land use plans, Natura 2000 areas, heritage zones, etc. Table 4 set out some examples of the influence elements.

<table>
<thead>
<tr>
<th>Influence Element</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport and logistics</td>
<td>Inland support for Antwerp and Rotterdam. Connection with NSE network</td>
<td>Desindustrializ. Uncertainty regarding heavy products.</td>
</tr>
</tbody>
</table>

Table 4: Influence elements.

The used quantitative scale is represented on a map by color shades, from red for very inadequate to green for very adequate. Map 1 illustrates this process using as example the PAL’s competences zone.

In the second part of the selection, we organized work groups with local stakeholders. Our previous
desktop analysis allowed them to identify relevant development zones, considering their field know-how. It was indeed considered that some sites, presently occupied by economic activities, may become available at a 20 to 30 years horizon and should hence be considered as a priority for future logistic projects in the view of recycling existing or future brownfields.

In a set on evaluation criteria. A is a finite set of possible alternatives to treat multicriteria problems of type  

In our case, the set of selected sites. The following explanations are based on Brans & Maireschal (2005).

3.2 Ranking of the selected sites

In a second step, those potential sites were classified against a series of 23 criteria, including inland harbour developments criteria (inland waterway capacity, available area of the site, distance from locks etc.), land use criteria (proximity to housing, distance from other economic activities, present allocation in land use plans) and accessibility criteria (rail and road connexions, distance to motorway junction etc.). The classification was based on the PROMETHEE II complete ranking methodology and included sensibility tests so as to check the importance and effects of weighting factors. The following explanations are based on Brans & Maireschal (2005).

3.3 The PROMETHEE methodology

The PROMETHEE methodology was designed to treat multicriteria problems of type max \( g_1(a), g_2(a), \ldots, g_n(a) \mid a \in A \) (1) where A is a finite set of possible alternatives \( \{a_1, a_2, \ldots, a_n \} \) and \( \{g_1(\cdot), g_2(\cdot), \ldots, g_n(\cdot)\} \) a set on evaluation criteria. In our case, \( \{a_1, a_2, \ldots, a_i, \ldots, a_n \} \) is the set of selected sites.

PROMETHEE methodology requests additional information between the criteria, expressed by the set \( \{w_j, j = 1, 2, \ldots, k\} \) which represents weights of relative importance of the different criteria. These weights are non-negative numbers, independent from the measurement units of the criteria. The higher the weight, the more important the criterion.

There is no objection to consider normed weight, so that \( \sum_{j=1}^{k} w_j = 1 \) (2). Assessing weights to the criteria involves the priorities of the decision-maker. Quite importantly the area of the sites and their present allocation in land use plan were considered as important dimensions in the analysis.

PROMETHEE methodology also requests additional information within the criteria. The PROMETHEE preference structure is based on pairwise comparisons. The deviation between the evaluation of two alternatives on a particular criterion is considered such that the larger the deviation, the larger the preference. There is no objection to consider that these preferences are real numbers varying between 0 and 1. In case of a criterion to be maximised, the function \( P_j(a, b) = F_j[d_j(a, b)] \) \( \forall a, b \in A \) (3) where \( d_j(a, b) = g_j(a) - g_j(b) \) (4) and for which \( 0 \leq P_j(a, b) \leq 1 \) (5) is giving the preference of alternative a over alternative b for observed deviations between their evaluations on criterion \( g_j(\cdot) \). For criteria to be minimized, the preference function is reversed or alternative \( P_j(a, b) = F_j[-d_j(a, b)] \) (6).

Brans & Maireschal (2005) define the pair \( \{g_1(\cdot), P_1(a, b)\} \) as the generalised criterion associated to criterion \( g_1(\cdot) \). A generalised criterion has to be defined for each criterion. Brans & Maireschal (2005) proposed six types of particular preference functions. These functions are exposed in table 5. In each case, parameters \( p \) (threshold of strict preference), \( q \) (threshold of indifference) and \( s \) (intermediate value between \( q \) and \( p \) which defines the inflection point of the preference function) may need to be defined. After that, the PROMETHEE procedure can be applied.

