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Balancing science and society through establishing indicators for integrated coastal zone management in the Balearic Islands

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ABSTRACT

This paper explores the process by which indicators may be developed as tools for communicating science to decision-makers using the participatory approach demonstrated by the Balearic Indicators Project. This initiative reflects a series of compromises considered necessary to achieve the objective of generating an indicator system that is scientifically viable, comparative internationally yet locally relevant, and to facilitate its implementation. The article highlights questions regarding the utility of science for addressing current global issues related to sustainability and why science often fails to promote change at the societal level.

1. Introduction

The coastal zone is an extremely complex social-ecological system that varies in relation to its environmental, socio-economic, cultural and governance factors. Integrated Coastal Zone Management (ICZM) seeks to develop an integrated model for sustainable development that is based on finding points of convergence among these factors [1–3]. In theory, it is an effective tool for advancing towards sustainability in the coastal zone, ensuring equitable use of coastal resources (natural, socio-economic and cultural) and integration among the different administrative and societal sectors. However, despite significant efforts from scientists and practitioners to mitigate the negative impacts of increasing anthropogenic and natural pressures, the state of the world's coasts is deteriorating [4–17].

The success of ICZM in supporting sustainability goals in Europe has been limited due to, among others, the challenge associated with translating the basic principles of ICZM into management action [9,18–20]. Viable, interpretable scientific information is critical for addressing this challenge [12,18,20–22]. However, separation (physical, philosophical and logistical) between the worlds of science and decision-making can hinder the translation of science into policy, with scientists conducting research without considering the needs of decision-makers and the latter basing their decisions on political premises. Science generally requires considerable data, resources and time to implement and is subject to continual verification and evolutionary changes. Decision-making, on the other hand, needs to be based on simple, interpretable, unambiguous information and generally requires time sensitive and resource efficient responses. This incompatibility between science and policy is being addressed through the emergence of increasing numbers of government science agencies, designed to generate policy orientated science, and with new approaches to science that attempt to bridge this "science-policy gap" that are integrated, aimed at addressing and solving specific problems, and encourage participation of stakeholders [23–26].

Indicators have been receiving considerable attention in recent years as one potential solution to bridging the science-policy gap [27–31]. In general terms, indicators are measurements that should quantify and simplify information related to trends that can not be easily observed. McCool and Stankey [12, p.295] write that the general purpose of indicators is, "to reduce complex, poorly understood systems to a limited number of variables that presage impending changes in life support and management systems." Indicators may be used to obtain punctual information about a specific phenomenon or may be measured over time in monitoring systems. Essentially, they can help decision-makers identify, evaluate and track progress towards solving sustainability problems. The objective of this paper is to explore the process by which indicators may be developed as tools for bridging the science-policy gap, using experience gained during the development of a system of

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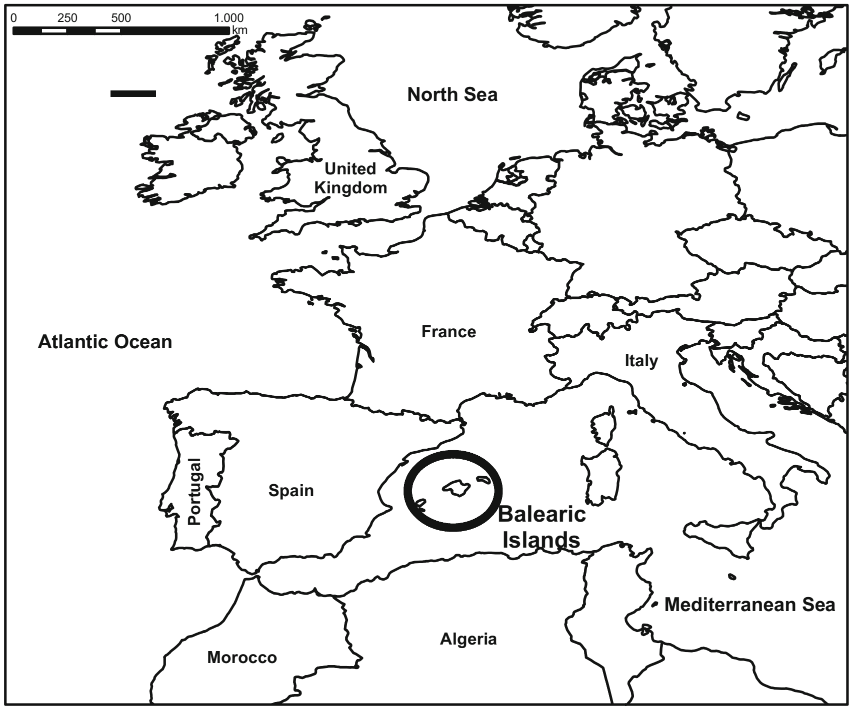

