A systemic perspective on multi-stakeholder sustainable development strategies

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A Systemic Perspective on Multi-Stakeholder Sustainable Development Strategies

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Abstract

This study attempts to formulate a conceptual and operational model that encapsulates the highlights of scientific sustainability research, and that identifies the critical success factors of sustainable development from the perspective of different stakeholder groups. It seeks to identify viable consensus pathways in sustainable development strategies that are marked by conflicts among different stakeholders. In order to do so, this study focusses on three case studies that are part of the EU-project SMILE, their way of sustainability thinking and their stakeholders, in order to encapsulate different sustainability approaches and different needs for sustainable development. To identify critical success/failure factors in the search for sustainable development at the interface of economic, environmental and social factors, we use interview results, first, to compose case-study-specific pentagon models. These models offer a systematic framework for sustainability and, in general, distinguish between five key forces, viz. software (e.g. knowledge), hardware (e.g. research facilities), finware (e.g. financial support), ecoware (e.g. environmental amenities) and orgware (e.g. institutional support systems). In a second step, we use both the questionnaire results and a multi-criteria spider approach to quantify the relative importance of the pentagon factors for each stakeholder group. This way we are able to develop stakeholder-specific pentagon models. Although there are many applications of the basic pentagon model in the sustainability literature, our attempt can be seen as the first one that combines cases at different time and spatial scales to generalize the interfaces between scientific research and policy arenas.

Keywords: Sustainable development, systemic approach, pentagon model, stakeholder, spider model

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1 Systems Thinking about Sustainable Development

Sustainability is a hard-to-define concept, and it is a popular term that everyone likes to use (Daly, 1996). Sustainability discourses already have a history of several decades which started with the publication of 'Our Common Future', otherwise known as the Brundtland Report, in 1987. The aim of the report was to stress that environmental issues deserve a prominent place on policy agendas in both developed and developing nations, and to search for a common understanding of sustainability objectives of nations. Therefore, the report paved the way for the future of sustainability initiatives, which later on resulted in the Earth Summit Convention in 1992, which led to the adoption of Agenda 21 and the Rio Declaration. Furthermore, the work of the IPCC (Intergovernmental Panel on Climate Change) and the more recent Copenhagen Climate Conference may also be seen as the offspring of the Brundtland Report.

According to that report, sustainable development implies the development of countries and regions that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). The concept was not limited to environmental issues but also included other developmental aspects, so that the concept gradually acquired a multidimensional meaning and became difficult to define in operational scientific or policy terms. Given the conceptual complexity of this term caused by the multidimensionality of sustainability, international organizations and researchers were tempted to identify their own parameters. The diversity of the necessary conditions (WCED, 1987) and the multiple dimensions of sustainability (Sachs, 1997) are often reflected in complex lists of indicators. In 1996, the UN produced a list of 134 indicators following the outline formulated in Agenda 21 (UN, 1996). Sustainability is not a neutral concept, however, and therefore there is a need to develop a generic analysis framework that is able to encapsulate conflicting views among different stakeholders.

From an operational perspective, there is a need for a proper framing of the sustainability concept, by paying more attention to the relevant spatial scales ('think globally, act locally'), and to the logical coherence among various indicators. Given the complex nature of sustainable development processes and policies, a systemic approach may then offer a practical frame of reference. In general, a systems approach aims at portraying the

interlinked processes and relationships in a complex system that encompass various components which are linked together by means of functional, technical, institutional, or behavioural linkages (Harvey, 1969). Systems theory —on the basis of Bertalanffy's works— aims to depict and explain systems functioning in the context of a variety of systems in all fields of research. According to Hwang (2000), system thinking enables us to see the overlapping and ever-expanding relationships among systems in multiple dimensions with regard to both problem framing and problem solving in (organizational) practice. The idea behind considering the whole of a phenomenon and its related elements as a system is based on the perception of (space-time) 'causality'.

Besides its broader definition and sense, sustainability is the ability of a system to maintain resilience under conditions of dynamism and to remain viable in perpetuity. Therefore, sustainable development is the development by means of which the continuity of settlements and environments can be maintained, while increasing the well-being of inhabitants and offering a fruitful seedbed for economic activities.

In this paper, sustainability will mainly be assessed as the continuity of interrelated dynamism of a complex system, with a special focus on operational perspectives through the use of case studies. These cases have a heterogeneous nature, in order to illustrate the broad applicability of our approach to sustainable development, including specific economic activities. In our study, we will also address policies focussed on sustainable development in a broad context. These policies can be national policies or local policies, or even product- or sector- specific policies.

Sustainable development has to find a balance between different conflicting objectives and courses of action. There are in general multiple stakeholders, each in charge of a specific interest. In general, a stakeholder is someone who is interested in, involved in, and feels responsible for, a certain issue. Stakeholders can be politicians, branch organizations, action groups, environmental organizations, but also non-organized groups such as households or single farmers. Some of these actors are perhaps already involved in discussions or decisions, but others not yet, though actually they should be. In our approach, we identify two groups of stakeholders, depending on the focus of the case study. One group is related

to sustainable development in the specific case study, while the other is related to the development and implementation of the scientific knowledge base.

