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A flexible framework for regional sustainable development indicators using system thinking criteria (INSURE).

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Summary

Developing politics and actions guided by sustainability criteria require to have elements that support decisions at the most strategic levels and facilitate the communication and justification of decisions made. To do so, indicators are simple tools aiming to facilitate high-level decision-making, playing the role of making complex systems understandable or perceptible. Sustainable development (SD) indicators are specifically designed to facilitate a perspective on sustainability, but sustainability is a blurred concept lacking a well based scientific theory that supports it, it is more a social and political approach that implies a transverse vision of different sectors strongly influencing each other in a complex system of mutual (and some times not well known) relations. SD indicators cannot therefore be conceived as isolated trends, unaware of the systemic vision implicit in the SD concept, being the real challenge not to identify SD indicators (there are hundreds of good lists available) but to look for the best way to put them all to work together providing a consistent and coherent vision of how regional systems are progressing towards SD objectives. This is the main objective of INSURE.

Starting from any hierarchical thematic framework that is also determined by policy targets and priorities[1], the INSURE system indicators (S-indicators), initially designed to be applied at regional scale, aims to interpret and to understand indicators and trends in connection with the regional sustainability system behind. Its objective is to link the structured view of the policy SD

priorities[2] —ordered around a hierarchical thematic framework— with a systemic view that represents how the most important elements operating in the region are integrated in the regional system. This means to understand how the different trends of SD are related each others and how they influence the behaviour of the regional system in relation to policy priorities.

What makes INSURE different from other SD indicators methodologies is its capacity to focus the analysis in the diagnosis of the regional system, placing particular emphasis in its systemic character, and then to transfer the richness and complexity of SD relations to a conventional hierarchical indicators thematic framework, based on a reasonable reduced number of SD trends, which is oriented by policy priorities. As a result, the data trends obtained from indicators are converted into SD trends values, which are determined not only by statistical data, but also integrating correction indices depending on how they are expected to influence other SD trends in the region.

Keywords: sustainable development, indicators, regions, system dynamics.

1 Brief note on the INSURE project

INSURE is a research project co-financed by the European Commission under the 6th Framework Program for Research and Technological Development (Ref. No. 505358) aiming to develop a flexible framework for sustainability indicators in regions, using system thinking modeling. The starting date of the project was April 2004. It has a total budget of 1.054.642,30 euros and it is been carried out by a consortium of nine European institutions[3].

The strategic objective of the project is to develop a 'systemic indicators framework' with techniques, tools and applications, linking regional SD indicators with a flexible systemic approach based on system thinking modeling to better define SD indicators, better comparison between regions, better flexibility for regional diversity, and better linkages with other models and data systems.

The specific objectives to carry out the above are:

a) Appling a system dynamic (quantitative) perspective of the region to build a prototype System Model (S-model), based on systems dynamic methods and software.

b) Appling a system thinking (qualitative) perspective of the region to build a prototype System Mapping (S-mapping).

c) Developing a 'systemic indicators framework' (S- Indicator), using both the S-model and the S-mapping results, for characterizing and linking different SD indicators obtaining reliable SD trends values.

d) Appling the S-indicator to the question of regional SD indicators, to link between an EU generic version and a regional version.

e) Reviewing the data quality and availability at regional and EU level to support the above.

f) Carrying out a series of regional case studies to test and validate the S-indicator, and the practical S-model and S-mapping.

g) Integrating the above components in a 'system dynamics framework' or System Toolkit (S-toolkit) to make the final result coherent and reliable, containing both theoretical and practical parts.

This paper is the result of a collective research process. S-mapping and S-model descriptions in this paper have been adapted from originals by R. Jiliberto & A. Oliva (S-mapping) and W. Schade & M. Krail (S-model). Further information can be found at the project's web page: http://www.insure-project.net/

2 Fundamentals

2.1 Purpose of the INSURE's SD indicators framework

Sustainable development is a complex concept based on the comprehension of reality as a system. Its objective is to avoid unbalances that question the viability of the system. The different components that integrate SD are functional to each other in every system, so their contribution towards the system's sustainability can not be understood isolated. What matters to analyze the sustainability of the system is more its integrated behavior than the status of its components, so once a set of SD indicators is identified for a region, it is desirable to explain the observed trends in relation with their contribution to the regional system progress.

In spite of the above mentioned, indicator's lists —either organized in a kind of structure (causal, hierarchical or whatever other structure) or just presented as a list of headline indicators— currently are the most accepted and extended SD indicators frameworks and most relevant institutions have elaborated their own set of indicators to assess SD. Nevertheless, these sets of indicators have some meaningful limitations since they present key issues as isolated, independent trends and, in consequence, it is not possible to make an integrated reading of the information they provide in terms of sustainability. Although a framework of key issues to structure SD indicators is essential, it has been recognized that such lists still are imperfect tools if we aim to express the complexities and relations among the different components of SD (Wolff, 2005).

The challenge for the SD indicator's systems production is not the selection of the best indicators but how to use its potential to offer an integrated view of progress towards sustainability, which takes into account the mutual influence's relations among the different SD components. This consideration is quite important, since an isolated trend that apparently is desirable for sustainability can be made at the expense of affecting negatively other key issues of SD. An ideal SD indicators system should also provide information on possible unbalances in the system and the direction of such unbalances with regard to SD.

Within this background, the indicators system in the INSURE framework —the S-indicators— can be defined as a tool aiming to estimate regional SD trends values, in other words, values expressing the regional system behavior towards identified policy priorities, based on a systemic approach to the region development. Expected additional benefits are an improved comparability among regions —now based in the more flexible concept of SD trends instead of the more conventional of SD-related statistics— and more flexibility in the use of indicators that will help to overcome the lack of data availability and/or homogeneity.