Fig. 1. Location of the Balearic Islands, Spain.

indicators for ICZM in the Balearic Islands, Spain (Fig. 1). This initiative involved a participatory approach and reflects a series of compromises considered necessary to achieve the objective of generating an indicator system that is scientifically viable, comparative internationally yet locally relevant, and to facilitate its implementation.

1.1. The role of the participatory approach in indicator development

In many cases indicator initiatives reflect the communication barriers between science and management by being, in themselves, too complicated to interpret or implement. The challenges involved in defining appropriate indicators are inherent in their definition. How does one measure a trend that cannot be readily observed? How does one gain a realistic understanding of a complex phenomenon using simplified data? Such questions have resulted in a significant number of scientific documents reporting potential systems, generic lists, frameworks and models for applying indicators (for example [3,4,11,13–17,30,32–45]).

Although standardized methods and lists may be useful, they cannot hope to capture the complexity of the issues facing every nation's coastline, much less at finer, local scales such as islands or municipalities, which is where ICZM is generally implemented [22]. Sustainability scenarios and indicators are not generic, rather, they are site specific and restricted by political and local realities. Their implementation is contingent upon available financial, technical and human resources. Entities wishing to select indicators first need to identify major goals or objectives associated with sustainability in their respective locations, which should reflect the opinions of stakeholders [3,46–49]. Indicators associated with evaluating and/or monitoring these objectives need to be viable from a scientific perspective (e.g. directly observable and measurable, interpretable, grounded in scientific theory, sensitive, response specific) and also practical from a management perspective (e.g. cost effective, relevant to management objectives, clear linkages to the outcomes being monitored) [3]. They should be part of the management and governance processes and not an end in themselves [3].

A participatory approach (i.e. communication among scientists; indicator "developers", and decision-makers and stakeholders; indicator "users") has been applied in a number of indicator initiatives to help to tailor them to local and political realities and ensure their implementation [2,20,22,26,31,47–51]. The varied results of these studies reflect additional challenges associated with the participatory approach including, among others, achieving consensus and effective coordination among a large number of stakeholders (scientific, political, resource users) with varying opinions, knowledge, and agendas (personal and logistical). Once consensus is reached, the translation of this information into action can also be ineffective, leaving stakeholders feeling frustrated and powerless. The process through which participation is carried out (i.e. who is involved and at what stage in the process, how they are consulted, frequency of meetings, formality of associated collaborations, conflict resolution process, etc.) can vary considerably from case to case and is critical to ensuring its effectiveness. Much like the indictors themselves, the way in which the participatory process is carried out will be constrained by local logistical and political realities and available resources, often necessitating compromises such as involving fewer stakeholders.