This study aims to formulate a conceptual and operational model that encapsulates highlights of scientific sustainability research, and that identifies the critical success/failure factors of sustainable development from the perspective of different stakeholder groups. In testing this approach, this study focusses on three case studies in Europe. We focus in particular on the perception of relevant stakeholders of what sustainable development is, and how it can be achieved. To identify critical success/failure factors in the quest for sustainable development at the interface of economic, environmental and social factors, we use the results of the interviews with stakeholders. This information is used as an input to design the analytical framework of our study, based on the what is called 'pentagon model'. This is an operational systemic methodology that has frequently been used to identify and to assess the importance and effects of the critical success conditions of sustainable development. We will design such a pentagon model for each of our case studies.

Following this conceptual introduction to systematic thinking on the evaluation of sustainable development, the Section 2 below introduces and highlights the pentagon model as a systematic framework for analysing sustainable development and examines the validity of the model for the use of sustainable development evaluation.

2 A Systemic Approach to Sustainable Development: the Pentagon Model

Systems thinking is an approach to analyse issues of a sub-system within the overall interlinked system. Therefore, it is a framework which encompasses the interacting and interrelating components of a system with a cyclical cause and effect relationship. In this respect, the pentagon concept has been developed and used in systems thinking/evaluation of a multidimensional complexity (Nijkamp, 2008). In the literature, there are several applications of the pentagon model which have demonstrated its methodological power and empirical validity in various studies. The pentagon approach has been applied in several policy studies during recent decades, in order to assess the critical success/ failure factors of a policy (see, e.g. Nijkamp et al., 1994; Nijkamp and Pepping, 1998; Capello et al., 1999;

Nijkamp and Yim, 2001; Nijkamp, 2008). Intrinsically, this model aims to map out, in a structured manner, the various forces that represent the critical factors that are essential contributors to the performance of a given policy (Nijkamp and Pepping, 1998). What this rather stylized approach does is to enable some of the key issues of the policies under research to be discussed in a systematic way. It highlights key dimensions in decision making and also enables us to look at those areas where policy initiatives can influence the way in which sustainable development is enhanced (Button, 1998). It is a systematic evaluation to determine the (most) critical success factors and sub-factors in sustainable development policies.

Success conditions refer to the necessary – though not sufficient – conditions that are to be fulfilled to meet a priori given objectives concerning sustainable development, such as economic performance, social cohesion, and ecological quality. The failure conditions are to be interpreted in a different way. They refer to those factors that drive the performance of a system towards levels that are unacceptable from the perspective of a priori specified objectives. By determining the critical factors, the pentagon model is formed by a pentagon prism which represents the cyclical relations between the necessary – though not yet sufficient – conditions for successful policies (see Figure 1). The original pentagon model, as it was when first developed more than a decade ago, distinguishes five key factors, viz. software (e.g. knowledge), hardware (e.g. research facilities), finware (e.g. financial support), ecoware (e.g. environmental amenities) and orgware (e.g. institutional support systems). These pentagon factors can be applied to both the supply side and the demand side of economic-ecological-technological systems.

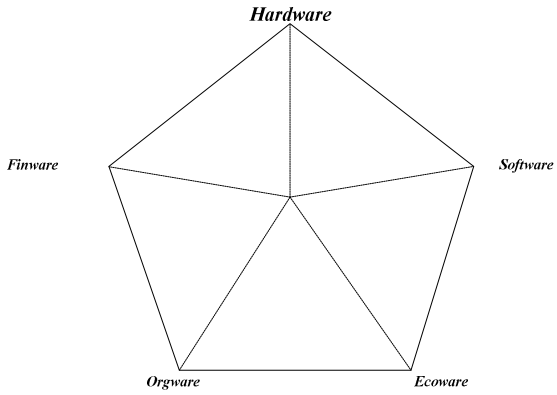

Figure 1. The original pentagon prism comprising necessary conditions for a successful policy

The pentagon approach offers a flexible methodology and has been used in various studies, viz. the evaluation of energy policies (Nijkamp and Pepping, 1998; Capello et al., 1999); the quality of the urban economy (Nijkamp, 2008); sustainable rural development (Gülümser, 2009). Each pentagon model is generated from the original stylized pentagon model so that critical factors of different systems are developed on the basis of necessary conditions. In addition, researchers have adapted the original model to fit any new topic under investigation. For instance, Capello and her colleagues in 1999 and Nijkamp and Pepping in 1998 used the original pentagon factors, but Nijkamp in 2008 adjusted these factors to assess the highest possible quality of an urban economy, where the pentagon factors used were: economic capital; ecological resources; technological systems; geographical infrastructure; and social suprastructure. In addition, the most recent example of the model published by Gülümser in 2009 to underpin sustainable rural development is based on the necessary conditions defined for sustainable development in the Brundtland Report in 1987, and used systems thinking with regard to the physical system, social system, economic system, locality system, and creative system.

In conclusion, pentagon models applied in various studies show the validity of the model for systems thinking. In other words, such a model offers a valid framework for analysing different problems of an overall system by identifying drivers of the whole system through the identification and analysis of its critical components. Therefore, in Section 3 below, we offer a systemic framework for sustainable development on the basis of diverse case studies.

3 A Systemic Framework for Sustainable Development

Sustainability has been the subject of intensive discourse at a conceptual level, but unfortunately it has not been treated so often in operational contexts. Our approach offers, as mentioned earlier, a systemic operational contribution through the use of case studies, in which the pentagon model is used as a methodological vehicle. As a part of the EU-project SMILE, the aim of this study is to provide the results of specific pentagon models for different case studies in order to develop a basic model applicable to sustainable development issues in general. Three case studies, from Finland, Italy and Romania, have

been chosen to apply and test the pentagon model. These case-studies are different in terms of their aim, time scale, spatial scale, sustainability aspects, and stakeholders, but they are similar in design and scope. In other words, the idea behind the selection of these case studies is to bring together different problems of sustainable development in order to formulate a better systemic framework which can be applied to different systems.