2.2 The INSURE components

The importance of an appropriate expertise for the production of regional SD indicators has often been underestimated. SD indicators are usually identified with some relevant available statistics

widely used at international level and the need of making possible the comparison among different countries and regions has often be used —more as an excuse than as a real argument— to simplify the task of producing SD indicators to a mere selection of already available indicators from some well-known international lists. However, the production of good SD indicators is really a complex task which requires a high level expertise, a good knowledge of SD principles and an in-depth knowledge of the context where indicators will be applied.

Regional systems are being recognized as an appropriate scale for tackling EU SD problems, a scale between the often too low scale of countries —too far from some real decisions— and the, for many other purposes, too high scale of municipalities. INSURE has initially be conceived for the regional scale at EU level, although it can be easily be up or down scaled if required. Producing SD indicators at regional scale implies, however, additional problems in terms of data availability, data homogeneity for comparison purposes and adaptation of national or EU policy priorities to the regional scope. These difficulties inspired the INSURE approach for the production of SD indicators, based in the principles of analyzing the regional progress towards SD policy priorities from a regional point of view, independently of the fact that we consider regional, national or EU policies. This mean we have two concepts to manage and to combine: the identification of policy priorities —that can be based in different policy scales— and the analysis of the regional patterns.

To achieve its goal, INSURE has been organized in a set of components working for the other, like the pieces of an engine. The engine or integrated and unified vision of INSURE components is called the system toolkit (S-toolkit), a collection of guidelines and procedures that combine the INSURE components ensuring its coherence and consistency. Other components of the INSURE S-toolkit are the S-data, the S-mapping, the S-model and the S-indicators (see Figure 1).

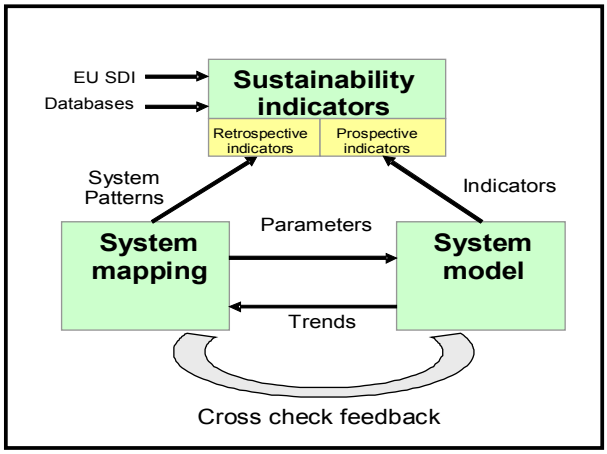

Figure 1: INSURE components in the S-toolkit

Modeling the regional system is the first step towards the production of the SD indicators. S-mapping and S-model, both tools based on system thinking modeling, are therefore key pieces of the INSURE framework, essential to achieve a well based knowledge of how the different

components of the region interact. This knowledge is then used by the S-indicators to transmit the regional systemic basic patterns to a framework based in SD policy priorities, process that is explained in more detail in this paper. In any case, for the purposes of understanding of the S-indicators fundamentals and results, some basic concepts on S-mapping and S-model are needed — to see more about them, you can visit the INSURE web page at http://www.insure-project.net/.

System Mapping

The S-mapping model provides the S-indicators model a graphical representation of the regional systemic pattern, which is used to put each linear indicator selected in a system framework (see Figure 2 and Figure 3). The S-mapping of a region models the perception the 'society' has of unwanted social side effects caused by a low integration level among the root-sustainability systems (environment-economy-society). The search of integration among them is hindered by the fact that there is no way to find a common analytical language to achieve it and to provide a substantive rational solution to the problem. S-mapping provides a particular language to describe the integration among the root-sustainability systems.

S-mapping makes use of existing evidence about main regional subsystems relations as the basis for the constructions of its maps. S-mapping acquires needed information from existing regional policy documents, analysis and diagnosis, open dialogue and other participatory forms, aspiring to be a representation of the non revealed current understanding the society has on the regional realm understood as a systemic one; it pretends also to be a non-arbitrary procedure of assembling the available social knowledge on the region understood as a system.

S-mapping identifies regional main SD components and how they are related each other —which components of the regional system influence others—, this being used by the S-indicator to identify the key components of the regional system responsible for the region progress towards identified policy priorities, as explained later. It also provides additional systemic indicators.

System Model

The system model comprises the quantifiable and comparable elements of a region. It generates quantitative indicators and a picture of the diverse European regions that enables their comparison. In the system model regions differ by their individual parameterization of the model, but are consistently implemented using the same model structure. This ensures the comparability of the sustainability position of European regions via the model. The system model is implemented with the standard system dynamics software Vensim.

The first objective of the S-model is to provide quantitative indicators to measure and describe the expected regional sustainable development considering the complex interactions within a single region and between the region and its environment. The second objective concerns the applicability of the model for a variety of regions enabling a comparison of the sustainability

position between European regions. The S-model has a predefined model structure that is uniform for any region that will be implemented in the model. This concerns *e.g.* the implementation of space in the model, where a specific maximum number and set of zones will have to be fixed; *i.e.* the structure of the model will not be changed to transfer it from one region to the other one. The system model is built out of a set of interrelated modules describing regional sub-systems on the base of the previously described structures. The modules comprise: population, economic, infrastructure, spatial dynamics, energy and water demand, transport and environment.

2.3 Identification of policy priorities

The concept of sustainability can be expressed in different scales: it can refer to the most global scale and also to the most local scale, having each scale different objectives and scopes. For instance, if we take the region as a reference, a same region can contribute to sustainability at different scales. In each scale, sustainability objectives —in other words, policy priorities regarding SD—vary. Therefore, we can ask ourselves what the contribution of a same region to the different SD objective's scales is: for example, the contribution of the region to its own regional SD objectives, or to the national policies, or in the case of the EU, to the European policy towards SD. For a same region, the regional system describer either by the S-mapping and the S-model is the same in every case; what can vary is the SD policy objective's framework that we want to use to assess the regional behavior.

