DEVELOPING A REGIONAL ENVIRONMENTAL INFORMATION SYSTEM BASED IN MACRO-LEVEL WASTE INDICATORS

Eva Cifrian*, Ana Andres, Javier R. Viguri

Department of Chemistry & Process and Resource Engineering,
University of Cantabria, Avda. de los Castros s/n, 39005 Santander, Spain.
*Corresponding author. Tel.: +34 942 206707
E-email address: cifriane@unican.es (E. Cifrian)

ABSTRACT

Waste information is necessary for proper management planning. However, data on waste generation and management are sometimes not reliable enough, do not exist or are not useful for the sector. This is due to the high number of waste types and flows, and actors (producers, managers and administrations), which make data collection and treatment difficult. Furthermore, data loss occurs because some waste flows have economic value and return to the second-hand markets without monitoring.

The development of a waste information system for a region is more than just about establishing a routine data collection on waste. It is a way to support the challenges of decision-making on waste management. These challenges range from strategic issues of waste management in the national government to the basic challenges of running local governments.

In the Cantabrian region, three indicator sets were defined to constitute the waste information system: (a) a Basic Indicator Set, which provides an overview of the status of the generation and management of the main waste streams, giving a national and international comparative analysis of the situation; (b) a Specific Indicator Set, which monitors the objectives of the different waste policies, and (c) a Transverse Indicator Set, which analyses the influence of different economic and social variables on the generation of specific waste streams.

The Waste Information System of the Cantabrian Region has been created using a specific methodology for developing indicator sets with multiple objectives. This methodology consists of seven steps: (i) the synthesis, selection of the indicators sets; (ii) analysis of the system under study and data sources; (iii) evaluation of the indicators proposed; (iv) application and interpretation; (v) public review, dissemination and updating protocol; (vi) improvement of indicators sets using SWOT analysis; and (vii) aggregation of all indicators in an aggregated index.

These indicator sets with a total of 27 indicators allow tracking the evolution of generation and management of waste streams and the achievement of the policy objectives, establishing a data record, evaluating the data and sources of data, monitoring proposed action and its effectiveness summarizing large amounts of data on waste in order to spread it to the public and finally, aggregate all information in a single index that allows the evaluation of the evolution of all waste sectors in time.

Keywords: Indicators; solid waste; management; decision-making; monitoring; methodology

1. INTRODUCTION

Developing a waste information system for a region or a country is more than just collecting routine data on an environmental issue. It is about facilitating an improved waste management by providing timely, reliable information to the relevant role-players. Such information is crucial for planners, authorities, social organizations, academic institutions, and the general public, and it is a valuable input for assessment purposes, for public policies and for the implementation of programs and projects. It is a means of supporting the waste governance challenges, ranging from strategic waste management issues at national government to basic operational challenges at local government (Godfrey, 2008; Rojas-Calderas and Corona, 2008; Wen et al., 2009).

Solid waste management involves technical, socioeconomic, legal, ecological, political and cultural components (Miafodzyeva, et al., 2013). Several models using a variety of methods and tools to support decision making in the MSW have been developed (Morrissey and Browne, 2004; Chang et al., 2011).

Indicators and indices (aggregated indicators) are important tools that assist decision-makers in formulating, implementing and assessing models, global strategies and policy measures for a sustainable MSW management plan (Yabar et al.,2012). They are a means to capture the complexity and transform it into small amounts of key information and therefore help non-technical specialists to make use of complex data sets (Bell and Morse, 2013). Besides, indicators can be used to track progress over time, to compare characteristics between one or more systems, and they can be used as criteria in decision making tools (EEA, 2003; Giljum et al., 2011).

Theoretical conditions that the indicators must fulfil depend mainly on the type of indicator and the purposes for which it is defined (Dewulf and Van Lengenhove, 2005; EEA, 2004; Suttibak and Nitivattanon, 2008). Among the multitude of possible requirements it seems reasonable to highlight the following (Cifrian, 2013): (i) Relevant:

related to goals; (ii) Credible: Based on complete and accurate data; (iii) Functional: Useful in decision-making; (iv) Quantifiable: Reasonable ratio cost – effectiveness; and (v) Comparable: Obtained at different spatial and temporal scales. Obtaining enough high quality data is a key issue that affects the whole methodological process of designing a set of indicators.

Currently, quantities of waste data are widely available and regularly published internationally by the European Environment Agency, Eurostat, the OECD and other relevant environmental agencies. However, there are significant limitations to this type of reports, such as the heterogeneity of sources of waste data, the variability in terminology to define each kind of waste, the lack of detailed data at regional and local level, the lack of information at operating level and the lack of information on the financial aspects. This lack of information is the main problem encountered when starting up an environmental information system, especially at regional level. To overcome the limitations in waste information, different authors propose agreed definitions and estimation methods, as well as the creation of platforms and observatories for information exchange and to share experiences between different geographical levels (De Clercq and Hannequart, 2010; Rodriguez et al., 2008; Wen et al., 2009).

The objective of this paper is the development of an environmental information system, which can be used as a decision-making tool for stakeholders. This environmental information system has been defined to comply with a threefold purpose: First, to give an overview of the status of the environmental issue studied; in this manner a comparison of the status and progress with other regions is allowed, obtaining a comparative analysis of the situation and sharing results. Second, monitoring the different environmental policy objectives. The third objective is to analyse the relationship between the environmental issue and social or economic variables. For these objectives, three sets of indicators have been proposed: Basic Indicators Set (BIS), Specific Indicators Set (SIS), and Transverse Indicators Set (TIS).

To obtain this environmental information system, a complete and integrated methodology has been developed; each step of the methodology is detailed in Section 2 of the present paper. Section 3 shows the application of the methodology to the Regional waste system of Cantabria, Spain, which allows to obtain aggregated indexes to analyse the actual situation and propose improvements in the waste management field.

2. METHODOLOGY DEVELOPED TO OBTAIN DIFFERENT INDICATORS SETS

The methodological procedure of developing a set of indicators must ensure an adequate definition of objectives, consistent development and a high degree of applicability. Often, the method for selecting indicators is based on historical practices or intuitive assessment of experts, and the admission of the indicators depends on the degree of individual compliance with the criteria, regardless of whether the set of indicators responds to the environmental issue to be monitored (Bossel, 2002; Donelly et al., 2007; Niemeijer and Groot, 2008). In the present paper an integrated methodology has been developed, in order to improve these historical practices, which in most cases does not detail the method used for the selection of indicators. This methodology is applied to obtain different sets of indicators according to the objectives proposed (Figure 1). It is a comprehensive process that includes all three sets of indicators. The first step of the methodology is particular for each set of indicators, related with its purpose, but most of the steps are common to all sets and can be applied in an integrated way. Each step of the methodology is detailed.

Synthesis of Indicators Sets

The synthesis step consists of selecting of the indicators that will form the indicators set using specific criteria. Criteria used vary in function of the objective of the indicator set, as Figure 2 shows. In the first case, the Basic Indicators Set, the indicators selected are those, which allow the comparability of results with other regions. The criterion used is that the indicators have to be widely used (Haghshenas and Vaziri, 2012). For the Specific Indicators Set, the starting points are the objectives outlined in environmental policies, and the indicators selected are those that allow monitoring the environmental policy issues behind these objectives (ETCWMF, 2002); the indicator selection is driven by questions that the indicators are supposed to answer (Li, et al., 2009). It is necessary to know the relation between the environmental issue and economic or social variables for the Transverse Indicators Set. The methodology to find the socio-economic variables associated with the environmental issue under study is specific since it depends on the characteristics of this issue. You cannot define a general method, although a common step applicable to any environmental issue is conducting a literature review. However the use of general transverse concepts as Intensity and eco-efficiency, can guarantee the homogeneity between sustainability concepts and the significance of the transversal indicators for each application. Hence, before the review, the variables that meet the criteria are selected (Sébastien and Bauler, 2013).

Analysis of Available Data

The analysis stage involves the qualitative and quantitative study of the environmental issue under study. It is also necessary to know which data of the different variables of the activity or sector studied are available. The goal is to find all sources of available data on studied issue, its characteristics, and developing a record of data sources for each indicator.