In this section, we first present the stylized pentagon model that was used during the interviews to develop stakeholder-based pentagon models. Next, we validate and improve this basic model with the aim of designing a stakeholder-based model. Such a model is able to evaluate the different perspectives in the three case studies regarding the main success/failure factors that contribute to sustainable development policies. And finally, we conclude by offering a systemic framework for sustainable development.

3.1 The basic pentagon model

The original pentagon conceptual framework can be seen as the basis, or starting point, for the development of our basic model. In developing specific stakeholder-based models, we start our systemic approach on the basis of five critical drivers of a system. First, with the help of a literature review for the case concerned and the expertise of researchers with specific knowledge about the case studies, a basic SMILE pentagon model has been formulated (Figure 2). In a second step, the model is validated and improved by (local) stakeholders or experts. This is done by extensive interviews and sometimes by additional questionnaires.

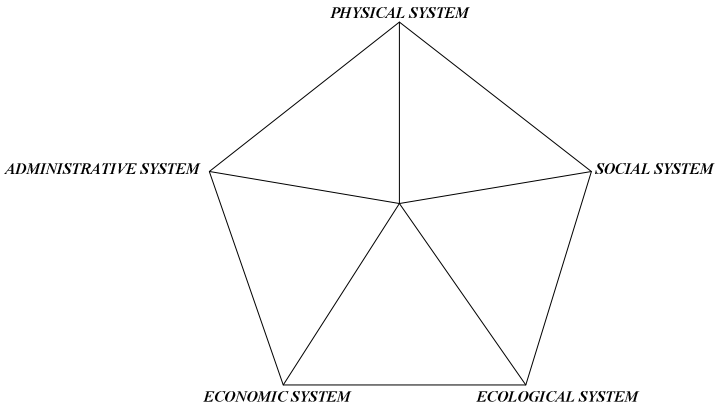

Figure 2. The basic pentagon model

The basic pentagon model comprising five key forces can interpreted as follows:

- The Physical system represents the quality of the human-made environment through which well-being and living standards of people can be determined. It includes aspects like quality of the built environment, infrastructure, accessibility, and the basic level of technology and innovation. Its sub-factors are:
  - The Built environment: This is related to the human-made physical surroundings that are necessary for the execution of all normal human activities (living, working, etc.);
  - Technology: This refers to (additional) technological systems and development in the related sector(s);
  - Infrastructure: This indicator refers to the technical infrastructure, e.g. roads, sewage, water, electricity, etc. In addition, it also refers to Internet and telecommunication infrastructure;
  - Accessibility: This is related to the availability and costs of different modes of transportation.

- The Social system is related to the quality of social networks in the case-study area. This consists of the basic level of education and training, but also of coherence, interaction, and the openness of society to new things. The sub-factors are:
  - Social capital: This indicator deals with the basic quality of the social system, e.g. the level of education and skills, but also the gender, age and ethnic distribution;
  - Openness: This is the level of tolerance/interest of inhabitants with regard to new suggestions and concepts in relation to sustainable development;
  - Participation: This refers to the level of involvement of inhabitants in decision-making processes. It is related to the social dialogue both inside and outside the community with experts and planners;
  - Awareness: This sub-factor refers to the awareness and understanding of society about sustainability and the particular policy in the case study.

- The Economic system refers to the economic activities and their characteristics inside the case-study area. It deals with the level of diversity of sectors, the level of uncertainty in relation to prices or profits, as well as the structure of economic activities by means of the size of the economic activity and its proprietorship.
  - Economic diversity: This concerns the number of different economic activities in the case-study area. Even though the case-study area can be focussed on one single sector, other sectors will also be evaluated in relation to economic diversity;
  - Uncertainty: This factor refers to the possible impacts of unexpected economic shifts, e.g. economic crisis, price changes;
  - Property rights: This refers to the structure of economic activities by means of the size of the economic activity, the proprietorship of the economic activity, etc.

- The Ecological system is related to both the quality and the quantity of natural environments/ ecosystems of the case-study area, as well as the effect of environmental impacts addressed in the case studies. The sub-factors are:
  - Ecological environment: This sub-factor reflects the quality and quantity (the state) of flora and fauna of the case-study area. Depending on the case study, it may also include parts of the ecological environment which are of interest, e.g. forestry or agriculture;
  - Environmental impacts: This includes factors that enhance or mitigate environmental impacts. Different indicators are possible to assess the environmental impact, e.g. energy consumption, etc.

- The Institutional system represents the quality of administrative and management issues related to the case studies, including quality of political decisions and policy implementation. The sub-factors consist of:
  - Governance structures: This refers to the basic quality of governance structures, related to the interaction between different governmental and institutional stakeholders who influence decisions, the efficiency of the decision-making processes, and also influence how well these decisions are implemented and managed in the case-study area;

- Integration: This refers to the degree of connectivity and coordination between different policies in one spatial area of policies (and policy makers);
- Continuity: This refers to the continuity of policies, policy measures and governments;
- Sustainability inclusion: This means the level of sustainability and its different aspects of inclusion in relevant policies;
- Opportunities: This refers to the opportunities provided to the stakeholders by policies, e.g. subsidies.