The INSURE S-indicators allows assessing the regional progress in relation to different agendas on SD based on an integrated vision of the regional dynamics. The selection of a framework expressing a political context is essential in an indicator's system: indicators taking part in this type of framework are related to policy objectives, thus making possible to measure how a certain region is behaving according to political SD concerns.

The use a set of policy objectives to assess behavior on SD is not an innovation in INSURE. In fact, most indicator's systems currently use this type of framework, such as the UN, the Eurostat and the OECD frameworks, which are the reflection of their correspondent SD political agendas. Additionally, national SD policy priorities can also be used as frameworks to assess regional behaviors on SD. Furthermore, there might be regions that defined their own SD objectives or, if not, a set of priorities can be devised with the purpose of evaluating regional behavior towards sustainability. But in INSURE, more than the logical framework in which indicators are organized the indicator's framework constitutes the structure in which indicators are integrated through the incorporation of the principles of mutual influence and comparability (see Figure 2), based on an integrated understanding of the regional dynamics developed in the S-mapping and the S-model (see 2.1).

Two different frameworks are being developed in four case study regions[4] following the INSURE methodology. Each selected region will apply INSURE to a hierarchical framework

based in the Eurostat SD indicators (EC, 2005) which is oriented by EU SD policy priorities as well as to a regional framework based in each region SD policy priorities. When using the EU policy priorities framework, the question that each region tries to answer is *how is the region behaving according to those external, trans regional, sustainability criteria?* Since the same structure can be used by different regions, it is possible to compare the SD progress of different regions in relation to a group of common objectives. On the other hand, a specific regional framework needs to be designed through a process of identification —review of regional documents and action programs on economy, social issues and the environment— of the main regional policy issues for SD. In consequence, this type of framework is perfectly adapted to the regional scale and provides an accurate image of the current political agenda on regional sustainability. Therefore, using a regional indicator's structure does not aim to compare different regional behaviors but to assess how a certain region is behaving towards a set of specific SD regional priorities.

To select or to design a S-indicators framework in INSURE, a hierarchical structure (or a structure that could be adapted to it) is required for several reasons. First, there is a formal reason due to the fact that policy issues are usually structured according hierarchies for action (themes and sub themes; strategic and specific objectives, etc). This facilitates to promote actions plans adapted to the standard distribution of institutional responsibilities. Such an understanding has been incorporated in the SD indicator's systems developed by UN, OECD and Eurostat, among other organizations. Consequently, the use of a framework of this type also allows the harmonization and the rationalization among the different SD indicator's systems existing, as well as to work in the construction and improvement of such initiatives, doing the maximum possible use of them.

Besides these formal reasons, there is a technical justification to use a hierarchical structure, since the INSURE S-indicators framework needs to have a hierarchy in the organization and division of the different elements of sustainability. This expression of a hierarchy is necessary to be suitable for the concept of integration developed in the S-indicators that will be subsequently explained.

2.4 Identification of regional components representing the SD policy priorities

The hierarchical thematic framework summarizes the policy priorities organized in themes and sub themes —similar to the scheme followed by Eurostat (op. cit.). In its most detailed level (sub themes, Figure 2) the indicator's scheme is the expression of a policy question, that is, a short question related to priority policy objectives. For instance, a policy question to be answered with regard to the EU policy objectives regarding emissions of acidifying substances could be *'what progress is being made to reduce emissions of acidifying pollutants across Europe?'* (EEA, 2005a). Trends in the S-indicator should answer these kind of questions. To identify the most appropriate trends in each region, INSURE links the political SD priorities with the regional system through the identification of the components in the S-mapping whose trends answer the

policy question behind the SD policy priorities more appropriately.

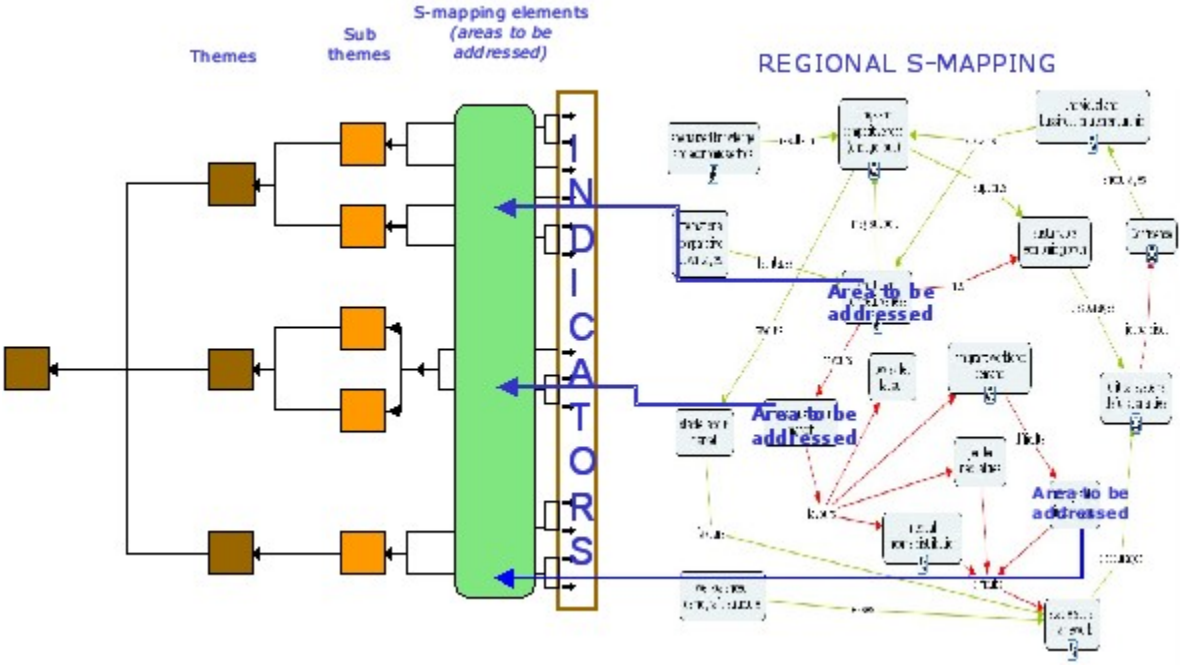

Figure 2: Integration of S-mapping regional representation (on the right) in the policy priorities summarized in a hierarchical structure (on the left)