Evaluation of Indicators

The indicators are evaluated under different criteria. Applying these criteria to define some questions (or sub-criteria) and providing a score depending on the answers (a maximum value of 18 points), the viability and feasibility of the indicators can be labelled. Only indicators with a score higher than 50% of the maximum value, i.e. 9 points, are considered with quality enough to be applied in the next step. This assessment shows the weaknesses associated with a lack of available data (EEA, 2005; Yli-Viikari et al., 2007). Criteria, sub-criteria and scores used are shown in Table 1.

Application, Interpretation and Evaluation of the results of the indicators

The application of the indicators makes necessary to calculate specific variables such as rates or ratios. The progress with time is represented graphically and, then, an analysis is performed to define the trends. All this information is included in a fact sheet, which also includes information, such as applicable rules or guidelines that can help to give an overview of the situation. The created indicators fact-sheet also specifies the characteristics of its data, the calculation method, its variables and the information sources.

For the evaluation of results, a criteria definition is required in accordance with the normalization criteria defined (aggregation step). The criteria for the evaluation and normalization have been defined taking into account the characteristics of each set (Figure 3) (OECD, 2002; 2008; Singh, et al., 2009). For BIS, the ranking method is used evaluating the situation of the region in a comparative way, so that the situation of the region, for this indicator, is represented in function of the position in the ranking (Greene and Tonjes, 2014). Although ranking is the simplest normalisation technique, this method is not affected by outliers and allows the performance of countries to be followed over time in terms of relative positions. Some examples that use ranking include: the information and Communications Technology Index (Fagerberg, 2001) and the Medicare Study on Healthcare Performance across the United States (Jencks et al., 2003). For SIS, the distance to a reference method is used, evaluating directly the degree of achievement of the policy objectives. This technique measures the relative position of a given indicator from a given reference. This could be a target to be reached in a given time frame (Ronchi et al., 2002). Many indexes use this technique for the evaluation and normalization of the indicators, such as the Eco-indicator 99 (Pre Consultants, 2004), the Index of Environmental Friendliness (Puolamaa et al., 1996) or the Environmental Policy Performance Indicator (Adriaanse, 1993). Finally for TIS, the method closest to its characteristics is the min-max, which normalises indicators to have an identical range [0, 1] by subtracting the minimum value and dividing it by the range of the indicator value. The most important indexes that apply this technique are the Human Development Index (United Nations Development Programme, 1990), the Technology Achievement Index (Nasir et al., 2011), and the Composite Sustainable Development Index (Kranjnc and Glavic, 2005)

Public Review, Dissemination and Update

Each set of indicators created is presented to the potential users and different stakeholders in order to achieve an in depth review. Criteria closest to users become more relevant, although conceptuality and aspects of validity of the indicator are still applicable at this stage. After public review, a new round of internal review and specific stakeholder and expert consultations starts. At this stage the criteria related to the end use of indicators become priority. The result of this step is a set of indicators representative of social concerns. Noteworthy is the importance that acquires the participatory aspects in this process (Bringhenti, et al., 2011). The indicators set will succeed only passing through the proper process of socio-political and institutional assessment**.**

The main objective of the indicators sets developed is to show the relevant information to managers, politicians, and general public, so an important step in the methodology is the dissemination of results.

It is also necessary to update all the indicators developed using data from the previous year. Beside the data, it is important to know possible changes in legal frameworks or any other aspect of concern that may have occurred during last year that can influence in the way of the information is managed or the objectives included in the indicators.

Continuous Improvement (SWOT Analysis)

SWOT analysis integrates internal resources of an indicator (Strengths/Weaknesses) and external environment analysis (Opportunities/Threats) under a classic strategic analysis tool for strategic management (Yang, 2010). Applying this analysis, a wide range of improvement tactics applicable to the indicators is obtained (Handakas and

Sarigiannis, 2012). Overcoming each of these weaknesses, it is possible to achieve a continuous improvement of the global information system.

Aggregation of indicators

In this step, all indicators from each set are normalized and aggregated in a single index. Methods proposed for the normalization of indicators are according to the criteria used in the evaluation, which have been shown in Figure 3. Once the values of the indicators are normalized in the range 0-1, it is necessary to select the methods of weighting and aggregation.

It is recognised that reducing assessment to a single dimension misses many of the cross-linkages and ultimately leads to poor decision-making (Paracchini, et al., 2011). To minimize this problem, the tool “Dashboard of Sustainability” (DS) was applied to aggregate the indicators to show jointly the results of each indicator, their relative importance (weight) and the aggregated index in the same figure. This tool provides visual results which are easier to understand by the stakeholders (Hardi and DeSouza-Huletey, 2000; Hardi et al., 2002; JRC, 2007).

The Dashboard of Sustainability organizes the assessment of information into two levels represented by the following concentric rings (Scipioni et al, 2009). In this work, these two levels represent: (i) the outer ring, the individual indicators used, with the same weight inside each set of indicators; (ii) the inner circle synthetic indexes, which integrate multiple indicators into a single measure.

The indexes allow a temporal analysis of the results. The main restriction of this methodology is that it is necessary that all data of indicators for all studied years are available. If the data of one indicator were unavailable the accuracy of the index to track the system over years decreases.

The obtained indexes allow comparison between different cases studies too due to the indexes are based on relative measures. It is important to always keep in mind what are comparing with these indexes. The Basic index represents the situation of the case study with regard to others; the Specific index represents the degree of achievement of the policy objectives, regardless of how ambitious that policies are; and the Transversal index represents the efficiency with respect to the socio-economic situation.

In recent years, DS is becoming a tool commonly used by the scientific community to analyse the dimensions of sustainable development through the use of indicators and aggregate indices. DS is a tool internationally accepted to compare progress in sustainable development between countries and aids decision-making and communication as well as dissemination of results. Furthermore, DS is a very versatile tool that can be applied at regional or even urban levels (Picollo et al, 2003; Scipioni, et al, 2009). The tool has also been applied to a strategic environmental assessment of the waste plan of a region (Federico et al., 2009).

As a result of the application of this methodology three sets of indicators are obtained. The first one (BIS), with general indicators, that allows comparison with other regions; the second set (SIS) with more specific indicators, that allows monitoring of environmental policy objectives; and the third set (TIS), with eco-efficiency indicators, that measures the influence of the socio-political situation on the environmental issue. In addition, three aggregate indices, one for each system, which allows studying global trends over time for each of these aspects, as well as a global index that summarizes all information obtained.

3. APPLICATION TO THE REGION OF CANTABRIA

Cantabria is a northern Spanish region, ranging from the Cantabrian Mountains to the waters of the Cantabrian Sea, covering an area of 5,326 km^2. The population is nearly 600 000 inhabitants, which represents only the 1.26% of the Spanish population. The GDP of the region represents 1.25% of the Spanish GDP, and it is mainly contributed by the service sector and the industrial sector which represent 81% of the regional GDP. 92% of the enterprises of the region have less than 5 employees (ICANE, 2014).

The production of municipal waste in the region reaches values of 579 kg per inhabitant/year, while the national average is 500 kg per inhabitant/year. In the case of industrial waste, the value of generation in Cantabria is 836 kg per inhabitant, and 10% of it is hazardous waste. The national average is 1075 kg per inhabitant, and less than 3% of it is hazardous waste (Cifrian et al., 2012; 2013).

Figure 4 shows the proposed policies in different legal frameworks on waste management, which are mandatory in the region of Cantabria. These policies propose a series of objectives that must be tracked. The objectives proposed in a broad legal framework (International, EU) have been adopted into the narrower legal frameworks (National, Regional); particularly the EU regions must develop and ensure the implementation of regional instruments in order to meet the environmental Municipal Solid Waste Management (MSWM) objectives and targets. In this context the proposed methodology has been applied, obtaining better elaborated information in each step.

3.1 Obtaining the indicators of each set (Synthesis Step)

The synthesis step aims to select indicators that will form each set. Each set of indicators has a particular synthesis methodology since they follow different objectives.