3.2 Sample of case studies

The case studies used in our study include Finland, Italy and Romania. The aim and focus of the Finnish case study is the sustainability of the forest ecosystem and its utilisation by humans. This case study is a nationwide case study for the next 20 years. The main sustainability target is to assess the well-being of the ecosystem i.e. the possibilities to regenerate and sustain ecosystem quality. This case study focusses on the forest ecosystem in order to provide the possibilities to regenerate and sustain the quality of the ecosystem in Finland. Next, the Italian case study aims to understand the complex interactions and metabolism of the agricultural sector in Italy. The main objective of the case study is to analyse the different scales in relation to relevant sustainability issues. The study focusses on three spatial scales, viz. local scale (farm level, with three farms being selected), regional scale (Campania region) and national scale (Italy). Finally, the main target of the Romanian case study is to analyse the energy sector including the integrated social, economic and environmental aspects in Romania. In other words, the case-study focusses on the transition economy in Romania by sectoral levels on the basis of the metabolism of the system in terms of its flows of energy, materials and money.

After presenting the basic pentagon model (Figure 2), in order to validate our model and to obtain a better insight into what the most important success and failure factors are for each case study, 5-10 interviews were held in which open questions were asked about the idea of sustainability and about the sustainability in the area. The interviews which took place in Spring 2010, lasted approximately 45 minutes and consisted of 6 parts concerning personal questions; general sustainability questions; case-study questions; pentagon model sub-factors; stakeholders; and methodological toolkits. All these questions, and in particular the evaluation of each of the sub-factors, were formulated so as to be used in the formulation

of the stakeholder-based pentagon models. We now briefly describe the results which emerged from our interviews.

During the interviews, stakeholders such as NGO representatives, researchers, governmental representatives, etc. were consulted. In the Finnish case study, four interviews were held in collaboration with the Finnish partners. The interviewees were two researchers, an NGO representative, and a researcher whose family owns forests. According to the interviewees' opinion, the three systems: economy, ecology and society, of sustainability are equally important and should be in balance with each other. When asked whether sustainability had increased in the Finnish forest sector, they felt that it is still important to separate ecologically sustainable development and economically-sustainable development, since the Finnish forest sector is still very much traditional and even today focusses on maximizing loggings and the economic benefits.

Finally, the interviews in Italy were conducted with five stakeholders: namely, two researchers and three NGO representatives from different organizations. According to the interviewees' understanding of sustainable development, sustainability and sustainable development objectives are not only related to the environmental sector, but also have serious consequences for the economic and social system. In general, the perception is that the Italian agricultural sector is becoming more sustainable as a result of new EU agricultural policies and the growth of interest in this area. Possibly because of the economic crisis, farmers were forced to look around in order to learn more and become aware of the potential of sustainable farming. In addition, work done by various organizations, environmental groups and associations have helped to raise the awareness of both the sector and consumers.

Finally, the interviews in the Romanian case study were held with five interviewees, two researchers and three administrative representatives. According to the Romanian stakeholders, sustainable development is a complex, systemic phenomenon, implying economic, social and environmental aspects in equal measure. It would have no meaning without the coexistence and evolution of the three sub-systems. The social system as both beneficiary and generator of sustainable development interacts with the ecological system through the economic system. Such an interaction may be constructive or destructive and is

strongly non-linear. At the moment, the energy sector in Romania is non-sustainable and experiences high energy and economic losses, the urban energy sector is nearly in a state of economic collapse, and the rural energy sector is not included in the national energy programmes, while many decisions have been delayed (especially with regard to energy generation) which led to a high need for finance not covered by programmes and funds. Most current actions are oriented towards maintaining the status quo, and not towards transformation. However, for the future there are some important developments with respect to sustainable energy, through the elaboration and implementation of new projects regarding the use of green energy. A positive aspect is that power generation is being mainly developed with the use of hydroelectric and nuclear technologies (without CO_2 emissions), while clean technologies are also penetrating in coal and hydrocarbon power generation. The potential for intervention in energy efficiency is high and the EU policy through national actions is beneficial to sustainable development.

In the following section, we describe our methodology to generate a stakeholder-based pentagon model and discuss the steps taken during the application of this methodology.

3.3 Methodology: pentagon model

The pentagon approach plays an important role as a systemic framework for identifying success/failure factors in the quest for sustainable development. In our study, based on a systemic approach to the necessary conditions for sustainable development using a basic model, we have generated the critical conditions for sustainability by means of the pentagon approach grounded in the informed opinions of the project partners. In the description of each factor, it is important to identify the sub-factors/decomposition of each pentagon factor. After generating the basic model, on the basis of the results of the interviews, we also generated the stakeholder-based pentagon models. To do so, we followed three steps.