This process of linking is called filtering in the INSURE methodology and it implies to identify from the S-mapping and S-model the most relevant regional components that represents each of the political concerns on SD represented in the last level of the indicator's structure. The selected components are called areas to be addressed (ABAs, see Figure 2) and they will make possible to asses, via indicators, the behavior of the region regarding the SD policy priorities.

Indicators will later be identified and calculated for each of the ABAs and then integrated in the SD framework, thus becoming the expression of the regional progress in relation to the identified policy priorities on SD.

To better understand the concept of ABA and how ABAs relate to indicators in the INSURE framework, we need to make some previous clarifications on the concept of indicator and how INSURE use it. There are many definitions available on what an indicator is and what it is for. Basically, an indicator is a trend that indicates the status of something. When referred to complex concepts such as it is sustainable development, an indicator "quantifies and simplifies the phenomena and helps us to understand" these complex realities (IISD). So an indicator usually first quantifies a phenomena —in other words, uses data usually obtained from statistics or other reliable sources to describe a phenomena— and then makes this phenomena alike to the complex reality we are trying to understand —that is, it assimilates the 'complex reality trend' to a more simple 'phenomena trend'—: this means an 'indicator' is itself a complex concept that can be

broken down into two different components or parts: *quantification* and *assimilation*. The concept of assimilation is implicit in every indicator identification exercise made, since basically an indicator illustrates the most important trends in each policy domain (EEA, 2002). Concepts such as relevancy, usually used to assess indicators quality, are clearly referring to this concept. 'Smiling faces' used by the European Environmental Agency (EEA) in many of its reports —and now widely extended—, point out the importance of the concept of trend linked to what an indicator is expected to show when referring to a policy issue: it indicates "progress, or lack of it" (EEA, 2002) towards a specific question, and EEA indicators are reduced to these 'smiling faces' when trying to summarize what they explain.

Therefore, assimilation can be clearly differentiated from the first component of any indicator, its quantification. Observed trends usually are obtained from a number or ratio (a value on a scale of measurement) derived from a series of observed facts that can reveal relative changes as a function of time. Concepts such as accuracy, calculation methods or comparability over time and over space are used to describe this part of an indicator. So we can differentiate between 'SD trend' and 'data trend' as the main components of an SD indicator: the SD trend is what we're interested in (assimilation) and the data trend is what we use to obtain an as good and precise as possible SD trend (quantification). For instance, 'fragmentation of forest and landscapes' (Eurostat, 1999) can be considered a relevant trend that contributes to answer the question '*are we reducing the degradation of natural resources?*'. To obtain this SD trend, different methods and data to estimate fragmentation might be used. It is important to be aware that data availability is not a problem when identifying a SD trend (when assimilating a policy issue to an indicator), but may be a problem when trying to estimate it (we need the data to do it).

Unfortunately, most of the available indicators do not make an effective use of these concepts and do not differentiate between the assimilation-SD trend and the quantification-data trend used to estimate it. However, this is something of the most importance for INSURE. In doing this differentiation, SD trends can be defined as the expression of the regional progress towards a policy issue (thus linked to the concept of assimilation, the ABA described above); SD trends can also be described aside from data availability and linked with other SD trends in a regional system model (*i.e*. S-mapping and S-model). This provides INSURE with an added flexibility: the S-indicator hierarchical framework is based in the policy priorities and regional system analysis (linked to S-mapping and S-model, as it is described in 2.6) and it is not affected by problems such as data availability, which only appear at the very end of the process when the adverse effects of the lack of data on the S-indicators are more easily and effectively controlled[5].

2.5 From data trends to SD trends values

INSURE formalize the process of assimilation, making understandable the meaning of obtained data trends in terms of sustainability trends, for which a scale has been defined. In doing so, every trend obtained in INSURE from different data sources (quantification) is expressed in the same scale of assessment of sustainability trends. It is just the same concept under the 'smiling

faces' and just the same implicit process a viewer is supposed to do when assessing an indicator in any specific context. Therefore, INSURE does not imply any added value to what is widely used when trying to formalize the meaning of indicator's trends in terms of sustainability. In this sense, the contribution of INSURE is to define precise criteria to ensure comparable and consistent results in the assessment of every indicator. Once the obtained trends are transformed into SD trends values, it is easier to compare results from different regions (even if using different indicators), to interpret these values incorporating new criteria (its influence in the regional system, see 2.6) or aggregate indicators into indices (see 2.7).