In the case of BIS, a thorough review of the environmental agencies that use indicators to show the corresponding waste data has been carried out. The review has covered the information posted on Web sites of the most important organizations in the dissemination of information in the environmental field at different geographical levels: (i) Municipal: Local Agenda 21 developed in different Spanish municipalities, (ii) Regional: Environmental Departments of different regional Governments and Statistical Offices of them; (iii) National: the Ministry of Environment, the Sustainability Observatory and the National Statistical Office; and (iv) International: the European Environmental Agency (EEA), the European Statistical Office (EUROSTAT), the Organisation for Economic Co-operation and Development (OECD) and the United Nations (UN). A total of 57 sources have been enquired.

Once the review has been completed, the management of information consists in grouping indicators with similar information, although the indicators proposed were not exactly the same. The main criterion for selecting indicators is its level of usage in different geographical areas (Figure 5). Amongst all indicators that meet this criterion, those that fulfil the rest of the criteria (to be relevant, reliable, functional, quantifiable and comparable) are selected. The final indicators of BIS are shown in Table 2.

For the synthesis of the SIS, the starting points are the objectives proposed in the Regional legislation and plans. To avoid a high number of indicators, first of all the objectives that can be tracked by the same indicator need to be gathered by grouping objectives about the same type of waste or type of management.

Policy questions related to the objective of the waste plan must be associated in addition to the environmental aim for which this objective was formulated. For example, for the objective "Creating a distribution plan of manure and slurry" the policy question proposed is: Are the manure and slurry properly managed?, and the indicator defined is "Management of manure and slurry".

In this way, applying this method to each objective or group of them, 16 indicators have been obtained to monitor a total of 28 objectives of the Regional Waste Plan (Table 2).

For the synthesis of TIS, a selection of variables with influence on the generation of waste has been elaborated. To begin, two waste streams, municipal solid waste and industrial waste were selected because they are large flows that include much of the waste generated in the Cantabria Region. Although in this work only global flows have been studied, this method can be used to analyse more specific waste flows with very specific characteristics. An example is the case of WEEE (Waste Electric and Electronic Equipment), affected by specific variables such as lifetime or growing consumption in technological items; another example is the CDW (Construction and Demolition Waste), affected by the large real estate crisis and the increasing regulations on the management of these wastes.

A literature review to select the variables which influence the generation of municipal solid waste has been conducted. The analysis of previous literature references had focused, on the one hand, on publications of agencies related to MSW management, such as Integrated Management Systems or technical reports from different institutions, such as municipalities, regional governments and environmental groups, among others. On the other hand it focused on scientific articles, highlighting those related to the modelling of the generation of solid waste. Once the variables are collected, it is necessary to classify them. Salhofer et al., (2007) describe a model for waste generation analysis based on input-output models. In this model, two flows of materials are defined, one to the waste generator (Input) and one from it (Output). Therefore, using this model a descriptive characterization of waste streams through the stages of the product life cycle is possible and each selected variable is classified in this framework (Niemeijer and Groot, 2008). For this purpose, three stages have been described, the production of goods and services, the consumption of them and the collection and treatment of waste (Figure 6). Variables that have been included in the indicators are those that accomplished three criteria: well defined, quantified, and independent. The variables selected are: population, number of households, population density, employment, purchasing power, life expectancy, GDP, and average expenditure.

For the generation of industrial waste, related variables are those associated with the sector in which they are generated, being able to classify data by sector or globally. For the selection of economic and social variables associated with each sector, tables of Regional Accounting (ICANE, 2014) have been used. In these tables, the key economic variables of the region are published, and the three most representative of them have been selected: GDP (Gross Domestic Product), employment (jobs) or number of companies.

The indicators proposed for TIS are efficiency ratios (Wang and Côté, 2011). Generation of waste is divided by the different variables selected, obtaining values that can be useful for cross-sectorial comparability and for analysing temporary evolutions (Ramadan and Sherif, 2008).

3.2 Defining the best sources of data (Analysis Step)

In this step, a deep analysis of waste management systems of different waste flows has been carried out and the sources of data with a higher reliability have been selected.

In the first step, the implementation of waste management activities in the Cantabria region is studied and different available records and the potential sources of data are gathered (Figure 7). In the second step, available data are compared, selecting best data sources, and creating a data catalogue with the information we have gathered.

3.3 Evaluating the indicators and the data (Evaluation Step)

The synthetized indicators and the selected data are evaluated according to the criteria and sub-criteria showed in Table 1. Total and partial scores obtained by each indicator are represented in Figure 8. The maximum value that an indicator gets in the scoring is 18. It was established in this work that those which obtain a value lower than 50% of the maximum value, 9 points, have a low potential for development and they cannot be applied in the short term.

As can be seen in Figure 8, Basic Indicators present high quality with more than 14 scoring points for all them. These indicators have the best score compared to other sets, both temporally (comp1) and geographically (comp2). About the Specific Indicators, from 16 indicators proposed, there are 4 without enough quality to be developed in the short term (SI6, SI8, SI9 and SI10). In the case of TIS, the scoring is applied separately to the indicators TI4, TI5 and TI6 for Hazardous Waste (HW) and Non Hazardous Waste (NHW), due to their different data sources. Those related with Non Hazardous Waste do not have score enough to be applied.

3.4 Main Results obtained about waste management in the Cantabrian Region (Application, Interpretation, and Evaluation of results Step)

With the indicators of each set selected and data sources defined, the application and interpretation of results have been carried out. The application involves defining the formula for calculating the indicator, and all the individual variables it composes. However, the application is not only about applying data to the indicators, it is also about developing the data sheets of the indicators. These sheets include information that allows the interpretation of the evolution of the indicator, and evaluate the results in a legal, temporally and geographical framework. Furthermore, the graphical representation of the indicator and its variables is discussed and selected, providing intuitive and easy knowledge of the current situation, the evolution over the years studied and the comparison to the objectives of each indicator. The main results obtained in Cantabria are summarized in Table 3.

The interpretation and evaluation of the results shown by the indicator is performed through a regional key (comparison with all Spanish regions), a legal key (current situation with respect to the policy objectives), and a temporal key (analysis of time trends and possible predictions of behaviour). In this sense, the evaluation of results consists in applying the criteria of Figure 3: (i) for BIS, depending of the position in the ranking of the results obtained by all Spanish regions, (ii) for SIS, the degree of achievement of the objectives proposed in the regional Waste Plan, and (iii) for TIS, the degree of decoupling of waste generation and socio-economic variables with respect the previous year.

Table 3 shows a good global situation of the waste sector in the region (green icons), (i) with respect to other regions, especially in waste management (BIS); (ii) achieving the policy objectives (SIS), and (iii) the decoupling of waste generation and economic and social development (TIS). For indicators with yellow and red icons a set of improvement proposals must be defined.

3.5. Dissemination of indicators and results and establishment of a protocol data update (Public Review, Dissemination and Update step)

The developed indicators were sent to different stakeholders of the region in order to comply with the public review (Environmental Department of the Regional Government or waste managers of the region, among others). Afterwards, the indicators were presented in different environmental forums. In the case of the Specific Set developed for monitoring policies, the indicators were published, together with the Regional Waste Plan, for public review and any citizen could suggest changes.

The comments and suggestions received were mainly related to the contents of the indicators and not about the definitions of the indicators themselves. There were comments about the management of any waste flows, or inquiries for more explanations about the data sources of recycling. All comments were taken into account, studied, and included in the indicators fact sheet.

Moreover, an essential activity in the management of the environmental information system (EIS) is the dissemination of the indicators developed. The information developed has to reach all interested people, so it must be published in a simple, accessible way and as widely as possible. For that purpose, the web page of the EIS was published in 2006 and it became in the main dissemination tool (FPW, 2006).

In addition to the website, many activities have been undertaken in order to disseminate the information: publication of leaflets, booklets, press releases, digital newsletters, mailings and presentations in some environmental forums.

Finally, a protocol for updating the indicators using data from the previous year has been developed. The first activity is to track changes in waste management, such as authorizations for new integrated management systems or waste managers or the opening or closing of management facilities. All these actions can change the way information is managed and the data sources. The second activity is to track the evolution of the legal framework, updating the new proposed objectives if necessary. The third activity is to request all information about the data sources, sending the requesting form to the different organizations. All information gathered in this way allows the indicators to be updated.