1.2. The Balearic Islands case study

The Balearic Islands are an autonomous community of Spain and one of Europe's leading sun, sea and sand tourism destinations. They are made up of the four main islands of Mallorca, Menorca, Ibiza and Formentera, plus the smaller island of Cabrera, a land and sea National Park. The islands cover an area of 497 000 ha, with a coastline of 1428 km and had a population of just over one million in 2006. In 2007, 13.3 million tourists (9.8 million foreigners, 3.4 million Spanish) visited the islands [52]. The islands face similar sustainability challenges as other coastal areas (see for example [4,53–57]). Furthermore, the fact that they are insular environments and mature tourism destinations exacerbates problems such as seasonal pressure on natural resources, residuals and unplanned coastal development, making the achievement of sustainability in the coastal zone all the more important and challenging. The need to address these challenges through sustainable development of the coast is recognized at the civil society level in the Islands, yet there is a significant lack of baseline science to support related actions.

The concept of ICZM was not fully contemplated in the islands until recently with the formation of a partnership between the Government of the Balearic Islands and the Mediterranean Institute of Advanced Studies (IMEDEA) in 2005–08, which resulted in the Balearic ICZM Project (I+D+i GIZC Balears). The main objective of the project, which is now being continued by OceanBit, a coastal ocean observing and forecasting system in the Islands, was to generate scientific knowledge to facilitate the achievement of sustainability in coastal areas of the Islands using the framework of ICZM. The Balearic Indicators Project was one of the main outcomes of this initiative. The following sections describe the participatory process and methods used in this project with emphasis on how participation influenced the final result, both in terms of the system of indicators and its implementation.

2. Participatory process and methods used for the definition of ICZM indicators

To reiterate, the overall objective of the Balearic Indicators Project was to generate a system of indicators for assessing sustainability objectives in the islands, within an ICZM framework, that was scientifically viable, comparative internationally yet locally relevant, and to ensure its implementation. A partnership was formed to facilitate this process, which is described in the following subsections.

2.1. Description of the partnership

There were two partners involved in the Balearic Indicators Project: IMEDEA and the Economic and Social Council of the Balearic Islands (CES). These partners represent a significant portion of the academic community (IMEDEA) and a range of local stakeholders (CES) (described in more detail in the following subsection). "Partnership" is broadly defined here in the context of Sherry Arnstein's Ladder of Citizen Participation [58], where both partners have equal influence over the decision-making process and the terms of agreement are defined at the start of the project and not subject to unilateral change. Scientists and practitioners from other institutions (government, research, non-governmental organizations and international organizations) were consulted at various stages of the initiative but were not included in the partnership.

The partnership was initiated in May 2006 by the Director of IMEDEA and the President of the CES at that time with the formation of a Technical Committee. This Committee was given the responsibility of developing a research plan and leading the technical aspects of the project. The group consisted of the president of the Working Commission for Economy, Regional Development and Environment and the chief economist of the CES, and the Director (an oceanographer) and a social scientist from IMEDEA. The proposal to develop a system of indicators to assess and monitor ICZM in the Balearic Islands was adopted and initiated in December 2006 with a specific interest from the CES in including the resulting system in their annual statistics memorandum. The potential for the system to be presented as an official opinion (*Dictamen*) of the CES (see Section 2.2.1) was also considered at this time and the role that each partner would play in the initiative was defined. The following subsections provide more details about each partner and their respective roles in the initiative.

2.1.1. CES

Economic and Social Councils may be described as organizations of participatory democracy (see [2]). Essentially, they are made up of employees' organizations, trade unions and other representatives of public interests. They represent the opinion and the needs of civil society and relate these opinions to government through official opinion papers (*Dictamen*) and advice. In Europe, they exist at regional, national and EU levels. In Spain, each autonomous region has its own government, parliament, and Economic and Social Council. The CES is the Economic and Social Council of the Balearic Islands and is the only organization in the islands that has legal competence to express opinions to decision-makers, generally on a consultative basis, of representative social groups. It is comprised of the Plenary (the highest level of decision-making), the Permanent Commission, and three Working Commissions (WCs) of: (1) Employment and Labour Relations, (2) Social Affairs and (3) Economy, Regional Development and Environment. These groups were assigned the following roles in the partnership:

The Plenary

- Responsible for the formal approval of the system of indicators and for deciding how it will be presented at the end of the process (i.e. in the memorandum of statistics or as a *Dictamen)*.