Obtaining a data trend from an indicator is the first step in the process of understanding progresses towards sustainability objectives. For instance, 'total landing of marine catches by Mediterranean countries' from 1884 to 1996 shows an overall increase of 0.2 million tones, about 17.5% (FAO, 1998). This is an objective trend that can have different meanings for different viewers. For someone interested in the evolution of the fishing sector, this increment in the total captures will be interpreted probably in economical terms; but for someone interested in the pressures of the marine environment, the data will have a very different meaning indeed. With this second purpose the series was used by the EEA in its publication 'State and pressures of the marine and coastal Mediterranean environment' (EEA & UNEP, 1999). How can the same series have different meanings for different viewers? Obviously, the process of interpretation varies in each case. Most of the times this is a implicit requirement for the viewer in order to understand the implicit message in the use of a statistical series as an indicator with a specific meaning in an specific context. What the viewer probably does is to observe whether the trend increase or decrease in the period of time of reference, to evaluate how significant this change is (and this would need an expert judgment in order to know how significant an increase of 17% is) and, finally, to link the observed trend with the implicit message of the indicator. The first two processes will probably be the same for any viewer (both for the one interested in the evolution of the fishing sector and for the one interested in the environmental pressures on the marine environment); however, the meaning of the observed trend will vary from case to case.

Of course, there is not guarantee every viewer will process mentally the observed data trend applying just the same criteria. Different expertise, different criteria linking data with policy issues and even a different understanding of the process of interpreting statistical data as indicators will influence the mental process each viewer will develop. The formalization of this process, ensuring homogeneity in the process of turning data trends in SD trends is advisable, making easier and more effective the understanding of the messages associated to each indicator. However, a greater transparency in the process is needed when the interpretation of data trends is made explicit in order to make clear to the viewer the criteria used and the concept (of sustainability, environmental pressure or whatever) assumed in the process. Good examples can be seen in different EEA and EC publications (Wolff, 2005; EEA, 2005a & EEA 2005b).

Being the transformation of data trends in environmental or SD trends a subjective, qualitative process, it is assumed a reduced scale of possible values is more than reasonable. For instance,

the 'smiling faces' icons used by the EEA have three different values, as well as those used by Eurostat in its recent publication on SDI (Wolff, 2005). INSURE has developed a process of formalization in three steps, which implies answering three consecutive questions to obtain up to five different possible values:

i. *does the observed trend increase or decrease in the period of reference?*: increase is given a '+' and decrease is given a '−';

ii. *how strong the observed change is?:* values varying from '2' meaning an intense change, '1' meaning a moderate change and '0' meaning not change or not significant change is observed;

iii. *is the observed change positive or negative in terms of SD policy priorities and targets?*: again a '+' is used for trends strengthening progress towards SD objectives and a '−' is for trends weakening this progress and some correction factors could be used to correct the 'intensity of change' factor depending on the distance to policy targets.

This results in 5 categories of possible values: +2, +1, 0, −1 and −2. To see how this apply we can use a simple example. If 'transport growth' has been identified as a SD policy priority (EC, 2005), a good indicator could be the evolution of the 'passenger-km by air'. TERM 2002 report (EEA, 2005), quoting data from UNECE and Eurostat, estimates the increasing of share corresponding to aviation from 2% to 3.1% in the period from 1991 to 1999, which is considered a meaningful change (very positive for airplane companies), quite the opposite to the EU policies promoting another modes of transport, in particular rail. So observed data trends mean, in this context, a very negative SD trend that can be expressed as −2 in the above scale. This SD trend value is obtained as follows: '+' because data trend is increasing; '2' because the observed change is significant; and '−' because this increasing trend is opposite to EU SD objectives, so: (+2) x (−1) = −2.

2.6 Integration of S-mapping sustainability components and relations in the S-indicators

Apart from the valuation of the indicator's trends, it is something admitted that a mere compilation of trends obtained through indicators is not enough to achieve a comprehensive vision of a SD system: the value of the trend expressed by each indicator is as important as its capacity to influence other elements in the system, as well as the meaning of these influences in terms of sustainability. Incorporating in the S-indicators not only the trends observed but also their relative importance and meaning in the SD system leads to a more consistent and comprehensive reading of the multiple trends observed.

To understand the concept of integration, just think that, in any regional system, every element influences or determines others. Thus, the regional system can be represented as a web, where some nodes are more powerful or influential than others in the dynamics of the system: the *intensity* of each relation of influence between nodes —its expected capacity to modify the system current status—, its *direction* —from where to where— and the *nature* of the relation —

basically if the from node influence is expected to contributes to increase or decrease the to node — may help us to understand the expected role of any element in the regional system and the meaning of every isolated trend —depicted by indicators— in terms of its expected contribution towards sustainability. This is the key concept underlying the integration model developed by INSURE (see Figure 3) and it allows considering, not only if an indicator's trend is positive or negative itself, but also how and how much it is expected to influence other components of the stated SD policy priorities.