3.6. Improvement of the indicators and results

A SWOT analysis is applied on all the indicators which have not presented enough quality in the evaluation step, and over the indicators which were proposed to be improved in the Application and Public review steps (Figure 1). The SWOT analysis consists in a systematic assessment of all activities with influence on the information management. These activities are classified as strengths, weaknesses, opportunities and threats, identifying the internal and external factors that are favourable and unfavourable to achieve the proposed objective. In order to increase the quality of the indicators, it is necessary to propose actions related to the weaknesses founded, so that an improvement in these activities can have a high impact on the quality of the indicators. The main weaknesses found were related to the absence of one or more of these elements: specific legislation, specific plans, obligation to provide periodic reports to the authorities, regional data records, computerization data, grants to allow the implementation of correct waste management systems or information campaigns.

For each of these weaknesses, a series of lines of action must be proposed. They must be operational and potentially improve the current situation of some of the indicators developed. They generally involve the implementation of changes in varying degrees and may involve particular resourcing and development of specific plans and regulations. Lines of action proposed include the creation of specific plans, establishing new management models, offering grants or economic agreements, information campaigns and developing data records.

3.7 Aggregated indicator for evaluating the situation and trend of waste management in the Cantabrian Region

The last methodological step is the aggregation of the indicators (Figure 1). First of all, the normalization of the values of the indicators is performed using ranking, distance to a reference and min-max methods respectively for BIS, SIS and TIS.
The weighting of the indicators used equals their weight inside each set (BIS, SIS, TIS), and the weight for each of the indicators sets to obtain the global index.
The Dashboard tool performs the aggregation of indicators by multiplying the value of each indicator with the weight coefficient and summing up each of the indicators that will form part of the index. The periods considered in the study are 2006 and 2010 as the years of approval and finalisation of the Cantabrian Waste Plan, and 2008 as the central year.
Figure 9 shows the results obtained by every indicator. The situation of the aggregated indexes, Basic Index (Figure 9a), Specific Index (Figure 9b) and Transverse Index (Figure 9c) are displayed in central circles. These indexes are obtained through the aggregation of the indicators around them. A global index called “Cantabrian Waste Overview” is obtained by aggregating the Basic, Specific and Transverse indexes (Figure 9d).
The evolution of aggregated indices during the study period is a continuous improvement of the situation, especially regarding compliance with the regulations (Specific Index), as in the case of the transversal index, showing the continued decoupling of waste generation and productive activities and social welfare. Compared to other Communities (Basic Index), no significant changes are shown in the studied period.
The global index “Cantabrian Waste Overview” reflects a continuous improvement during the period 2006-2010. The analysis of these results reflects in a simple, understandable and complete way the evolution of the global environmental situation in the waste area in Cantabria.

4. CONCLUSIONS

This paper summarizes the design of a waste information system based on three sets of complementary indicators which provide information on: (i) The current situation of the region and the trend followed throughout time in a compared way; (ii) the level of compliance with the waste policy objectives for European, national and local legal frameworks, and (iii) the influence of different economic and social variables on generation trends of specific waste streams.

To obtain the environmental information system, a novel methodology to develop indicator sets has been designed. The proposed methodology represents a breakthrough in the field, for his aforementioned triple vision and because it proposes an objective method for the selection and evaluation of indicators, issues that hitherto had given them a relatively minor importance. This methodology can be applied to whatever topic and scale both temporal and geographical. Three sets of indicators have been designed according to the objectives proposed in the synthesis step; a basic set with 6 indicators, a specific set with 16 indicators, and a transversal set with 5 indicators. Furthermore, a quantitative, objective method of evaluation of the indicators is included in order to show the quality of the indicators and those that do not have enough quality have been rejected: 4 indicators in the specific set and 3 in the transversal set, all of them because there are not any reliable data about these waste streams. Finally, the indicators are aggregated to present the global situation, without losing the information of each individual indicator using a "Dashboard of Sustainability" tool.

From the application of this novel methodology to the Cantabrian waste sector, it is important to highlight that there are satisfactory trends in the studied years, with a high degree of compliance with waste policy objectives, especially those related to waste management, and showing the continued decoupling of waste generation and economic development and social welfare. Using the individual indicators, activities are detected on which efforts should be focused in coming years, mainly related to the minimization of the generation of different waste streams. Through the aggregated index, the overall situation of the generation and management of waste at the regional level has be analysed, obtaining a continuous improvement over the years studied.

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Table 1. Criteria and sub-criteria with their score to evaluate indicators.

CRITERIA	Questions or Sub-criteria	Scoring
Relevant Related to goals	Relev1. Is the indicator linked to policy targets, objectives or legislation?	0= No 1= Yes, indirectly 2= Yes, directly
	Relev2. Could the indicator provide information that is useful for policy decisions?	0= No 1= Yes
Credible Based on complete and accurate data	Cred1. Are the data complete?	0 = No data record 1 = Data from various sources 2 = Data from a single source
	Cred2. Are the data accurate?	0= No data record 1= Estimates 2= Direct measurement
Functional Useful in decision-making	Func1. Could the indicator provide clear and easy information?	0= No 1= Interpretation requires prior knowledge 2= Direct interpretation
	Func2. Is the indicator sensitive to changes?	0= Slow; delays the response 1= Fast; Immediate response
Quantifiable Easiness measure	Quant1. Are the data easily accessible?	0= No 2= Yes
	Quant2. What is the format of the data?	0= No data record 1= Paper record 2= Electronic record
Comparable Obtained at different spatial and temporal scales.	Comp1. Are time series are available?	0= No data record 1= No, only data points 2= Complete data record
	Comp2. Does the indicator have good geographical coverage?	0= No 1= Comparable across Municipalities or Regions 2= Comparable across Municipalities and Regions

BI1. Generation of MSW BI2. Treatment of MSW BI3. Recycling Rate of Paper and cardboard and Glass BI4. Recovery rate of plastic, metal and wood packaging waste BI5. Production and destination of sewage sludge BI6. Management of Hazardous Waste	SI1. Generation of waste SI2. Treatment of Construction and Demolition Waste SI3. Treatment of Used Tyres SI4. Production and destination of sewage sludge SI5. Packaging Waste Collection and recycling by an Integrated Management System SI6. Treatment of Waste Electrical and Electronic Equipment SI7. Quantity of oil-wastes collected at Municipal Collection Points SI8. Management of manure and slurry SI9. Contaminated soil remediation SI10. Excavation Land Management SI11. Rate of sale of compost SI12. Energy from waste SI13. Rate of landfill of biodegradable waste SI14. Disposal in landfills SI15. Installation of Municipal Collection Points SI16. Installation of Landfills	TI1. Social variables related to generation of Municipal Solid Waste TI2. Eco-efficiency of Municipal Solid Waste Generation TI3. Intensity on waste (HW and NHW) of the company TI4. Eco-efficiency of the generation of waste (HW and NHW) of the company TI5. Intensity on employment of the generation of waste (HW and NHW) of the company

Table 2. Indicators selected for each Set of Indicators.

Table 3. Main Results obtained in the application, interpretation and evaluation of the three sets of indicators in the Cantabria Region during 2011.