Permanent Commission

- Formal leadership of the participatory process.
  - Responsible for defining and facilitating the role of the individual members of the WCs in the process.
  - Acting as an interface between the Technical Committee and the Plenary.
  - Presenting formal requests to the Plenary related to changes to timeline and pre-established arrangements.

Working Commissions (WCs)

- Consultative role through participation in a series of technical meetings.
- Two members of the WC for Economy, Regional Development and Environment formed part of the project's Technical Committee (president and chief economist).

2.1.2. IMEDEA

IMEDEA, located on the island of Mallorca, is a public, joint research centre of the Spanish National Research Council (CSIC) and the University of the Balearic Islands (UIB). IMEDEA emphasizes interdisciplinary approaches to marine, coastal and insular science, including the transfer of scientific knowledge to society and innovation. There are currently over 100 researchers from a variety of natural and social science disciplines working at the centre. The role of IMEDEA in the partnership was, through leadership of the Technical Committee (led by a social scientist), to provide interdisciplinary scientific expertise needed for the project.

2.2. Selection of the indicators: methods and process

The Balearic Indicators Project was carried out in two phases, initiated in December 2006 after the research proposal was approved by the Plenary of the CES. As mentioned previously, project activates were led and coordinated by the Technical Committee, comprised of members of both partner organizations.

2.2.1. Phase 1. Definition of ICZM objectives, literature review and preliminary list of indicators

The first phase involved the definition of a series of objectives for achieving sustainability through the implementation of ICZM in the Balearic Islands. The objectives were classified into three general categories: governance, socio-economics (including culture) and environment, including a series of sub-categories. For example, the governance objectives were separated into four sub-categories: integration, legislation, implementation and organizations [3]. The first draft of the objectives was prepared by the Technical Committee, who consulted with a diverse selection of local and regional scientists and practitioners within and outside of the partnership. These consultations were carried out in person or via email where necessary. No priority was assigned to these objectives at this stage.

Once a general consensus on the objectives had been reached within the Technical Committee, the lead scientist at IMEDEA conducted a review of the literature and projects related to indicators at international and local levels and, from this, selected indicators associated with each objective. In order to avoid duplication of work efforts were made, wherever feasible, to select indicators that have already been established and are being implemented at international, regional and local levels ([3,43], DEDUCE Project (http://www.deduce.eu/, accessed 11/9/09)). Using established indicators allows for comparability among data and also helps to ensure the viability and functionality of the measurement. It is also important to draw upon existing data sources in order to minimise the costs (time, financial, technological) necessary to implement indicators, therefore freeing up resources needed to obtain additional measurements. Following this first definition, three meetings were convened during April and May 2007 with each of the WCs of the CES to discuss the preliminary selection of indicators. Alternatives and additional measurements were selected at this time using the inputs from the WCs. Appropriate spatial and temporal scales were also discussed and agreed upon for each indicator. The resulting draft document contained a proposal for 56 indicators, with associated measurements, and spatial and temporal scales.

The proposal from Phase 1 was presented to the Permanent Commission of the CES in May 2007. They convened an *ad hoc* Commission (one member from each of the WCs, secretary general and chief economist of the CES) to evaluate the preliminary system of indicators developed in Phase 1 and the activities proposed by the Technical Committee for Phase 2. This proposal, which was that Phase 2 should include a more profound evaluation of the indicator system from a practical perspective in order to develop a viable plan for their implementation, was submitted to the Plenary with no changes and approved in September 2007.