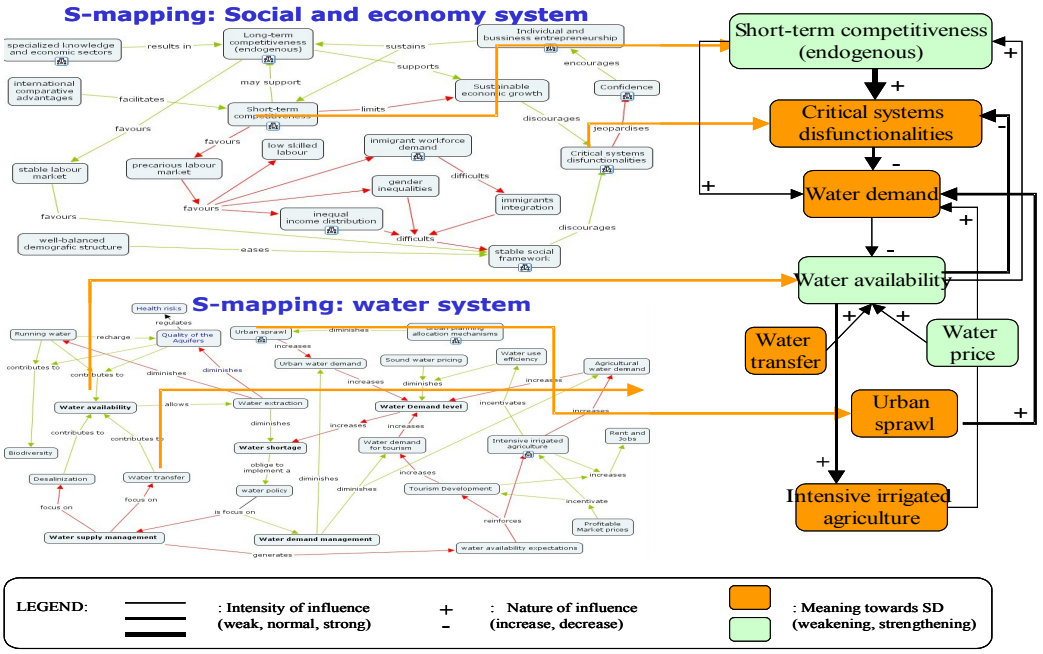

Figure 3: Interpretation of S-mapping relations in terms of influence in the dynamics of the regional system

As it can be observed in figure 3, the relationships between elements describing the regional dynamics can be of different types: some increase the trends associated to the element of the system that they influence, and others decrease them. Furthermore, it can be observed that the influence an element exerts on other elements can have different intensities. This concept is expressed in INSURE as the *Intensity of influence* and it is defined as the direct expected influence that a certain element in the S-mapping has on the elements directly linked to it.

However, an element does not only affect elements directly linked to it but it can also influence other elements by means of intermediate elements. For instance, if the element A influences B, and B influences C, there is an indirect influence of A on C through B. In consequence, the total influence capacity of A within the system will be the sum of all its influences, both direct and indirect. This idea is developed in INSURE through the concept *Relevance of Influence* and it expresses the expected gross capacity of each S-indicators component to influence the rest of the

elements in the system[6]. As a result, S-indicators components can be order by the global influence they exert on the system. Figure 4 shows a partial example of the Relevance concept. It can be noted that the element 'High rate of ageing population' reaches the higher relevance value, thus being the most influent element in this particular example.

ELEMENTS EXPLAINED / ELEMENTS EXPLAINING

	RELEVANCE OF INFLUENCE (as	high rate of ageing population	disincentive to move to Limburg	government programmes	high rate of unemployment	lack of diversification and vitality of	lack of employment opportunities	lack of social cohesion
high rate of ageing population	5,6757	1	0		0	0,01	0,01	0	0,13
disincentive to move to Limburg		0,2	1		0	0,01	0	0	0,07
government programmes	4,9049	0,01	0,01	1	0,03	0,08	0,06	0,01	0,07
high rate of unemployment	5,1386	0,06	0,1		1	0	0	0,03	0,03
lack of diversification and vitality of economy		0,1	0,17		0,4	1,01	0,75	0,11	0,05
lack of employment opportunities	5,3848	0,07	0,15		0	0	1	0,12	0,03
lack of social cohesion		0	0		0	0,01	0,01	1	0
Low innovation rate	4,4292	0,01	0,02		0,04	0,1	0,07	0,01	1

ELEMENTS EXPLAINED / ELEMENTS EXPLAINING

	MEANING OF INFLUENCE	high rate of ageing population	disincentive to move to Limburg	government programmes	high rate of unemployment	lack of diversification and vitality of	lack of employment opportunities	lack of social cohesion
high rate of ageing population	0,0042	-1	0		-0	0,01	0,01	0	0,13
disincentive to move to Limburg	1,0426	-0,2	1		-0	0,01	0	0	0,07
government programmes	0,9177	0,01	-0	1	0,03	-0,1	-0,1	-0	-0,1
high rate of unemployment	-0,449	-0,1	0,1		-1	0	0	0,03	0,03
lack of diversification and vitality of economy	2,2117	-0,1	0,17		-0,4	1,01	0,75	0,11	0,05
lack of employment opportunities	1,5971	-0,1	0,15		-0	0	1	0,12	0,03
lack of social cohesion	0,9038	-0	0		-0	0,01	0,01	1	0
Low innovation rate	0,9827	-0	0,02		-0	0,09	0,07	0,01	1

Figure 4: Partial views of Relevance and Meaning matrixes showing the influence of some regional components on other components and their total influence on the regional system[7]

But the influence of any component over the regional system may be expressed not only in terms of its capacity to cause changes in the regional system, but also in terms of what these changes mean for the SD objectives. To understand this idea, think that an increase in one element which strengthens sustainability could be made at the expense of negatively affecting other elements trends which could also strengthen sustainability. Consequently, a trend that could initially be favorably valued in terms of sustainability objectives, may not be so favorable when the trend is analyzed in the framework of all the elements integrating the S-indicator. This idea is incorporated in INSURE through the *Meaning of influence* concept, which aims to express that every change of an element's trend may cause changes in other elements, which could have different meaning in terms of sustainability. In consequence, *Meaning of influence* considers the expected net contribution that an element has over the regional system in terms of its progress towards SD objectives.

The importance of the *Meaning of influence* concept is essential to improve the understanding of indicator's trends in a specific regional context (see Figure 4). Thus, along with isolated interpretations of each tendency, the system's interpretation in terms of sustainability is based also in the likely capacity of such a trend to influence positively or negatively the behavior of the system, this way affecting its sustainability. To understand the logic of this modification, imagine that the indicator 'Elimination and treatment of solid urban waste' was initially given a relatively good state. Nevertheless, the systemic valuation of this indicator reveals that such a relatively good state is, on the other hand, generating some pollutants and affecting human health. The systemic approach allows interpreting this initial indicator value trough assessment

of its "collateral" effects. Thus, if the initial value for this trend was +1 according to the scale explained in section , it would be logic to qualify that trend as SD trend and give it a lower value, whose magnitude will depend on the degree of expected positive and negative affection produced in the other elements of the system[8]. To intensify this idea, the colored code with smiling and sad faces is also helpful. For instance, imagine that a certain indicator's trend was initially valued as +2 (very smiling face), so it had a bright green color. However, if the influence that trend has on other components is negative, bright green color may be modified to a pale green (smiling face), yellow (indifferent) or exceptionally even orange (sad), depending on the magnitude of the influence exerted in the system's sustainability.