Ind. Code	Application	Interpretation	Evaluation (2011)
BI1	Sum of the quantities of MSW collected in different ways: selective, bulk, clean points, voluminous.	Change in production trend in 2008, begins to decrease MSW production due to change in consumption patterns. Fourth region in MSW production rate.	
BI2	Percentages of the amounts of MSW managed in each treatment over the total generated: recycling, composting, energy recovery and landfilling.	Decrease in the quantities of MSW managed in landfill in favour of techniques such as incineration with energy recovery, recycling or composting. Second region in MSW valorisation rate that includes the recycling, composting and energy recovery.	
BI3	Ratio of the amount recycled divided by the amount consumed The amount recycled is calculated as the sum of the amounts separately collected and recovered from mixed waste.	Continuous increase in the amounts recycled, up to 60% for glass and 70% for paper and cardboard Fourth region in glass, and paper and cardboard recycling.	
BI4	Ratio of the amount recovered divided by the amount consumed (for each material: plastics, metals and wood).	Continuous increase in the amounts recovered, up to 40% for plastics and near 100% for metals and wood packaging waste. Fourth region in plastic, metal and wood packaging waste recovery.	
BI5	Total quantity of Sewage Sludge (SS) produced and Percentages of the amounts of SS managed in each treatment over the total generated: used in agriculture, incinerated, and landfilled.	Change in production trend in 2007. Decreasing SS production due to improvements in sewage treatment stations. Changes in management model: from total landfilling to use in agriculture as a fertilizer. Third region in production of sewage sludge rate.	
BI6	Sum of the quantities of Hazardous Waste (HW) send by each producer of HW to each manager of HW.	Decrease in the HW production, due to an industrial production drop in the region. Second region in hazardous waste production rate.	
SI1	Sum of the quantities of Hazardous Waste (HW) send by each producer of HW to each manager of HW and quantities of Non Hazardous Waste (NHW) treated in the region.	General decrease in HW and NHW produced in the region. The objective, Stabilization of waste generation rates for each sector, is reached by all sectors: municipal, special, industrial and primary sector, but it is not enough to achieve the objective for municipal waste of reduce the generation to 2003 level.	
SI2	Percentages of the amounts of Construction and Demolition waste (CD) managed in each treatment over the total generated: Recycling, environmental restoration, and landfilling.	Changes in management model: from total landfilling and environmental restoration before 2010 to reach a rate of recycling over 95% after 2011.	
SI3	Percentages of the amounts of Used Tyres (UT) managed in each treatment over the total generated: Recycling, environmental restoration, and landfilling.	Main treatment for UT is recycling, decreasing the percentage of UT that were recycled between 2008 and 2011. The second treatment is energetic valuation, followed by reusing and landfilling. The objective of recycling more than 25% is widely accomplished.	
SI4	Percentages of the amounts of SS managed in each treatment over the total generated: used in agriculture, incinerated, and landfilled.	The objective of use in agriculture more than 95% of SS produced, has been accomplished since 2010.	
SI5	Quantities of each kind of packaging waste (glass, paper and cardboard, packaging, phytosanitary packaging, and medicines packaging) managed by each Integrated Management System (Ecovidrio, Ecoembes, Sigfito and Sigre).	Quantities managed of each packaging waste have increased with time, so the objective of increasing the packaging waste managed has been achieved.	
SI7	Quantity of oil wastes collected in clean points (vegetable used oil and mineral oil wastes).	Quantities of both oil waste have increased in the period 2005-2010, so the objective is achieved.	
SI11	Rate of sale of compost: quantity of compost produced divided by quantity of compost sold.	Rate of sale of compost is near 100% of compost produced, so the compost produced has enough demand and the objective is achieved.	

SI12	Sum of the energy produced from biogas of landfill and incineration of MSW.	Total power generated is around 97.9 million of kWh, and this power has slight decreased last years due to a drop in the MSW managed in this facilities.	
SI13	Rate of disposal of biodegradable waste in landfills over biodegradable waste generated identified.	Rate of disposal has decreased from 100% in 2001 to 19% in 2011. It is mainly due to the implementation of the compost production facility, and the SS drying plant.	
SI14	Amount of waste disposed in each landfill.	Large decrease in the amount of waste deposited in landfills in the region, both non-hazardous waste and municipal waste.	
SI15	Installation of Recycling points in municipalities with more than 5000 inhabitants	Only one of the 20 municipalities with more than 5000 inhabitants of the region, have not got a recycling point in its area of influence.	
SI16	Number of operating landfills in the region.	Now, there are two landfills in the region, one for Municipal Waste and other for Non Hazardous Waste. The other three existing landfills have been closed until 2010.	
TI1	Graphical representation of social variables that influences Municipal Waste generation: population, number of homes, employment, population density, or life expectancy.	The generation of MSW has decreased in the period 2006-2010, and the rates of MSW generation by inhabitant or home have decrease too. However, the rate of MSW generated by employed has decreased, due to lost of employment in the region in that period. The study of the relation of variables like population density or life expectancy with MSW generation shows no change with time.	
TI2	Eco-efficiency ratios: Economic variables that influence Municipal Waste generation (like consumption, production of goods and services or purchasing power) divided by the MSW production.	Eco-efficiency ratios respect of consumption or purchasing power, have increased in the period studied, due to changes in the consumption patterns. However the ratio with the production has an irregular trend due to the changes in this variable in an economic crisis time.	
TI3	Quantity of Hazardous waste generated per company.	The amount of waste generated by company has decreased, from 3.36 t/company, in 2005, to 1.47 t/company, in 2011.	
TI4	Value of goods and services produced, measured as Gross Value Added, per tonne of Hazardous waste generated.	The eco-efficiency of HW generation has increased, from 83,250 Euros/t, in 2005, to 211,130 Euros/t, in 2011.	
TI5	Employment per tonne of Hazardous waste generated.	The Intensity in employment of HW generation has increased too. From 2.08 employs/t, in 2005 to 3.91 employs/t in 2011.	

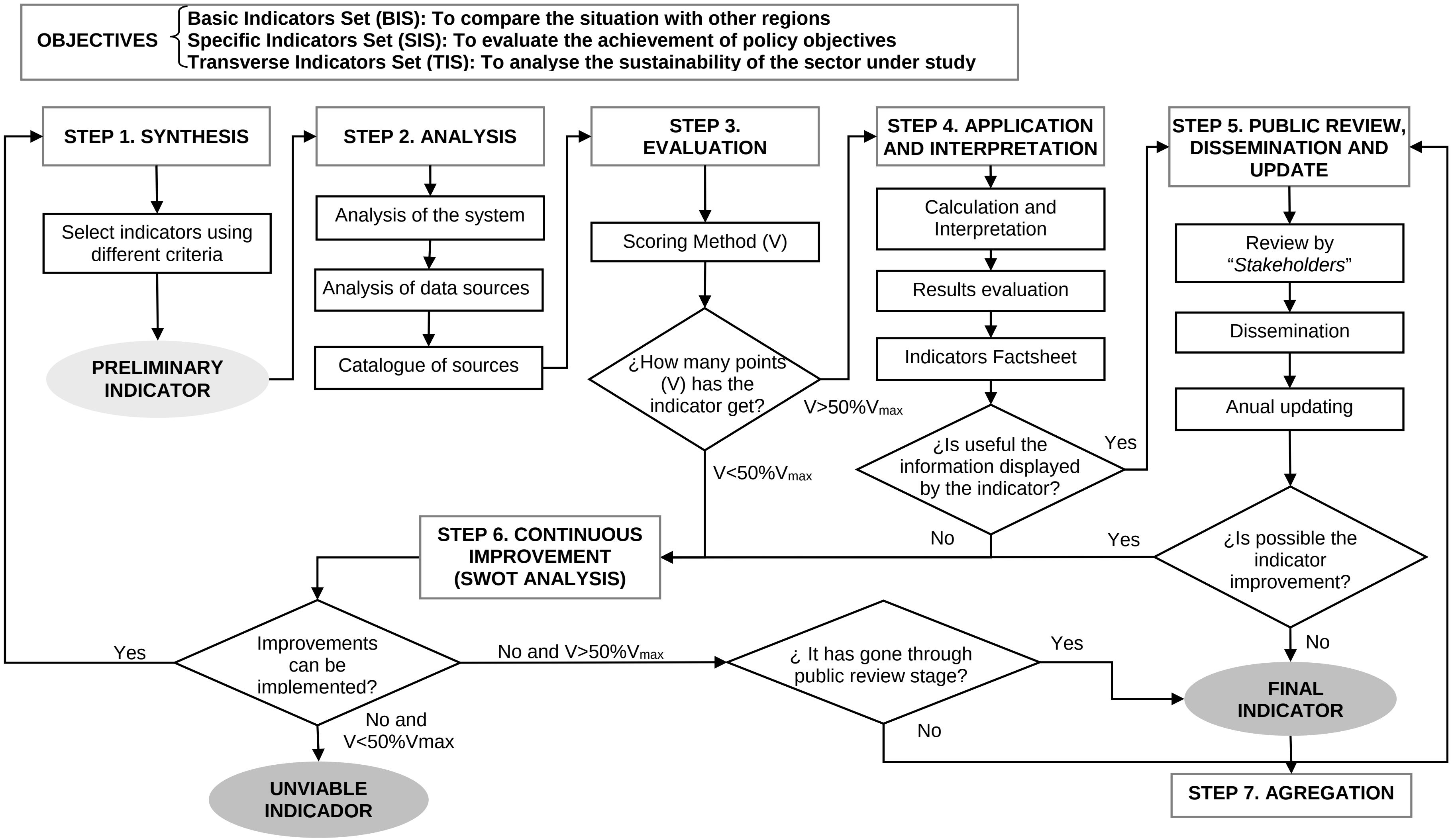

Figure 1. General methodology for the development of the indicators sets

Indicators Set	Objective	Starting Point	Criteria	Selection method		
BIS	Comparability	Indicators developed by other agencies	Comparable Credible	Indicator review	Selection of indicators that meet the criteria set	
SIS	Monitoring policies	Policy Objectives	Relevant Functional Comparable	Policy question behind the stated goal	Indicator that answers the policy question	
TIS	Associated sustainability	Socioeconomic variables related	Functional Quantifiable Comparable	Review of socio-economic variables influence	Selection of variables that meet the criteria	Eco-efficiency indicators

