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Abstract

This paper describes the use of Soft System Methodology (SSM) as a problem structuring tool, paving the way for the development of a decision support model in the process of planning the location of a freight village. The SSM approach contributed with a deeper understanding of the problematic situation, the identification of the main stakeholders and their relations, in a complex setting involving several Government bodies, municipalities, regional agencies, companies, in the presence of legal, technical, social, economical, and environmental aspects. The SSM analysis enabled to uncover, clarify and structure issues relevant for the development of a multi-criteria model to provide decision support.

Keywords: Logistics, transportation, freight villages, soft systems methodology (SSM), multi-criteria

1 Introduction

The evolution of the economic integration process in the European Union (EU), allied to market competitiveness and to new demands from clients, highlight the importance of the transportation sector in the economy. However, the EU is aware that the rapid growth of the road transport of goods has caused important problems, namely regarding traffic congestion, accidents, and pollutant emissions, with strong economical, social and environmental implications [EC, 2001].

The EU recognises that this situation is the result of a low efficacy and efficiency in the organisation of the European transportation system and a failure to make optimum use of
transportation and new technologies. The transportation sector is crucial for competitiveness, and its malfunction is reflected into lost opportunities to create new markets and hence in a level of job creation that falls short of its potential. To overcome these bottlenecks, it is necessary to foment the investment in transport infrastructures and efficient modal nodes to promote inter-modality (namely rail-road interfaces).

Modal nodes, in particular freight villages (FV), are placed in connection nodes of the transportation network links. This type of infrastructure is an important point of local and regional economic development, characterised by the specific functionalities it offers, the strategic location, and the activities of added value, among others. [Lambert et al., 1998; Rushton et al., 2000]

The location of modal nodes is crucial for the success of the logistic operations, where the time economy and the transportation cost are key issues. Other important aspects at stake are the framing of these infrastructures within the scope of the land planning and transportation policies and the assessment of their impacts according to several criteria, at local and regional levels.

The location of FVs is an example of strategic decisions to be made in an environment of increasing complexity, where a balance between multiple (often conflicting) aspects of evaluation is required to assess the merit of alternatives courses of action. In fact, several criteria of technical, social, economical, legal and environmental nature must be explicitly considered in decision support models for FV location.

Multi-criteria models help decision makers rationalising the comparisons among distinct alternative courses of action, providing them with a better perception of the conflicting aspects under evaluation and the ability to grasp the nature of the tradeoffs to be made.

In Portugal, according to the DGTT (General Direction of Land Transport; “Direcção Geral dos Transportes Terrestres”, in Portuguese) [DGTT, 1999], the logistic activity is characterised by the use of logistic facilities built in a disordered fashion, the non-existence of efficient and competitive FVs, in national and European markets, and the poor organisation and technology in the main transportation companies.

The aim of this paper is to show how SSM has helped to structure the problematic situation and provided insights which revealed fundamental to build a decision support model for assisting public and private entities to make decisions regarding FVs’ location. By enabling to structure a mesh of inter-related problematic issues, SSM also unveils the evaluation aspects which contribute to assess the merit of different courses of action.
(location of FVs), therefore helping to shape the criteria to be used in multi-criteria decision support models.

SSM begins exploring the problematic situation by identifying its very nature and all stakeholders involved and their relations. Activity models for relevant systems are developed, according the perception that each actor has of the real-world. These models are compared with the real-world, resulting in a set of possible changes to be implemented to improve the problematic situation.

Moreover, SSM helped to structure the discussion on the kind of tools to use to provide decision support regarding FVs location. This study shows the relevance of SSM to structure the problematic situation in a way that a multi-criteria decision support model emerges naturally as the most adequate methodological approach to follow [Daellenbach, 1997; Belton et al., 1997; Bana e Costa et al., 1999; Neves et al., 2004].

SSM has been used to improve the perception of complex and problematic situations in different contexts, such as in information systems, industry, health, public services, management, among others [Checkland and Scholes, 2000; Rosenhead and Mingers, 2001]. To our knowledge there is no report in the scientific literature of the application of SSM to logistics, in particular for structuring the problem of FV location.

The final aim of this work is to propose a comprehensive operational methodology encompassing SSM and multi-criteria analysis, which can be used by any entity involved. To accomplish this, the methodology must be flexible to adapt to the different concerns of private and public entities and its results must be clear and meaningful to decision makers.