2.2.2. Phase 2. Evaluation of indicator feasibility and importance and development of implementation plan

Specific tasks carried out in Phase 2 included:

a. *Viability analysis.* A viability analysis was carried out for each of the indicators proposed in the first phase. Since the parameters used for this analysis are basically objective, only the Technical Committee was involved in this task. Seven parameters were used, ranked on a scale of one to three (1 = low viability, 3 = high viability). The parameters were: (1) availability of data, (2) availability of data at necessary spatial scales, (3) availability of data at necessary temporal scales, (4) state of development of the methodology for calculating indicator (i.e. are all the measurements and formulas defined or is more work/research required?), (5) complexity of managing the indicator (i.e. does it require coordination among a large number of people? Does it require a lot of time or expensive technology?), (6) highlights tendencies over time (i.e. sensitive to change) and (7) provides a response to a specific objective related to sustainability or ICZM. Indicators with a score of less than 15 were categorized as having low viability, 16–18 medium, and over 19 high (based on methodology in [59]). The indicators were ranked according to their level of viability.
b. *Estimate of cost.* An estimate of cost was carried out for each of the indicators. Again, because of the basic objectivity of this task, it was performed exclusively by the Technical Committee. The estimate was based on the dedication of personnel and technology that would be required for its development, implementation and measurement. It was not possible to calculate the exact cost in euros due to the fact that voluntary involvement of entities already obtaining these measurements can not be anticipated until the list is actually implemented. In this context, indicators were simply defined as requiring high/medium/low dedication of personnel and as to whether or not additional research or technology would be required.
c. *Designation of level of importance.* Independent of the viability analysis and estimation of costs, the indicators were ranked on the basis of their perceived importance (high, medium, low) for monitoring sustainability and ICZM-related objectives for coastal areas in the Balearic Islands. This was considered important because viability scores were based largely on objective measurements, which resulted in the fact that many indicators which are highly important (in particular environmental indicators) had low viability scores as a result of being complicated to measure and lack of data. A first ranking of importance was carried out by an interdisciplinary team of IMEDEA scientists. This was considered to be the "expert" scientific opinion of the most important elements necessary to achieve sustainability in the Balearic Islands. Following this, in November 2007, IMEDEA researchers carried out a Delphi Study [60,61] with a group of 13 members of the WCs of the CES. Their opinion was considered to represent local needs and perspective. Specifically, without prior knowledge of the IMEDEA rankings, participants marked their personal opinion on the importance of each indicator using the scale of 1 (very low) to 5 (very high). The study was carried out in two rounds. The second round allowed the participants to see the average scores from the first round and gave them the opportunity to adjust their opinion on the basis of these scores. Final mean scores were compared with the IMEDEA scores, and if they were different they were debated and adjusted accordingly. Conflicting opinions were rare (see results section) but, in the few cases where they did occur, CES was given the final decision in the case of socio-economic and governance indicators and IMEDEA in the case of the environmental indicators. Indicators were ranked according to their level of importance.

3. Results

The results of the Delphi study reflected that, out of the 56 indicators proposed in Phase 1, the opinion of the WC expert group coincided with IMEDEA's for 45 indicators. The other 11 resulted in small discrepancies in the opinions. There were no significant differences between allocated scores for the first and second rounds of the study. It was also agreed that two of the indicators from the preliminary proposal would be eliminated due to low viability and importance scores. The importance and viability rankings represent two complementary perspectives that can help with decisions regarding which indicators should be implemented in the absence of resources to implement the entire system: where resources are limiting factors, the viability ranking would be a more important reference since indicators with high viability require minimal or no resources to implement. If resources are available, the table of importance would be a better reference since it represents a more complete system of indicators with respect to measuring sustainability objectives. Table 1 shows the relationship between importance and viability rankings. There are 17 indicators with high importance and viability and an additional 19 that are highly important with lower viability scores. As one would expect, all but 3 of the highly viable indicators are highly important.