Figure 2. Synthesis Step: Indicators Selection methodology for each Indicators Set

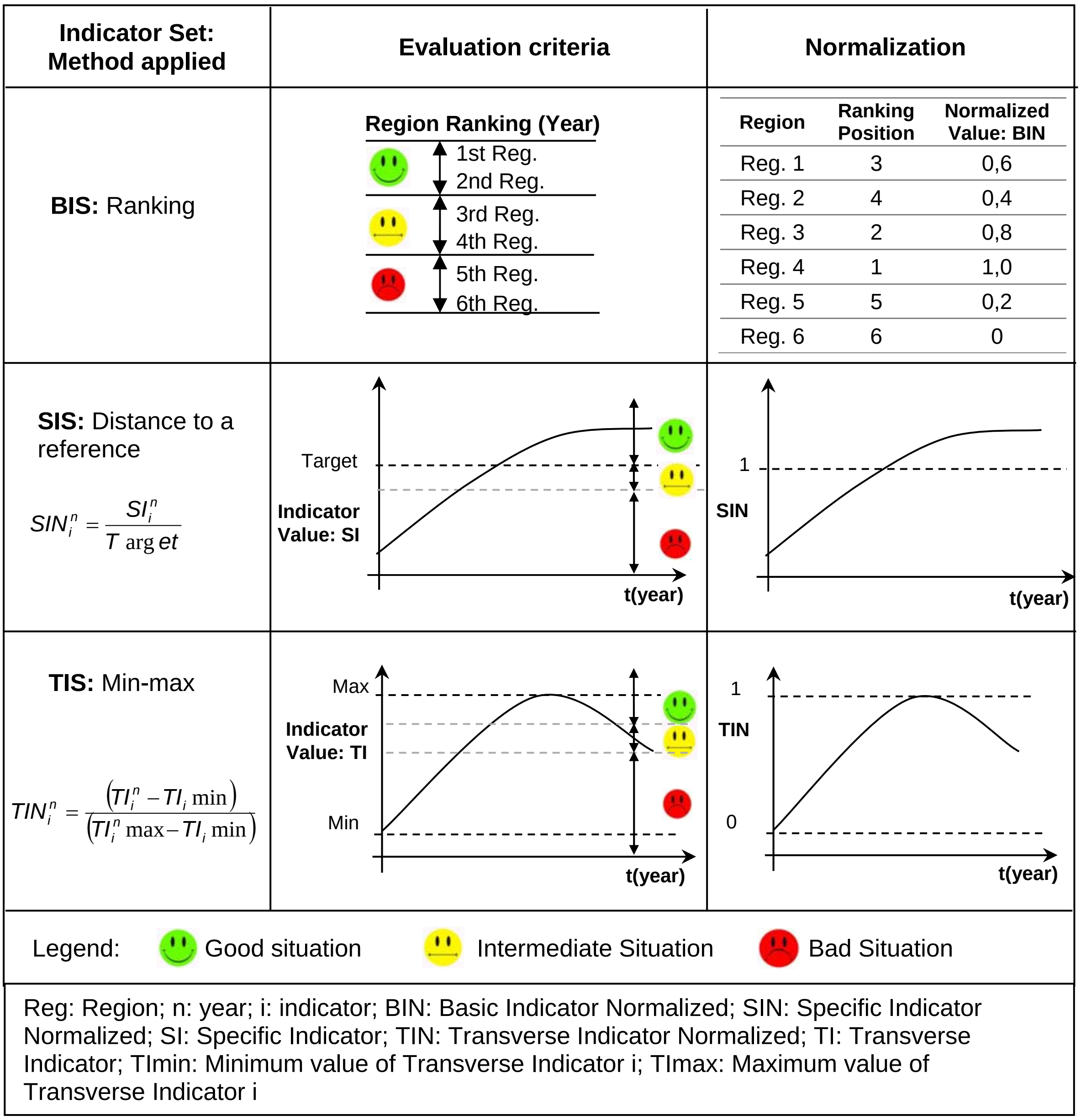

Figure 3. Evaluation and Normalization Method for each indicators set

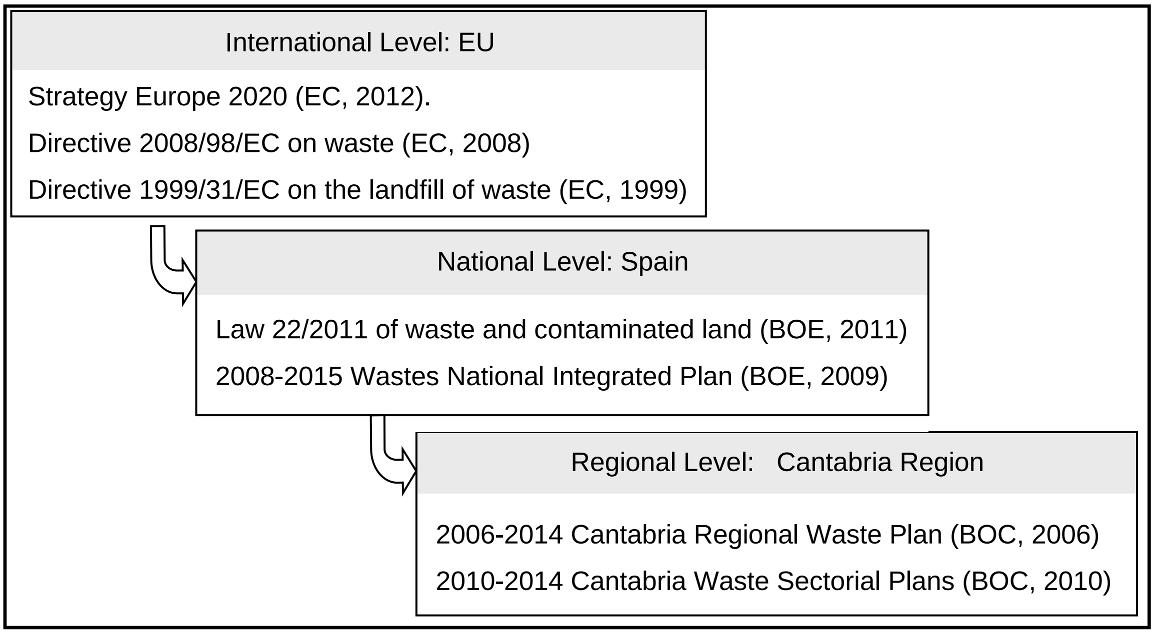

Figure 4. Waste Policies at European Union, Spanish and Cantabria Region levels

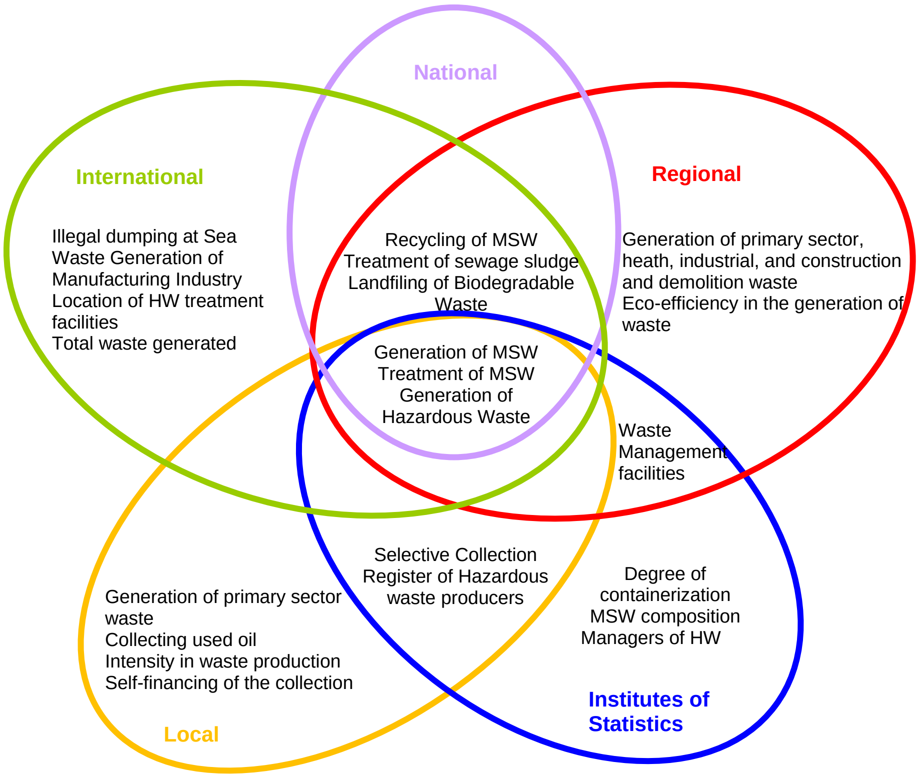

Figure 5. Synthesis of Basic Indicator Set

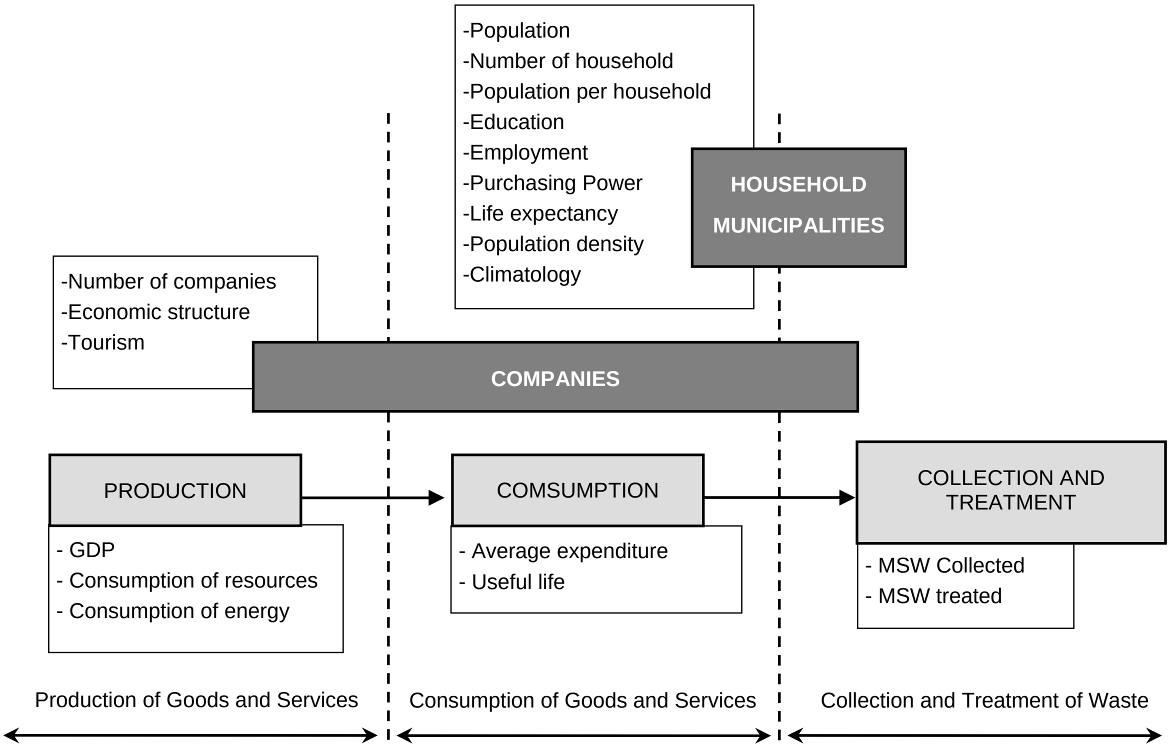

Figure 6. Synthesis of Transverse Indicators Set for Municipal Solid Waste flow.

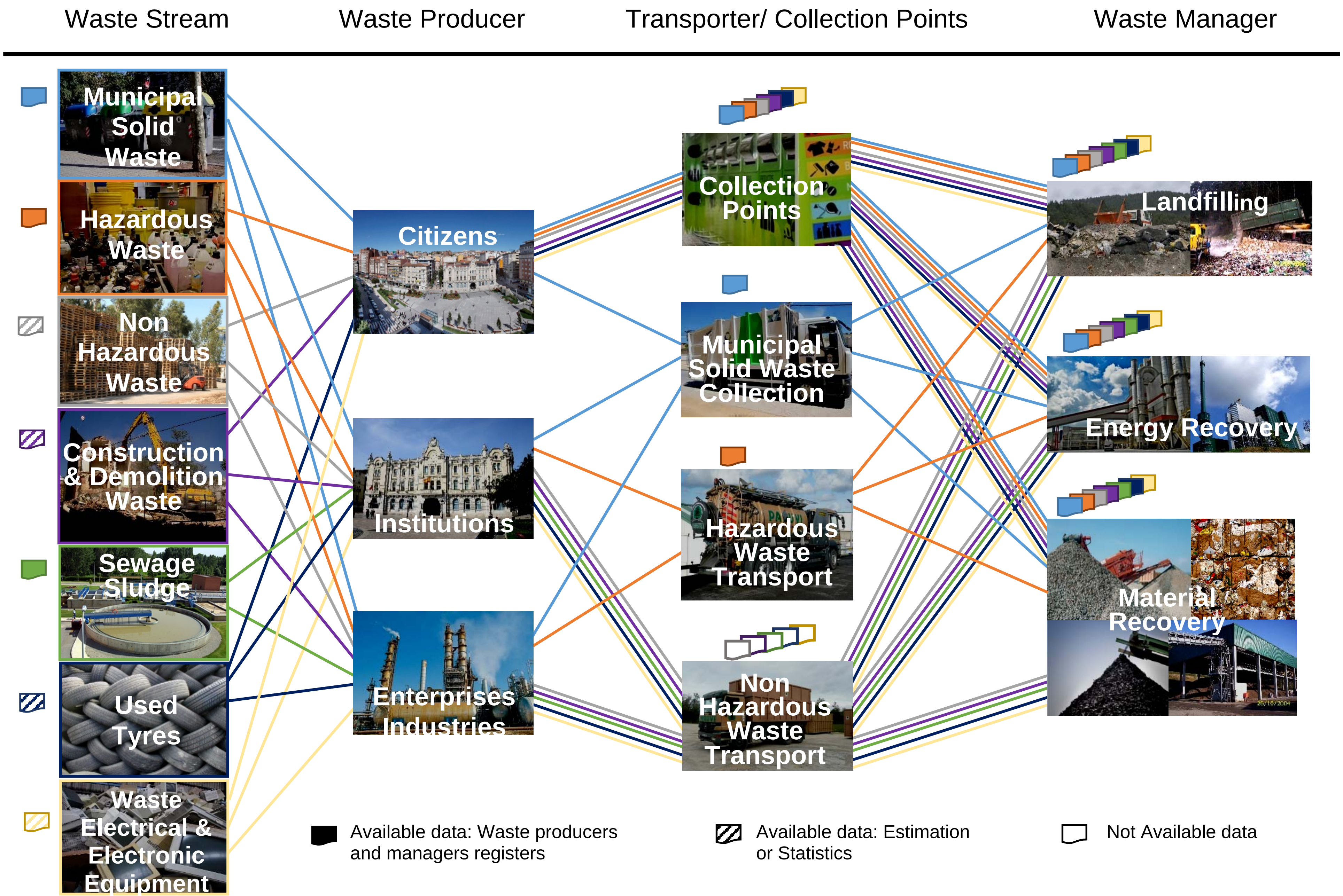
Waste Stream
Waste Producer
Transporter/ Collection Points
Waste Manager
Municipal Solid Waste
Hazardous Waste
Non Hazardous Waste
Construction & Demolition Waste
Sewage Sludge
Used Tyres
Waste Electrical & Electronic Equipment
Citizens
Institutions
Enterprises Industries
Collection Points
Municipal Solid Waste Collection
Hazardous Waste Transport
Non Hazardous Waste Transport
Landfilling
Energy Recovery
Material Recovery
Available data: Waste producers and managers registers
Available data: Estimation or Statistics
Not Available data

Figure 7. Analysis of Cantabrian waste sector and the available information.