The interest and motivation of the study have been provided in this introduction. In section 2, the context of the study (the problematic situation) is described. The application of the SSM approach as a problem structuring tool is developed in section 3. Some conclusions are drawn in section 4, particularly referring to the follow-up of the study consisting in the development of the multi-criteria models and the multi-criteria methods to be used to provide decision support.

2 The context of the study (situation considered problematic)

The set of policy proposals in the POAT (Operational Program of Accessibilities and Transports, “Programa Operacional de Acessibilidades e Transporte” in Portuguese) [IOT, 2000], elaborated by an entity called IOT (Operational Intervention of Accessibilities and Transports, “Intervenção Operacional de Acessibilidades e Transportes”), aimed at
contributing for the definition of a transportation policy and a global strategy for the logistics sector. This document clearly indicates the structural reorganisation of the logistic system and the transportation companies, as well as the set up of a modernisation and expansion program of the transportation infrastructures, as indispensable actions to develop a modern and efficient Logistics System (LS).

The LS should assume a major role in the national development policy:

a) taking in account its structure and qualifying function in the process of European integration of Portugal, and for constituting a competitive factor of the economy;
b) as a strategic vector to link the Portuguese territory with the macro-regions of the Iberian Peninsula and the balanced integration of Portugal in the Iberian space.

In this context, FVs play an important role as nodes of a multi-modal network by providing:

- a new culture in the traffic and movement of goods;
- an increment in the sector development through the introduction of new management methodologies and tools, thus improving productivity;
- the establishment of new partnerships, allowing to reduce the fixed costs, through the allotment of services and equipment.

A preliminary screening of the FV implementation problem has been done by developing a SWOT analysis (table 1). This helped to clarify some issues contributing to the need to structure the problematic situation.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Some sectors of this industry present quality in production and services</td>
<td>- The existing logistic infrastructure (FVs) has been built disorderly</td>
</tr>
<tr>
<td></td>
<td>- Inefficient inter-modality in transportation of goods</td>
</tr>
<tr>
<td></td>
<td>- There is no tradition and practice of enterprise co-operation</td>
</tr>
<tr>
<td></td>
<td>- Small investments in information technologies and R&amp;D</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Markets of the recent EU members</td>
<td></td>
</tr>
<tr>
<td>- PALOP (African Portuguese-speaking Countries) markets</td>
<td>- Intensification of external competition</td>
</tr>
<tr>
<td></td>
<td>- Some legal and technical procedures impair the rapidity of commercial transactions</td>
</tr>
<tr>
<td></td>
<td>- Highly-qualifed and low cost labour from eastern European countries</td>
</tr>
</tbody>
</table>
3 The use of SSM

In an environment characterised by an increasing complexity and uncertainty (also deriving from the presence of multiple evaluation aspects), strategic decisions are harder to make. These turbulent environment characteristics stem from the distinct nature and interests of stakeholders and players (organisations and individuals), the sometimes unpredictable behaviour of these players, the fact that decisions are interactive, as well as most resources, agents and activities are mobility endowed. Therefore, there is a poor knowledge of the problem in all its facets (there is a mesh of inter-related problems) and the need for a problem structuring tool emerges.

Taking into account the authors’ background in electrical and computer engineering, namely the awareness of systems theory, SSM was a natural choice to help us in the problem structuring task because of the systemic nature of its foundations and processes. Moreover, the intention was to structure the problematic situation in such a way that the development of a decision support model devoted to providing assistance to decision makers in the location of FVs would be the next step. SSM enabled us to look at the whole problematic context, uncovering new possible stakeholders (for instance, entities affected by a particular FV location) and relationships, to gain new insights into the problem without limiting possible courses of action.

The application of SSM follows the classic seven stages [Rosenhead and Mingers, 2001; Checkland and Scholes, 2000; Checkland, 2001, Checkland, 1990].

3.1 Stage 1: the situation considered problematic

The main objective of this stage is diagnosing the problematic situation by identifying the nature of the problem and the stakeholders involved.

The description of the situation is based on the so-called Analysis One (exploring the actual problematic situation by identifying the players in the process), Two (identifying the "existing culture" of the social system) and Three (examining the policy situation and exploring power relationships) [Checkland and Scholes, 2000; Rosenhead and Mingers, 2001].