Step 1: The identification of the nature of the critical sub-factors and their importance ranking. In this step, we first identify whether a sub-factor is a success or failure factor from the point of view of the interviewees. In addition, we calculate an equally-weighted (EW) and weighted (W) scale based on the interviews. The critical nature of a factor depends on the criticality of its decomposition so the weights are the clarification of the criticality of

factors compared with each other. Therefore, the two types of weights allow us to better understand whether the defined factors are seen as robustly critical from the point of view of different stakeholders of different case studies. A sub-factor is identified as a success or failure if more than half of the interviewees agree on the nature of the factor. For the calculation of scales and the weight for each sub-factor, we generally use the arithmetical average so as to better understand the level of agreement of interviewees about the importance of each sub-factor[1]. Equations 1-3 describe the derivation of the weights. The notation for the calculation of these three aforementioned scales and weights is as follows:

i: Interviewee

j: Sub-factor

I: Total number of interviewees

J: Total number of sub-factors

Imp: Importance scale of sub-factor by the interviewee

IImp: Total number of interviewees who considered a sub-factor as one of the two most important

w: Weight

EW: Equally-weighted scale of sub-factor

W: Weighted scale of sub-factor

$$EW_j = \frac{\sum_{i,j} Imp_{i,j})}{I} \qquad i=1,....,I;\ j=1,....,J \qquad (1)$$

$$w_j = \frac{IImp_j)}{I} \qquad j=1,....,J \qquad (2)$$

$$W_j = EW_j \ x \ w_j \qquad j=1,....,J \qquad (3)$$

Step 2: Visualizing the stakeholder-based pentagon model, including the importance of critical factors. In this step, the aim is to visualize the static basic pentagon model on the basis of the importance of sub-factors. In order to do so, we used what are called spider models. The spider model is an appropriate analytical tool to show the relative score of various factors, while enabling different cases to be compared (Rienstra, 1998; Baycan-Levent et al., 2007). The spider model is not a real quantitative model but just a visualization

[1] If a sub-factor was not mentioned by any of the interviewees as one of the two most important factors, it was eliminated.

tool. These spiders are depicted later on in Figure 3. Just as we calculated the weighted scales for each sub-factor, now we recalculate them for each critical factor that is called a system. This enables us first to see the importance of each critical factor in relation to each other and to see the relative importance of the factors through the shape of the pentagon model. In addition, by using EW and W scales we can test the robustness of the basic stakeholder-specific pentagon model. The calculation of these is shown in equations (4) and (5):

j: Sub-factor

c: Critical factor

I: Total number of interviewees

J: Total number of sub-factors

F: Number of sub-factors named as one of the most two important sub-factors

w_j: Weight of sub-factor j

EWF: Equally-weighted scale of the most important sub-factor of the critical factor

WF: Weighted scale of the most important sub-factor of the critical factor

EW: Equally-weighted scale of sub-factor

W: Weighted scale of sub-factor

If w_j *> 0.50, in other words if the sub-factor is accepted by more than half of the interviewees, then:*

$$EW_c = \frac{\sum_{j,c} EWF_{j,c}}{F_c} \qquad j=1,\ldots,J;\ c=1,\ldots C \tag{4}$$

$$W_c = \frac{\sum_{j,c} \frac{w_j}{F_c} WF_{j,c}}{F_c} \qquad j=1,\ldots,J;\ c=1,\ldots,C \tag{5}$$

Step 3: Listing the new set of critical factors. After doing all the calculations, in this step we listed the new set of critical factors and their sub-factors and their definition that will be used for the further steps of our research. In the following subsection, we applied our approach to our three case studies in order to operationalize our model.

3.4 Analysis: stakeholder-based pentagon models

The basic pentagon model acts as the basis for each stakeholder-based model. According to the results, the basic pentagon model remained the same for each case study. This already shows the importance and perception-orientation of the concepts 'sustainability and sustainable development'. In our approach, we have focused on the definition of critical factors, as well as on the sub-factors for each case study.

The information about the scales and calculations of each factor is shown in Table 1. According to the results, the critical factors remain the same for each case study, while the decomposition of these factors differs from each other. Because of the limited number of interviews and their pilot structure in the evaluation of success/failure factors, we first took into consideration the scores of each interviewee equally, and thus the average of scores is calculated as one scale for each sub-factor (Table 1); see (1). Each interviewee indicated two most important sub-factors. This information was used to generate a weight changing from 0 to 1 for each sub-factor; see (2). This calculated weight was used to calculate a weighted scale to avoid the subjectivity of the scaling of sub-factors; see (3). Therefore, the weighted scale was calculated by the multiplication of our equally-weighted scale and the weight related to importance (see Table 1). We then proceeded by formulating a kind of consensus about the importance and scales of the sub-factors in order to better understand their importance ranking and to ascertain the robustness of our model. When we took into consideration that all sub-factors which together comprise the critical factors are equally important, we calculated the average scores of each interviewee's response (Table 1). Moreover, we used the identification of the two most important factors as the weight to calculate a weighted scale and avoid the subjectivity of scaling. In this way, we were able to obtain the weighted scales.