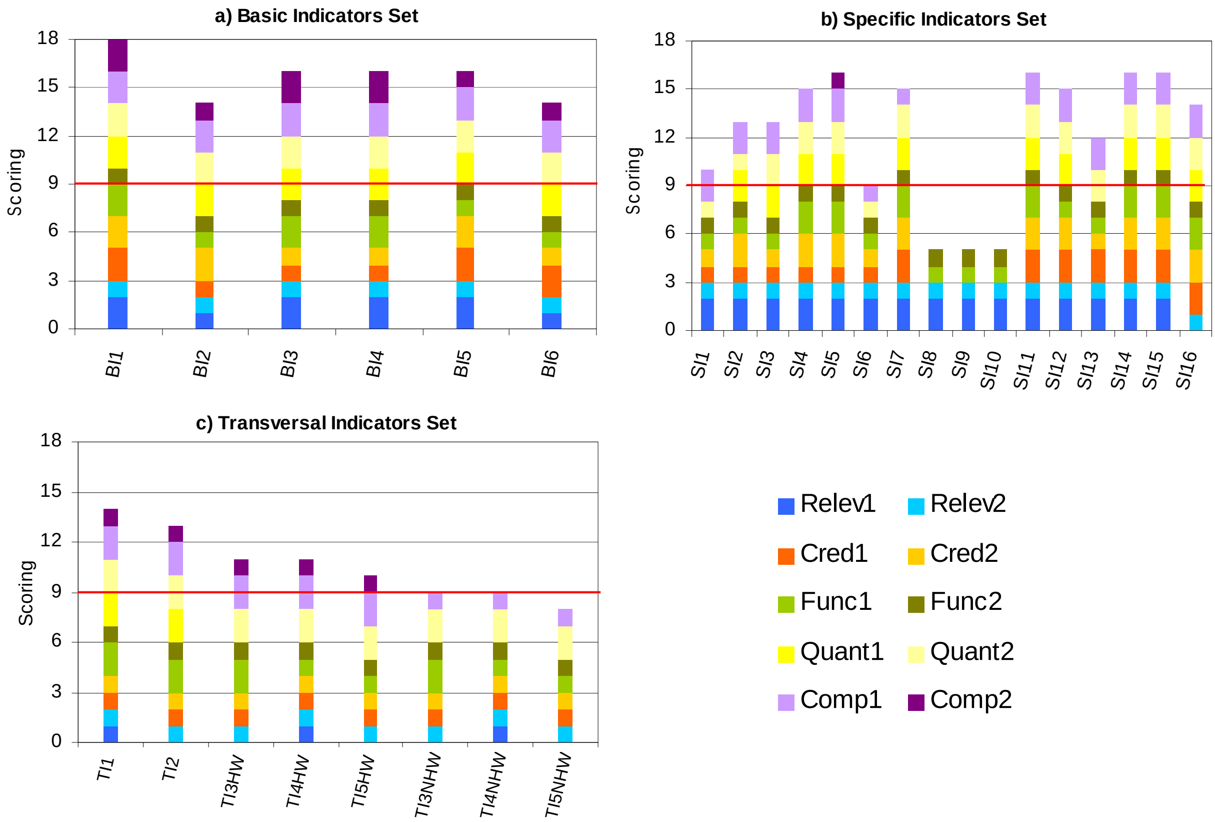

Figure 8. Evaluation of the indicators sets: (a) Basic Indicators, (b) Specific Indicators and (c) Transversal Indicators

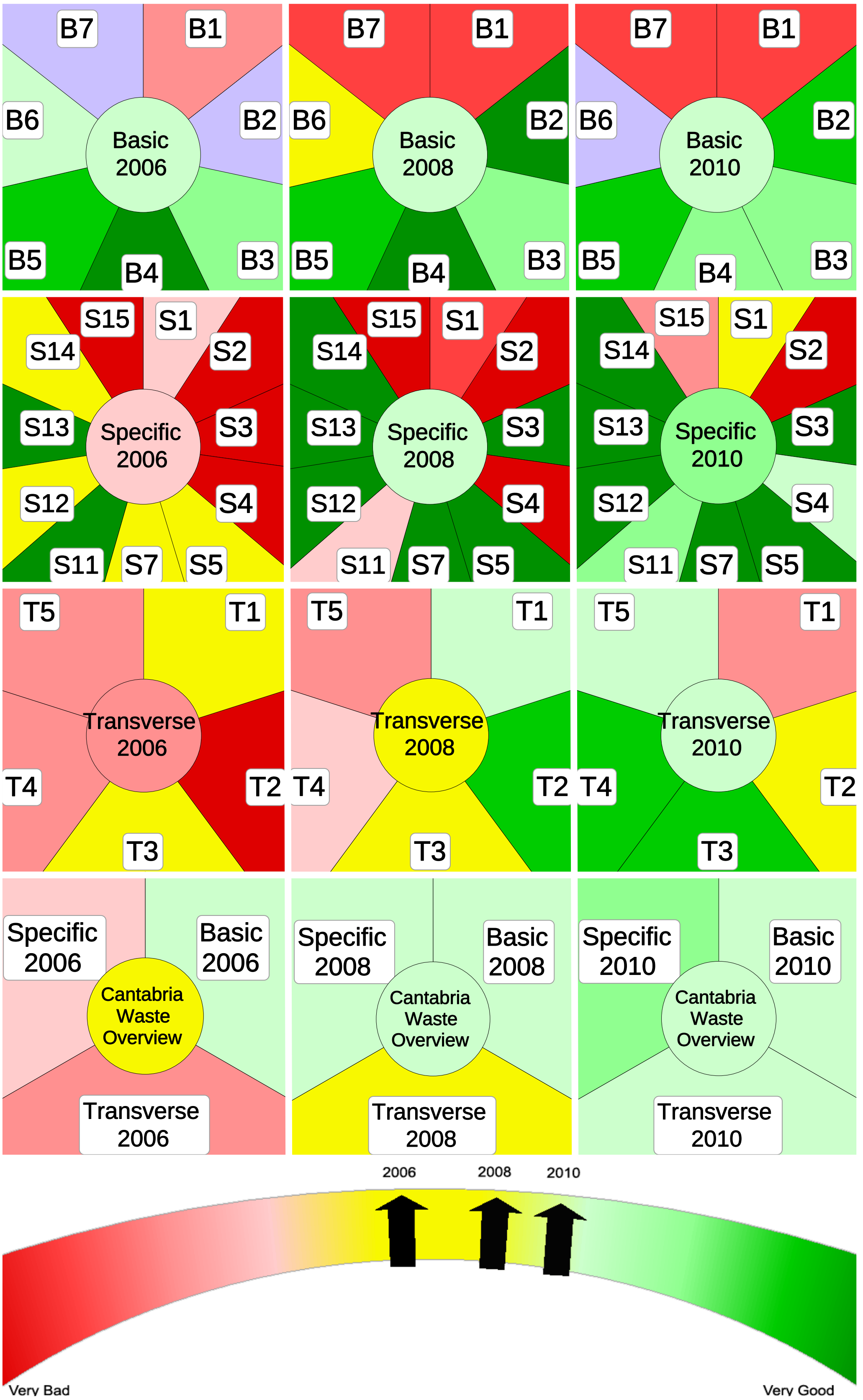

Figure 9. Aggregation of the indicators sets by Dashboard tool: (a) Basic Indicators Set; (b) Specific indicators Set; (c) Transversal Indicators Set; (d) Global Index.