Here again, it is important to remark that the characterization of identified relations among elements in the S-mapping does not imply to develop a new level of knowledge in the region but just a formalization of already existing and implicit knowledge. What INSURE makes is to translate the already existing knowledge of the region into a model of representation that emphasize the underlying dynamics already identified in the regional diagnosis.

2.7 Obtaining SD indices

From the two above headings, we can underline three ideas: (i) the data trends entry into the S-indicators framework as SD trends values (varying from +2 to −2, as explained in 2.5), which means they all use the same unit expressing the progress of each ABA towards identified SD policy priorities; (ii) these SD trend values are subsequently interpreted depending on how they are supposed to affect the regional system and (iii) their relevance in the S-indicators framework adapted according their expected influence intensity in the regional system. So we have a common non dimensional unit expressing SD trends values and we also have a value of relevance for every ABA. With these two components, is easy to define an index.

Indices are aggregated measures that combine most important indicators to describe the performance of an institution, region or economic sector. INSURE obtains indices of progress towards policy priorities objectives at different levels of aggregation, fitting the different levels of the selected hierarchical thematic framework. Supposing a hierarchical framework of three levels (e.g. themes, sub-themes and ABAs), this means that it is possible to obtain an aggregated value for every sub-theme —from the SD trend values obtained for its ABAs—, then aggregate sub-themes indices for every theme and, finally, to obtain an aggregated SD trend value for the whole region aggregating themes values (see Figure 5). Having an index that can be broken down in sub-indices makes easier to identify the expected real contributions of the different SD components in the overall regional progress towards SD policy priorities.

2.8 Improving comparability among regions

The comparability issue is critical when addressing it from a trans-regional or a trans national point of view, as the problems of insufficient data, disparity of calculation methods used and

different ways of understanding concepts and definitions strongly limits comparison. Generally, data sources provided by countries come from their own statistical sources, so it is usually difficult to assume a complete homogeneity among them.

As it was explained in 2.4, the process of generating an indicator follows two main steps: obtaining a trend —preferable from sound statistical data— and interpreting this trend in the context for which the indicator has been defined. While the focus is often on the first step, INSURE is more interested in the second step: what produces an effect when trying to understand an indicator is the meaning the showed trend has for the viewer in a specific context.

INSURE assumes this criteria in the process of interpretation of indicators trends, since they are interpreted as trends useful for the evaluation of regional response to policy priorities. The questions that INSURE aims to answer are: is the trend showed by an indicator positive or negative according the identified SD policy priorities?; and how much? To provide an answer to these questions is the relevant thing in INSURE, as well as the capacity to provide a regional overview beyond isolated trends, as has already been justified. To do so, and in order to obtain comparable trends in different regions using different indicators, interpretation of trends in INSURE is based on the context the indicator is inserted in.

Apart from being understood in a certain SD context, that means a trend shall also be interpreted according to the regional, national, European or other standards implied in the level of the S-indicators structure chosen. Furthermore, the interpretation of a trend shall also depend on the nature of the S-indicator component, (*i.e,* there might be indicators whose interpretation requires standards from a different scale than the S-indicators scheme been used—for instance, assessment of the Kyoto commitments, which depend on supra regional objectives) and on the nature of the indicator itself (i.e., the more or less critical role that the trend is having in the regional SD dynamics).

Therefore, an indicator in INSURE is a measure of the response showed by evidences and/or reliable data to specific concerns about sustainability. INSURE assumes this assumption to improve comparability among regions: comparison among trends showed by different regions should be based on the response we obtain for each indicator towards sustainability (the SD trends) and not just on the statistical data used to obtain the indicator.

To obtain such a response, the starting point is to obtain measured variables (indicators) an then to transform them into a new value representing its real meaning in terms of its contribution to regional sustainability, as it was explained in section 2.5. As far as the scale to value indicators is homogeneous for every indicator and for every region, and as far as inputs used in each case guarantee a reasonable homogeneity in the obtained estimations —trends that in each case provide the best and more reliable response to a given question—, comparability should be possible, even if the data sources or even the indicator description are not the same.

In addition, lack of available and appropriate data can be exceptionally overcome in INSURE through well-known and well-founded trends (in case they exist). These allow the user to express

the indicator's trend in the same way other indicators based in appropriate and complete data, according to the common understanding and scale. This can be considered as a lifebelt for those indicators which are not easily measurable by conventional available statistics or covered by standard data collection processes, such as wetland loss (which cannot be simplified to loss of surface) or governance indicators, but for which a well-founded knowledge on trends are often available from scientific studies or scattered and non homogeneous collected data. Nevertheless, having in mind that trends obtained by this —often less verifiable and reproducible— direct and simplified method are not easily updatable and not so reliable as statistical trends, they should be maintained to a minimum in the system.

3 Final products of the S-indicators

3.1 Representation of results

To be able to comply its function in an effective way, indicator's systems need to be supported by a communication method able to represent the results obtained in an easy and understandable way. Nevertheless, simplicity must be balanced with the amount of information that feeds the indicator's system. A method of representation in INSURE should also be able to allow integrating the comparability criteria developed and to represent the different levels of the selected hierarchical framework, as well as to incorporate the concepts of intensity of influence of each element within the system and the meaning of such influence in terms of sustainability.