The project report, which was completed in November 2007, contained a proposal of 54 indicators for ICZM (8 governance, 41 socio-economic, 4 environmental). Table 2 shows the indicators (not including specific measurements), associated ICZM objectives, categories (i.e. governance, environmental, socio-economic) and sub-categories, and the viability and importance rankings. The final document also contained a factsheet for each of the indicators with specific information on existing methodology, data sources, appropriate scales of measurement, viability scores and additional costs. Based on this information, a recommendation for the implementation of each indicator was provided, including the identification of the entity potentially responsible for its measurement. Finally, the document contains a series of general recommendations for implementing the system including the creation of supporting legislation and the formation of an observatory by the Balearic Government's Statistics Institute (IBESTAT). This final document was formally submitted by the Permanent Commission to the Plenary in December 2007, with a proposal to adopt the document as a *Dictamen* of the CES. The Plenary approved the proposal the System of Indicators for ICZM in the Balearic Islands was published as *Dictamen* (Official Opinion) 05/2007 [62]. Since the focus here is on the process that was used to develop the system of indicators and not the actual system itself, more details about measurements and associated methodologies, scales and thresholds are outside the

Table 1
Total number of indicators in importance and viability categories.

Category	High importance	Medium importance	Low importance	Total
High viability	17	3	0	20
Medium viability	10	3	1	14
Low viability	9	9	2	20
Total	36	15	3	54

Table 2
Viability and importance rankings (high (H), medium (M), low (L) of Balearic ICZM Indicators including associated objectives and indicator category (governance (G), socio-economic (SE), environmental (E)).

Indicators	Reference[a]	Objective	Category	Viability	Importance
1. Area of land and sea protected by statutory designations	DEDUCE[b]	Legally protect the maximum area of land and sea in coastal areas from negative human impacts.	G-Legislation	H	H
2. Unemployment	[43]	Maximise employment and qualification of human capital.	SE-Employment and human capital	H	H
3. Occupation of tourism accommodation supply		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	H	H
4. Evolution of tourism demand		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	H	H
5. Consumption of water	[43]	Decrease anthropogenic pressure on natural resources and maintain sustainable levels of use.	SE-Use of natural resources	H	H
6. Consumption of electricity	[43]	Decrease anthropogenic pressure on natural resources and maintain sustainable levels of use.	SE-Use of natural resources	H	H
7. Fishing	[43]	Decrease anthropogenic pressure on natural resources and maintain sustainable levels of use.	SE-Use of natural resources	H	H
8. Density of resident population	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
9. Seasonality of population	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
10. Immigration	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
11. Construction of homes	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
12. Water treatment	[43]	Minimise pollution in marine and coastal environments.	SE-Pollution	H	H
13. Number of moorings	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
14. Existence and use of roads and social infrastructures		Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	H	H
15. Quality of beaches	[43]	Maintain the environmental quality of beaches.	E-Beach Quality	H	H
16. Quality of tourism accommodation supply	[43]	Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	H	H
17. Cost of tourism accommodation supply	[43]	Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	H	H
18. Existence and level of activity of organisations supporting ICZM	[3]	Establish a network of organisations at all levels of governance to support and facilitate the implementation of ICZM.	G-Organizations	M	H

Table 2 (*continued*)