The integration of Portugal in the EU asks for the insertion of its Transportation System (TS) into the European and intercontinental networks. Moreover, it requires a bigger efficacy and competitive capacity of the LS, allowing to strength the country in the
relations of Europe with other economical spaces. For this reason, the Portuguese Government began in March 1998 the elaboration of the PNDES (National Plan of Economic and Social Development, “Plano Nacional de Desenvolvimento Económico e Social”). This document emphasises the role of logistics in the process of national development, considering it a priority area of intervention for the period 2000-06 [MEPAT, 2000], regarding the installation and dynamics of the LS infrastructures and organisational bases.

A Government resolution issued in March 2000 assigned to the DGTT the competencies to promote the elaboration of the plan for a national network of Freight Villages in the continental territory. Legislation was then issued to promote the development of the LS, with emphasis on inter-modality, as well as its integration in the transportation chains and European and world-wide logistic chains. A group of mission called Gablogis (National Logistic System Development Office) was also created to promote the implementation of a FV national network (RNPL, “Rede Nacional de Plataformas Logísticas”) plan, to reorganise micro-logistics in metropolitan areas and medium towns, and to support the development of companies in the sector. In fulfilment of a Government decision, the company Halcrow Fox presented in April 2001 the study "Portuguese Freight Villages Masterplan" [Halcrow Fox, 2001].

The Public Administration has responsibilities in the creation of the adequate conditions to the development of the logistic activities, to guarantee the balanced development of the national territory and its regions. In this context, the Commissions of Regional Coordination and Development (CCDRs) play an essential role, regarding the practical application of the sector policies in the regional space.

The Environment Institute (IA, “Instituto do Ambiente”) presented in July 2003 a plan for the National Strategy of Sustainable Development (ENDS, “Estratégia Nacional de Desenvolvimento Sustentável”) [IA, 2003] for the transportation sector. In the ten lines of strategic orientation in the ENDS, it is mentioned the need to make compatible the LS’s policies with the environment and the territorial planning, as well as to review the accessibility and mobility issues in a sustainability perspective beyond the transportation sector planning.

In summary, some entities had been nominated to promote studies and projects of implementation in the scope of the logistic sector or in the transportation domain. Some studies had been carried out, but the fact is a RNPL Plan approved by the Government does not exist and, therefore, no project related with the plan was implemented. That is, the
LS is a system lacking a legal and institutional framework and a strategic orientation, where the existing infrastructures have been created in a disordered manner in the territory, presenting low efficiency and efficacy, thus originating a weak competitiveness, in national and international levels.

3.2 Stage 2: Express the problem situation

In this stage, the analyst should collect the information and describe the situation in the space where the problem occurs, conceiving an illustrative diagram (Figure 1) to allow the identification of:

- the structure of the system and the stakeholders (with direct and indirect intervention);
- the processes occurred in the system, with focus on the relationships between its elements;
- the social issues relevant to the elements of the system.

This enables the design of a model that facilitates the reflection on the system and helps the analyst to diagnose the problematic situation.

The rich-picture diagram (Figure 1) displays the entities that play a relevant role in the system:

- Government: it defines the global strategy of economic development for the country, the sector-based and horizontal policies. It supports the investment through the management of incentive schemes, as well as the introduction of programs and mechanisms to support companies, with the aim to modernise the enterprise fabric and to create conditions for strengthening it. Decisions supported in social-economical evaluations are made, having into account:
  i. the reduction of domestic territory asymmetries;
  ii. the approach of Portugal to the European average level of development, speeding up the course of real convergence;
  iii. the economic growth through the public investment in infrastructures;
  iv. the compatibility between the great projects and the guidelines of territory planning policy, including the consideration of the environmental and historical-cultural values.
✓ Gablogis: entity responsible for the promotion of studies in the sector, the implementation and the dynamics of infrastructures, the organisation of the LS, and the co-ordination of the RNPL implementation.

✓ API: entity that manages and negotiates incentive schemes to the investment, which can contribute to the dynamics of companies and industrial parks in the framework of an RNPL plan.

✓ Transportation system: it integrates the entities that manage the infrastructures and operate in the different transportation modes. The system ensures the mobility of goods, combining different transport modes, with a national and international scope, with the aim of rationalising the use of resources when establishing the links between the FVs.

✓ Economic agents: these are the agents of the enterprise network in the national and international markets that intend to develop their economic activity, installing themselves in well-located FVs that offer services with quality, efficacy and efficiency, thus adding value to the company.