At present, some commonly accepted practices of representation comply with the requirements here exposed, such as the dashboard representation (http://esl.jrc.it/envind/), which can be easily adapted for the INSURE purposes. In the adapted dashboard model, the intensity of influence of an element is represented through the width of the different parts in the dashboard —being the widest portions the most influential components in the system— and the meaning of the trends in terms of sustainability can be represented through a colored faces code. Colored faces represent the status of the trend (more o less sustainable performance) of every S-indicators component, within the regional sustainability framework (see Figure 5).

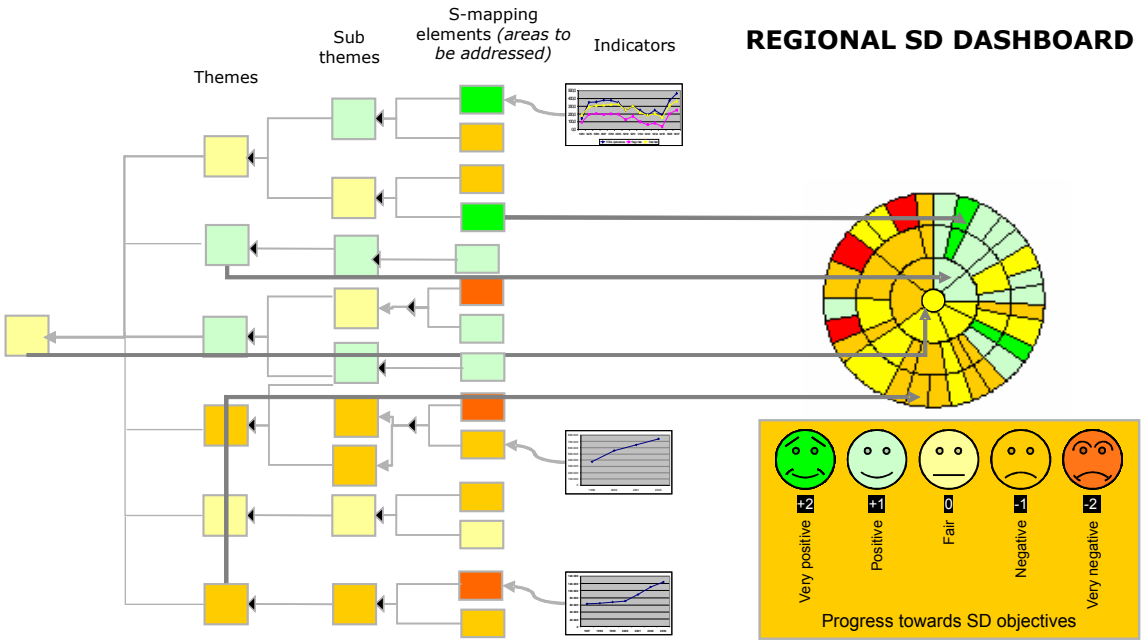

Figure 5: Tentative outline of the INSURE S-indicators

3.2 Production of headline indicators

Not being the main output of the INSURE S-indicators, headline indicators are also produced in INSURE from the relevance and meaning matrixes (see Figure 4). This way, if indicators schemes are not always ease to be defined and estimated, they can simply be replaced by a reduced list of indicators very much linked to key components of sustainability or key SD policy objectives. Headline indicators do not attempt to provide a complete coverage of the SD problems or topics, but just to show several key trends which considered all together, can provide an overall vision of the region in terms of SD.

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NOTES

1 The recent publication by Eurostat on SD indicators constitutes a good example of a hierarchical theme framework (Eurostat, 2005)

2 Indicators set development is usually "guided by the need to identify a small number of policy−relevant indicators" (Eurostat, *op. cit*.)

3 TAU Consultora Ambiental, S.L. (Spain), which is the project's co-ordinator; International Centre for Integrative Studies (ICIS) of the University of Maastricht, the Netherlands; Fondazione Eni Enrico Mattei, Italy; Institute for Prospective Technological Studies (IPTS), Joint Research Centre of the European Commission, Spain; Institute for Economic Policy Research (IWW) of the University of Karlsruhe, Germany; Centre for Urban and Regional Ecology (CURE) of the Victoria University of Manchester, United Kingdom; Middle East Technical University (METU), Turkey; Institute for Structural Policy, Czech Republic; Fraunhofer Institute for Systems and Innovation Research (ISI), Germany.

4 INSURE case study regions are: Limburg in The Netherlands, Lombardy in Italy, Pardubice in Czech Republic and Antalya in Turkey.

5 This mean, different alternative data and/or methods can be suggested as data trends to obtain the same SD trend. This added flexibility implies even different indicators could be used, under certain criteria, in different regions to assess progress towards a same SD policy objective.

6 As a first step, relevance values are determined for each area to be addressed through an iterative matrix calculation. This calculation is based on the Intensity of Influence values and it allows us to quantify the multiplying effects of areas to be addressed on the rest of the system. As a result of this automatic calculation, it is possible to obtain the dimension of the expected influence that every area to be addressed has on the whole system, taking into account both direct and indirect influences on other elements. Then, through aggregation of the relevance values to higher levels in the S-indicators structure, we will be able to get to know the influence capacity of each S-indicator component (from ABAs to sub themes and then themes) in the whole system and, in consequence, the most relevant components at the different levels in the S-indicators structure.

7 In the Meaning matrix, the sign means whether the influence (over a specific component and over the total system) is positive or negative in terms of its contribution to SD policy priorities.

8 To calculate the *Meaning of influence* values, the method used is the same iterative matrix method used to calculate the for Relevance values. The calculation is also based on the Intensity of Influence values but in this case the calculation also includes:

- The intrinsic sense of the relation between two elements, *i. e*, how an element evolves when an increase on an element directly linked to it is produced.
- If the influenced element weakens or strengthens sustainability, or what is the same, the intrinsic sustainability meaning that each trend acquires when it becomes the expression of a current priority on desired SD model set in a certain S-indicators structure.