Table 1. Scales of each pentagon factor and sub-factors

	Equally-weighted scale (1-5)			Weight related to importance (0-1)			Weighted scale (1-5)		
	Finland	**Italy**	**Romania**	**Finland**	**Italy**	**Romania**	**Finland**	**Italy**	**Romania**
Physical system									
Built-Environment		3.80	4.60		0.80	0.80		3.40	3.68
Infrastructure	2.67	3.20	4.00	0.50	0.20	0.40	1.33	0.64	1.60
Technology and innovation	3.50	3.40	3.80	0.75	0.20	0.40	2.63	0.68	1.52
Accessibility	3.00	4.40	2.80	0.75	0.80	0.40	2.25	3.52	1.12
Social system									
Social capital	2.50	4.80	4.80	0.50	0.20	1.00	2.50	0.84	4.80
Awareness	4.00	4.60	4.20	0.75	0.40	0.40	3.00	1.84	1.68
Openness	3.75	4.60	3.00	0.75	0.80	0.60	2.81	3.68	1.80
Participation		5.00			0.60			3.00	
Economic System									
Economic diversity	2.75	3.20	3.20	0.50	0.40	0.60	1.38	1.28	1.92
Uncertainty	2.75	4.20	3.80	0.75	0.60	0.60	2.06	2.52	2.28
Property rights	2.50	3.80	4.40	0.75	0.60	0.80	1.88	2.28	3.52
Ecological System									
Ecological environment	3.50	5.00	3.60	0.75	1.00	1.00	2.63	5.00	3.60
Environmental impact	3.75	4.20	4.20	0.75	0.40	1.00	2.81	1.68	4.20
Institutional system									
Governance structure	3.00	4.00	3.40	0.50	0.40	0.80	1.50	1.60	2.72
Integration	2.75	5.00	3.80	0.50	0.40	0.60	1.38	2.00	2.28
Continuity	3.00		3.20	0.25		0.20	0.75		0.64
Sustainability inclusion	3.50	4.60	3.40	0.75	1.00	0.40	2.63	4.60	1.36

For instance, in the case of Finland, two sub-factors, viz. continuity and opportunities, were not mentioned as important at all by any interviewees. Although sustainable development is shared as a common concept, its critical factors are prone to subjective perceptions. Since all interviewees agreed that these two sub-factors are not among the most important factors, we excluded them from the list of factors in the following steps of our evaluation for the Finnish case- tudy. In addition, the results showed that three sub-critical factors: energy dependency of the sector and of society; international markets and relations; and EU policies were missing. We, however included EU policies and international markets as a critical factor, while the sub-factors: 'the built environment', 'participation' and 'the opportunities' were excluded from the Finnish stakeholder-based pentagon model, as they were not mentioned in any interviews as one of the two important factors.

For the case of Italy, the critical sub-factors 'participation' and 'integration' were not mentioned as one of the most two important sub-factors by any of the interviewees, so they were omitted in the following steps. It should be noted that these views are still perception-oriented and cannot be generalized for all stakeholders, but will be used only to generate the stakeholder-based pentagon model. In addition, apart from the uncertainty sub-factor, Italian stakeholders think that all factors are success factors rather than failure factors (Table 2).

For the Romanian case study, all sub-factors are evaluated as success factors except three sub-factors, viz. 'uncertainty'; 'ecological environment'; and 'environmental impact'. Moreover, the interviewees agreed on the nature of the critical sub-factors except for the sub-factor 'infrastructure'. Therefore, the 'awareness', 'ecological environment' and ' environmental impact' sub-factors by taking '1' as a weight are shown as the most important sub-factor by each interviewee. In contrast, the most important disputed sub-factor is 'sustainability inclusion' that was mentioned only by one interviewee (see Table 1).

In conclusion, according to the Finnish results, the success or failure effects of the majority of sub-factors are subject to the perceptive evaluation that their effect cannot be provided clearly. Besides this unclear situation, respectively, for most sub-factors viz., technology and innovation, social capital, awareness, economic diversity, sustainability inclusion, and for the sub-factors uncertainty and environmental impact a clear cut-off of success and failure

can be derived (Table 2). According to the Italian interviewees, they agree on almost all success failure factors, except for the technology and innovation sub-factor. As an overall evaluation, most cases show the possibility to identify the success or failure nature of pentagon factors, except the ecological system sub-factors (Table 2). Only the Italian case-study interviewees evaluate the ecological system and its decomposition as a success factor, while the Romanian and Finnish stakeholders evaluate it as failure factor. This is because of the sectoral base of the case studies: in the Italian case study, the agriculture sector is ecologically friendly, while the forest sector in the Finnish case study and the energy sector in the Romanian case study have a negative impact on ecological systems.

Table 2. The nature of pentagon factors and sub-factors

	Success or Failure		
	Finland	Italy	Romania
Physical System			
Built-Environment		S	S
Infrastructure	-	S	-
Technology and innovation	S	-	S
Accessibility	-	S	S
Social System			
Social capital	S	S	S
Awareness	S	S	S
Openness	-	S	S
Participation		S	
Economic System			
Economic diversity	S	S	S
Uncertainty	F	F	F
Property rights	-	S	S
Ecological System			
Ecological environment	-	S	F
Environmental impact	F	S	F
Institutional System			
Governance structure	-	S	S
Integration	-	S	S
Continuity	-		S
Sustainability inclusion	S	S	S

The previous representation of the pentagon models does not include the importance of factors. To better evaluate the importance of the critical factors, we have therefore, generated a new information table comprising the most important sub-factors (the most important factors are the sub-factors which are identified as one of the two most important sub-factors by at least 50 per cent of the interviewees). As a second step, we now use the spider model to visualize our static model in a dynamic way. To use the spider models for the generation of basic stakeholder-specific pentagon models, we calculated a general equally weighted scale for each set of sub-factors: in other words, for each critical factor, while we also calculated a weighted scale by using the average of the most important factors that were chosen by more than 50 per cent of the interviewees (see Tables 3, 4 and 5). In this way, we were able to convert the pentagon models into spider models to test the robustness of our basic stakeholder-specific pentagon model related to the importance ranking of each factor.