A set of other entities are represented in the rich-picture diagram, that are affected by or can influence decisions, namely the financing agents (IOT and GEP), sector-based agents, the CCDRs, and the society as a whole. However, none of them can be considered as a user of the analysis system, except in an indirect way, through the other entities.

A brief description of the diagram follows to provide a better understanding of the entities involved, the roles they perform and their relations.
Figure 1 – Rich-picture diagram
The IOT and the GEP are two public entities (under guardianship of the Ministry of Public Works, Transports and Housing and the Ministry of Economy, respectively) that have the power to decide the financing of initiatives, studies and projects in the logistics and the transportation sectors. However, they do not have any intervention directly in the analysis of the FV locations.

The society is another of the indirect actors in the system, because it has the power to choose the Government and the municipal authorities.

The sector-based agents include entities such as the associations in the logistics and transportation sectors. Municipalities and the CCDRs are also entities with indirect intervention in the system. These entities establish the dialogue with Gablogis, which plays the co-ordinator role, transmitting their concerns and solution proposals, with the aim to develop in a sustainable way the social and economic spaces they represent. Although they do not interfere directly in the system, they provide inputs to Gablogis.

3.3 **Stage 3: Formulate root definitions of the relevant system for the purposeful activity**

After the analysis and identification of the relevant system, the formulation of the root definition is an essential step for the creation of the conceptual model in the next stage. These definitions must be interpreted according to the perception and values of the entities involved on how the system would have to function.

This stage allows the identification of the perspectives most relevant for the analysis:

- **Customer:**
  
  i. Customer – the economic agents and the transportation system agents, because these are the entities that offer or use services in the FVs;
  
  ii. Society - with the implementation of well located FVs, it is possible to identify a set of resulting benefits for society: the optimisation and rationalisation of resources contribute to increase productivity, then more prosperity; a reduction of the road transportation with the consequent reduction of accidents and environmental impacts, offering better quality of service, improves the quality of life;
iii. Municipalities - in the scope of the regional development strategies, they must stimulate a balanced economic and social growth within the region. Therefore, structuring projects such as FVs can foment the creation and the setting of companies in the region.

✓ Actor:

The Gablogis was selected because it is the entity that has the responsibility to conceive a national plan to foment the creation, the exploration, the operation and the management of FVs.

✓ Transformation process:

This procedure transforms data that characterise the possible FV locations (I) into a proposal of classification of the FV locations in pre-defined ordered categories (O).

The quality of the transformation process can be evaluated by the Efficacy, Efficiency, and Effectiveness criteria.

Efficacy: Does the means work?

The system allows to classify the FV proposed location into pre-defined categories (for instance, possible categories are “Very adequate”, “Adequate”, “Less adequate”, “Non-adequate”).

Efficiency: Is there a minimum use of resources?

Through a rigorous data gathering and sound methodological tools it is possible to provide decision support encompassing the relevant evaluation aspects. Other (ad-hoc) approaches could easily lead to big investments in infrastructures, which could not fulfil the aims and expectations.

Effectiveness: Is T meeting the long-term aim?

A well structured decision support model helps to make well informed decisions, considering economical, social and environment aspects that influence a sustainable land planning with benefits in medium and long terms.
✓ **Weltanschaung:**

A FV location is approved if the advantages outweigh the disadvantages (thus involving concordance and discordance principles), considering all aspects contributing to assess the merits/demerits of installing a FV in a given candidate place, also taking into account the co-ordination between its operational subsystems and the interconnection with other national and international FVs.

✓ **Owner:**

The Government is the agent that defines the model for the sector, establishes the strategical guidelines, delegating in specific entities the responsibility to manage and to implement actual actions. The financing entities (IOT and GEP), although depending from the Government, also have an important role because they can authorise or not the financing of initiatives, studies and projects in the sector.

✓ **Environmental constraints:**

Social (e.g., population density, unemployment rate), economic and financial (e.g., land cost, incentives), available information, capacity to get relevant and restricted access information (e.g., enterprise activity data), environmental (e.g., air quality, predominant wind direction, noise level, land use, agricultural reserve, ecological reserve), legal (e.g., national and municipal regulations, labour laws, enterprise activity legislation), geographical (e.g., quotas, latitude, longitude), infrastructures (e.g., access to roads, railways, ports, airports), human (e.g., academic qualifications, professional training), material resources, technological resources (e.g., energy and telecommunications infrastructures), national and international policies.