In a first time, we determine aggregated preference indices. Considering \( a, b \in A \),

\[ \pi(a,b) = \sum_{j=1}^{k} P_j(a,b)w_j \] (7) is expressing with which degree a is preferred to b over all the criteria and \n
\[ \pi(b,a) = \sum_{j=1}^{k} P_j(b,a)w_j \] (8) with which degree b is preferred to a.


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In a second time, we calculate outranking flows. Each alternative \( a \) is facing \( (n-1) \) other alternatives in \( A \). The positive outranking flow

\[
\phi^+(a) = \frac{1}{n-1} \sum_{x \in A \setminus \{a\}} \pi(a,x)
\]

(9) expresses how an alternative \( a \) is outranking all the others such that the higher \( \phi^+(a) \), the better the alternative. The negative outranking flow \( \phi^-(a) = \frac{1}{n-1} \sum_{x \in A \setminus \{a\}} \pi(x,a) \) (10) expresses how an alternative \( a \) is outranked by all the others such that the lower \( \phi^-(a) \), the better the alternative.

Finally, in PROMETHEE II complete ranking methodology, the net outranking flow is expressed by

\[
\phi(a) = \phi^+(a) - \phi^-(a)
\]

(11) The higher the net flow, the better the alternative, so that \( a \) is preferred to \( b \) iff \( \phi(a) > \phi(b) \) (12) and there is indifference between \( a \) and \( b \) iff \( \phi(a) = \phi(b) \).

### 3.3 Results

At the end of the exercise, some 62 potential sites were identified whose mean area is 41 hectares (5.5 times larger than the mean area of the existing sites) and total area 2,538 hectares. Furthermore a significant amount of these 62 sites, namely 38 of them, were considered as rapidly available, namely in a time horizon of 5 to 10 years (priority I). The Table 6 summarize the main results for the four ports and at the Walloon level.

<table>
<thead>
<tr>
<th>Nb of sites</th>
<th>Priority I (5-10 y.)</th>
<th>Priority II (&gt;10 y.)</th>
<th>Total area (ha)</th>
<th>Mean area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAL</td>
<td>16</td>
<td>10</td>
<td>768</td>
<td>48</td>
</tr>
<tr>
<td>PAN</td>
<td>14</td>
<td>9</td>
<td>468</td>
<td>33</td>
</tr>
<tr>
<td>PAC</td>
<td>9</td>
<td>7</td>
<td>226</td>
<td>25</td>
</tr>
<tr>
<td>PACO</td>
<td>23</td>
<td>12</td>
<td>1.175</td>
<td>47</td>
</tr>
<tr>
<td>Wal.</td>
<td>62</td>
<td>38</td>
<td>2,538</td>
<td>41</td>
</tr>
</tbody>
</table>

**Table 6: Main results.**

### 4 DISCUSSION

The impact of the area of sites and their availability, which were considered as most debatable during the research, must be more specifically discussed in particular for the first one through a comparison of the efficiency of inland harbour sites in Wallonia and North-West Europe.

#### 4.1 Availability as a factor of decision

Availability of the selected sites was not taken into account as a criterion in our methodology, so it had absolutely no influence on the ranking. However the final ranking mentions the availability status of each site (5-10 years and more than 10 years). This information could be useful to the public authorities to manage short and long-term requirements and opportunities, and to manage stock and offer.

#### 4.2 Area as a key criterion

Area was considered as one of the most important criteria in our ranking methodology. It influenced largely the final ranking. Different reasons could justify our choice.

First, we observe that concentration of sites must be preferred to scattering. In fact, concentration is a factor of efficiency because it increases average tonnage per site and reduces management costs. Figure 2 shows the average tonnage per site and the number of sites for the port of Paris, the port of Liège and the port of Duisburg. We can clearly observe that the most concentrated sites, like Duisburg, have the better efficiency in terms of flows...
per site. On the opposite, the port of Paris presents a large number of sites, but smaller average flows per site.

Figure 2: Average tonnage per site and number of sites for Paris, Liège and Duisburg.

Second, we observed in our initial research (Teller et al., 2010) that in the Walloon context, high-added value projects require area superior to 10 hectares.

REFERENCES