Table 3. Scales of critical factors

	Finland		**Italy**		**Romania**	
	EW	**W**	**EW**	**W**	**EW**	**W**
Physical System	3.25	2.44	4.10	3.46	4.60	3.68
Social System	3.88	2.91	4.80	3.34	3.90	3.30
Economic System	2.63	1.97	4.00	2.40	3.80	2.57
Ecological System	3.63	2.72	5.00	5.00	3.90	3.90
Institutional System	3.50	2.63	4.60	4.60	3.60	2.50

Note: EW = equally-weighted ranking; W= weighted ranking.

Although the results do not appear to affect the critical factors significantly — as reflected in the visual presentation of the basic pentagon model—, the importance ranking of sub-factors differentiates drastically from the point of view of stakeholders. In other words, when taking into account the importance ranking of sub-factors, the shape of the pentagon model in terms of critical factors may change.

For the Finnish case, the spider model shows that the the social system and the ecological system are ranked first and second, respectively, while their rank and importance are highly

robust as are the other factors. In other words, the spider model has shown for the Finnish case study that the basic stakeholder-based pentagon model is robust (Figure 3).

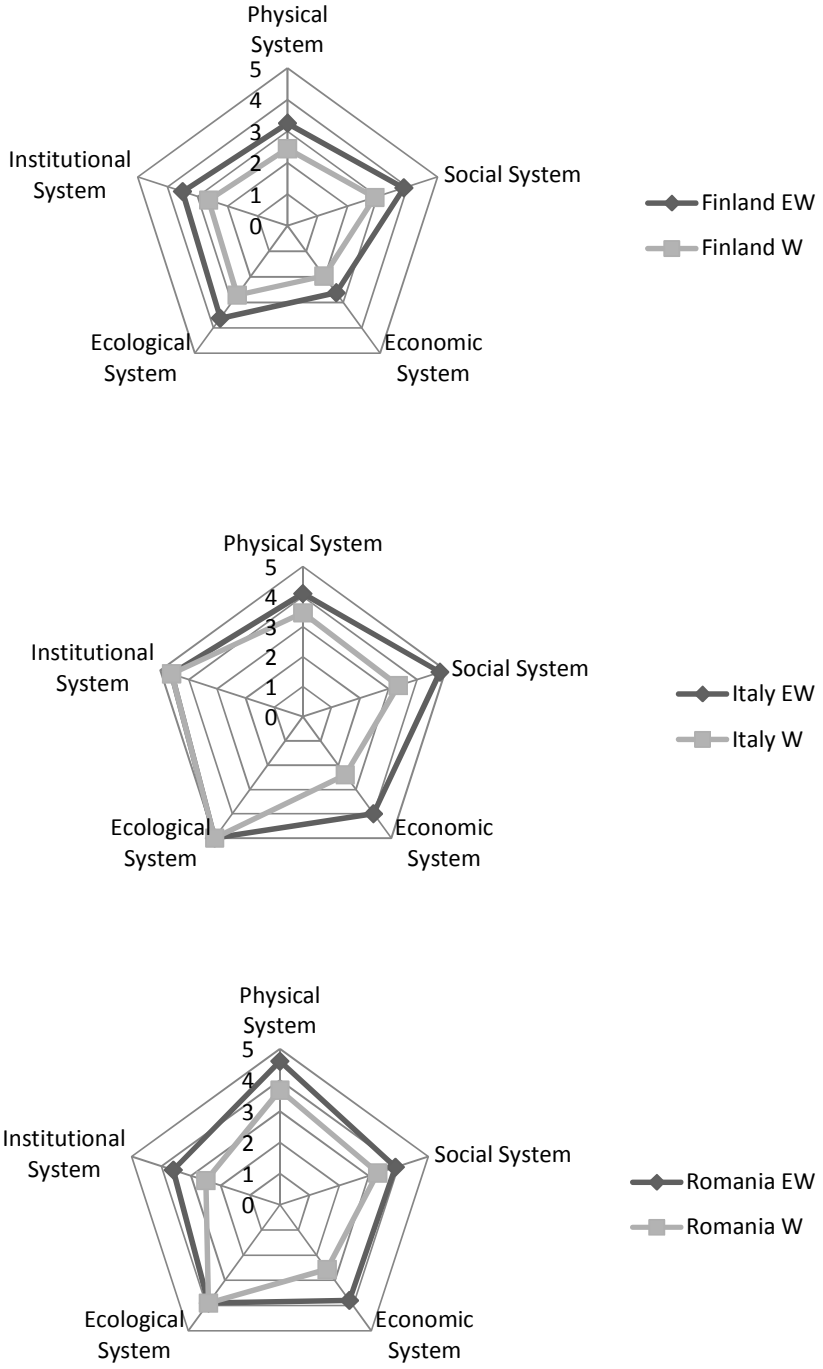

Figure 3. Spider representation of pentagon models by the importance of critical factors

Note: EW = equally-weighted ranking; W= weighted ranking.

As can be seen from Figure 3, the stakeholder-based model for the Italian case study is also robust: the importance ranking of the critical factors is the same for the equally-weighted and weighted ranking. Additionally, we can observe that, for the Italian case, the institutional system and the ecological system are very important from the point of view of each stakeholder interviewed. Therefore, we can also state for the Italian case that our model is robust.