The system is controlled by the Government and the financing entities, being the Gablogis responsible for presenting a proposal of FV location classified into pre-defined ordered categories, with the aim to provide a sustainable development for the customer, the municipalities and the society.
3.4 **Stage 4: Build conceptual models of the systems in the root definitions**

This stage consists of assembling the minimum number of actions associated with the activities in the system in the root definitions and structuring them according to logical dependencies. Figure 2 illustrates the conceptual model of the system.

The model structures the discussion about the problematic situation with the goal of helping to find feasible and desirable alternatives to improve the present performance and to find or create motivation to act.

The diagram illustrating the modelling process consists of seven main activities, being action 6 developed in the subsystem "Definition of requisites". It also includes activities which control the performance in the transformation process.

The first activity consists in identifying the necessary information to develop the system, namely the goals to reach, estimates of costs, the expected results, the agent who implements it, the available resources, the entities which are related with the agent, information management issues, among others.

In action 2, mechanisms are defined to implement the data collection and recognise dialogue partners in different entities. Action 3 proceeds with the collection of the data available from the agents and entities identified.

Action 4 consists in identifying a set of constraints of different nature with influence on the system success, namely financial, legal, environmental, territory planning, infrastructure availability, social, economical, information availability, capability to get relevant and restricted access information, geographical information, human and material resources, national and international strategic policies, among others. Action 5 consists in analysing and evaluating the data collected in action 3 and the impact of the external influences on the system identified in action 4.

The comparison of all the advantages and disadvantages (involving concordance and discordance principles for the criteria vis-à-vis each alternative) in action 7 is the system’s goal, and it reinforces the need to use a multi-criteria decision support tool capable of classifying the alternatives (location proposals) into pre-defined ordered categories.

The identification of alternatives is made in subsystem 6 and they are characterised in Action 6.
Figure 2 – Conceptual model of the relevant system built from root definitions and CATWOE
The model describes the activities of the relevant system, obtained from the root definitions, which are considered necessary to execute a specific transformation process. The models support the discussion on changes to improve the system’s performance, providing the foundations to rethink in many aspects the activities occurring in the real world.

3.5 **Stage 5: Compare models with real world actions**

This stage consists in comparing the problem analysed in stage 2 with the conceptual model built in stage 4, with the aim of generating the debate which is the source of the discussion on the changes to be performed. The result of this procedure is briefly illustrated in table 2.

The comparison process was carried out by the analyst/consultant based on the information acquired from several sources (Government bodies, Statistics Institute, etc.) and the knowledge obtained in the meetings with some entities, namely the Gablogis.

The actions are concentrated in the entity promoting the process, the Gablogis, and the links between them are simple ways of information transmission, the exit of action N being the input of action N+1.