The application of the spider model for the Romanian case study showed that the equally-weighted scales of the five critical pentagon factors are very close to those of the basic pentagon model, while the weighted scales somewhat change the pentagon model, as in the other case studies. What makes the Romanian case study distinct from the others is that the application of the pentagon model for the Romanian case study is sensitive to the stakeholders' opinions about the importance of sub-factors. In addition, the ranking of three critical factors changes according to the two weighted scales. For instance, the physical system according to the equally-weighted scale ranking is the primary factor, while according to the weighted ranking it is the second critical factor, and vice versa for the factor 'ecological system'. In other words, the pentagon model depends on the composition of the interviewees, so that a more extensive sample is needed for the Romanian case study to reach consensus.

The following section evaluates our first findings from a general perspective in order to develop a stakeholder-based pentagon model for sustainable development.

4 Evaluation

In order to evaluate our findings on common ground across all case studies, we calculated an importance ranking for the five pentagon factors for each case study under the heading of weighted (W) ranking (Table 4). After the calculation of the weighted rankings, the complexity of working with diverse and multiple case studies led us to use an additional visualization to better understand the situation of each case study compared with the others (Figure 4). It can be seen that the basic pentagon model seems to be quite suitable to all cases, when some (minor) adaptations are made.

Table 4. Rankings by the weighted scales of the five pentagon factors for each case study

	Weighted rankings		
	Finish	**Italian**	**Romanian**
Physical System	4	3	2
Social System	1	4	3
Economic System	5	5	4
Ecological System	2	1	1
Institutional System	3	2	5

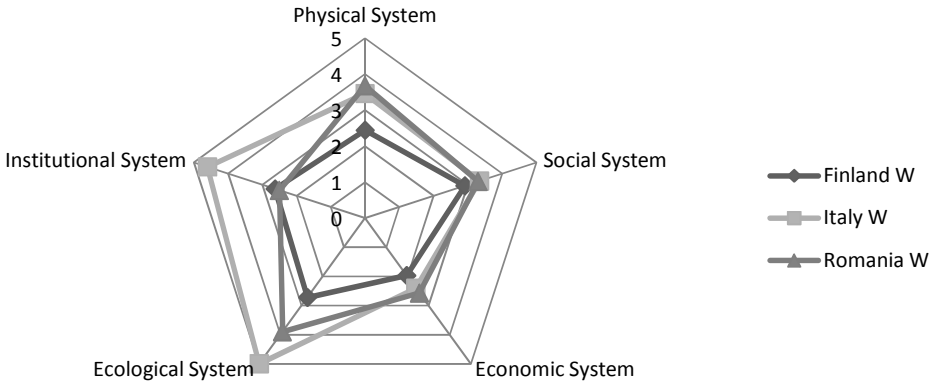

Figure 4. The importance rankings of the three pentagon models for each case study

Note: W = Weighted ranking.

When we evaluated these rankings one by one for each case study, we were able to draw the following conclusions:

- Finnish case study: Social and ecological systems are the most important factors.
- Italian case study: The ecological system is the most important factor. But the duality between the social system and institutional system can easily be seen. This can be explained by the strong social bonds in Italian culture and the strong belief in (EU) policies.

- Romanian case study: Even though there is no unambiguous 'most important' factor, it is clear that ecological, social and physical systems are the important ones. Romania's economy is in transition and that country considers a strong physical system as a necessary basis.

The results show that the ecological and social systems are generally seen as the most important ones to achieve sustainable development. The other three systems (physical, economic and institutional) are — with a few exceptions — seen as less important; however, they do have a significant effect. In particular, the importance of the physical and institutional system varies significantly between the case studies. Because of the limited number of interviewees, our tentative results cannot be seen as the universal stakeholder-specific model, but they do show that the application of the pentagon model holds its validity for such an evaluation. Therefore, we may conclude that, on the basis of the illustrative application, the proposed systemic framework is valid and robust from different perspectives of sustainable development. In the concluding section, we suggest some future research directions and some policy guidelines.

5 Conclusion

Due to the complex systemic structure of sustainable development, it is difficult to fulfil and determine its necessary conditions and to generalize them for each local and/or national perspective. The quest of formulating a generally accepted systemic framework from the perspective of different stakeholders was our challenge in conducting this study. In order to formulate a conceptual and operational model that encapsulates the highlights of scientific sustainability research, and that identifies the critical success factors of sustainable development from the perspective of different stakeholder groups, we have used a pentagon approach which is a powerful and valid way of systems thinking. In addition, we used a spider approach to quantify the stakeholder-based models in order to generalize the findings retrieved from our interviews.

The results showed that the basic pentagon model formulated has a physical system, a social system, an economic system, an ecological system and an administrative system as five critical components, while the evaluation of the interviews showed that this model is

robust and valid from the perspective of all stakeholders who participated in this study. Although, our model is robust, the importance of factors depends on the focus of the case study. Therefore, we may conclude that, in general terms, the five factors defined in the basic pentagon model are no doubt the critical factors for sustainable development. Clearly, their importance ranking depends on the main goal of the policies and research in the areas concerned. Although our model is helpful to generalize and identify the critical factors of sustainable development, the limited number of interviewed stakeholders implies that our model is not yet a general model but just a tentatively valid model for such an evaluation. Therefore, this model can be a guideline for policy evaluations, but in order to formulate better insights for the policy-making process, the model needs to be enriched with a broader sample of stakeholders to increase its robustness and to be generalized for various types of sustainable development processes.

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