3.6 **Stage 6: Define possible changes which are feasible and desirable**

From the results obtained in the previous stages, the changes suggested are evaluated whether they are feasible and culturally desirable. This procedure has been carried out through several meetings between the consultant and the Gablogis to identify correctly the actions to be implemented.
<table>
<thead>
<tr>
<th>Action #</th>
<th>Activity</th>
<th>How is it developed?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify the information necessary</td>
<td>List the entities which constitute the Permanent Commission for the development of logistics and combined transportation. Identify other entities or economical agents associated with the logistics activity. List studies developed for this sector. Obtain statistical social-economical and sector operation data.</td>
<td>References are missing regarding international entities with experience in the sector. More statistical information of the sector activity is needed as well as data related to environment impacts, road accidents, technological resources.</td>
</tr>
<tr>
<td>2</td>
<td>Establish mechanisms of information gathering</td>
<td>Program meetings to establish contacts with relevant entities. Visit European FVs. Attend specialised conferences and seminars.</td>
<td>Perform surveys about entrepreneurship. Consult international bodies supervising the sector. Consult national and international (EUROSTAT) statistical institutes.</td>
</tr>
<tr>
<td>3</td>
<td>Information gathering</td>
<td>Promote a meeting with the Permanent Commission for the development of logistics and combined transportation. See studies performed by other entities. Attend specialised conferences and seminars. Consult statistical data.</td>
<td>Same as above.</td>
</tr>
<tr>
<td>Action #</td>
<td>Activity</td>
<td>How is it developed?</td>
<td>Comments</td>
</tr>
<tr>
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</tr>
<tr>
<td>4</td>
<td>Identify environmental constraints</td>
<td>The entities belonging to the Permanent Commission for the development of logistics and combined transportation. Inform about constraints during the consultation process.</td>
<td>Perform a preliminary screening of the constraints in the main topics. Continuous observation process to identify the evolution of constraints.</td>
</tr>
<tr>
<td>5</td>
<td>Analyse and evaluate the information</td>
<td>Participants in the process analyse and evaluate the information available.</td>
<td>The information available is scarce and unstructured.</td>
</tr>
<tr>
<td>6.1 a 6.5</td>
<td>Sub-system “Definition of Requisites”</td>
<td>The evaluation criteria are identified according to the experience and perception of the participants in the process.</td>
<td>A multi-criteria analysis is required.</td>
</tr>
<tr>
<td>6</td>
<td>Evaluate advantages and disadvantages</td>
<td>Perform a multi-criteria analysis, according to the knowledge and sensibility of the entities intervening in stage 5 and sub-system “Definition of Requisites”.</td>
<td>Use of multi-criteria methods. Dealing with uncertainty is a key issue.</td>
</tr>
<tr>
<td>7</td>
<td>Compare advantages and disadvantages</td>
<td>To be developed using a multi-criteria method devoted to classify the alternatives in pre-defined ordered categories.</td>
<td>Use a decision support system based on a multi-criteria method such as ELECTRE TRI.</td>
</tr>
</tbody>
</table>
Sometimes, new questions until then unknown emerge during the discussion. For this reason, it is necessary to return to the previous stages to re-evaluate the problematic situation (stage 2). Consequently, stages 3, 4 and 5 have been reviewed. This process can originate new changes to be analysed in stage 6. This makes the process interactive and provides a constant learning.

3.7 **Stage 7: Take actions to improve the problematic situation**

The goal of this stage is to implement the proposed actions resulting from the last stage to help the intervention in the problematic situation. The FV location problem was identified as assigning the proposals to pre-defined ordered categories, to be evaluated according to multiple criteria. Both quantitative and qualitative (ordinal) scales should be accommodated. Alternative locations could be evaluated in groups or as isolated cases (for instance, whenever a proposal is made). Therefore, ELECTRE TRI method [Mousseau et al., 1999] emerged as the methodological tool most adequate for this purpose with these requirements. It must be remarked that the ELECTRE TRI method requires several parameters, such as criterion weights, and thresholds of indifference, preference and veto for each criterion, as well as reference alternatives which define the boundaries of the categories. An analyst with expertise on the meaning and influence of these parameters must assist the decision makers throughout the decision support process.

4 **Conclusions**

The application of the SSM methodology in the context of FVs location helped to investigate the whole problematic situation, structuring the problem to be tackled by a multi-criteria methodological approach. SSM contributed to describe the problem in a clear and objective way, thus helping to structure a consistent family of evaluation criteria, from what in the beginning were only more or less established perceptions.

The complexity of the real-world problem became evident from the structuring phase. The process is controlled by the Government and financing entities, the Gablogis being responsible for the elaboration of FV location plans. Potential locations are proposed and approved by Municipalities, respecting their territorial planning and investment attraction strategies. Multiple, often conflicting, evaluation aspects to assess the merit of different alternatives are at stake. As a result, a multi-criteria decision support model aimed at classifying these alternatives in pre-defined
ordered categories is being developed. The use of SSM as a problem structuring tool enabled to bridge the gap from the problematic situation to a decision support model.

This model accommodates the different concerns of the stakeholders intervening in the process, by considering explicitly evaluation criteria of distinct nature (social, economical, environmental, technological, financial, etc.) to maximize the benefits associated with the installation of FVs as a means to achieve a sustainable development for the customer, municipalities and the society as a whole.

In this context, the E, T and W elements from CATWOE gave an important contribute to shape the multi-criteria model:

- **Transformation process** - The (preliminary) evaluation of the potential FV locations is made assigning the alternatives to pre-defined ordered categories. This also enables to assess each alternative *per se*. For this reason the ELECTRE TRI method was selected as the most adequate multi-criteria analysis tool in this framework.

- **Weltanschaung** - The broadest goal is the maximisation of the benefits associated with installing FVs in the best places.

- **Environmental constraints** - Issues of distinct nature have been identified, such as social, economical-financial, environmental, geographical, human resources, technological, among others, to be considered in the multi-criteria analysis.

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