Indicators	Reference[a]	Objective	Category	Viability	Importance
19. Existence and adequacy of legislation facilitating ICZM	[3]	Develop, incorporate and implement legislation and rulings in the mandates of organisations involved in ICZM.	G-Legislation	M	H
20. Existence and functioning of a representative coordination mechanism to resolve conflicts in ICZM	[3]	Guarantee effective communication and coordination amongst bodies related to ICZM and different political levels and ensure the participation of actors from all levels in the ICZM process.	G-Integration	M	H
21. Patterns of sectoral employment	DEDUCE	Maximise employment and qualification of human capital.	SE-Employment and human capital	M	H
22. Evolution of tourism accommodation supply	[43]	Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	M	H
23. Production of urban solid waste	[43]	Minimise pollution in marine and coastal environments.	SE-Pollution	M	H
24. Rate of development of previously undeveloped land	DEDUCE	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	M	H
25. Area of artificial coast	[43]	Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	M	H
26. Quantity of social services		Maintain a good coverage of social services.	SE-Social Cohesion	M	H
27. Negative social effects of seasonality		Minimise the social effects of seasonality.	SE-Social Cohesion	M	H
28. Efforts to minimise environmental impact in coastal areas	[3]	Aid the ICZM process with scientific information derived from the assessment of the environmental impact of proposed activities on coastal areas.	G-Implementation	L	H
29. Existence of mechanisms for the routine control, assessment and adjustment of ICZM initiatives	[3]	Apply adaptive management to ICZM initiatives to improve and readjust efforts.	G-Implementation	L	H
30. Sufficient availability and adequate distribution of human, financial and technical resources for ICZM	[3]	Guarantee the sustainability of ICZM initiatives through the maintenance of a sufficient flow of human, financial and technical resources.	G-Implementation	L	H
31. Existence, dissemination and application of research and information related to ICZM	[3]	Disseminate relevant information related to ICZM to inform the public and actors involved in coastal areas.	G-Implementation	L	H
32. Values (not market) of sea and coastal economy		Maintain a healthy, sustainable and productive economy on the coast.	SE – Economy	L	H
33. Indicator of residential tourism		Achieve sustainable levels of tourism in coastal areas.	SE – Tourism	L	H
34. Indicators associated with the European Union Water Framework Directive	2000/60/EC.	Maintain, monitor and where necessary recover the healthy state of aquatic ecosystems.	E-Quality of Aquatic ecosystems	L	H
35. Biological diversity	[3]	Conserve the structure, biodiversity and natural resilience of the ecosystem.	E-Biodiversity	L	H
36. Evolution of complementary tourism supply		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	L	H
37. Existence of cleaning routines for beaches and coastal waters		Minimise pollution in marine and coastal environments.	SE-Pollution	H	M
38. Regeneration of the coastline	[43]	Minimise the cost of coastal erosion.	SE-Population, construction and development along the coast	H	M
39. Indicator of public expenditure related to tourism		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	H	M
40. Economic production by sector	[3]	Maintain a healthy, sustainable and productive economy on the coast	SE-Economy	M	M
41. Direct investment in coastal areas	[3]	Maintain a healthy, sustainable and productive economy on the coast.	SE-Economy		
42. Housing prices		Facilitate access to housing	SE – Social cohesion		
43. Resident perceptions of tourism		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	L	M
44. Density of beach users		Minimise the negative effects of population, construction and development on the coast.	SE-Population, construction and development along the coast	L	M
45. Index of physical integrity	DRAFT Spanish Coastal Directive Plan	Maintain the physical integrity of beaches, dunes and cliffs.	E-Physical Integrity of the coast	L	M
46. Qualification of human capital		Maximise employment and qualification of human capital.	SE-Employment and human capital	L	M
47. Patterns of tourism demand		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	L	M
48. Natural, human and economic assets at risk	DEDUCE	Minimise the impact of climate change on coastal residents and habitats.	SE-Climate Change	L	M
49. Investment in technology and technological training		Maximise innovation contributing to the sustainability of coastal areas.	SE-Innovation	L	M

Table 2 (*continued*)

Indicators	Reference[a]	Objective	Category	Viability	Importance
50. Indicator of second residences of local population		Achieve sustainable levels of tourism in coastal areas.	SE-Tourism	L	M
51. Density of occupation of housing		Facilitate access to housing.	SE-Social Cohesion	L	M
52. Public employment service		Maximise employment and qualification of human capital	SE-Employment and human capitol	M	L
53. Evolution of GDP	[43]	Maintain a healthy sustainable and productive economy on the coast.	SE-Economy		
54. Corporate Social Responsibility		Encourage Corporate Social Responsibility (CSR).	SE-Social Cohesion	L	L

[a] In many cases, the measurements have been adapted from the original source. Indicators with no reference were proposed directly by IMEDEA/CES. This does not mean they have not been applied elsewhere, it simply means that the associated methods/measurements were decided without using additional references.
[b] DEDUCE (Développement durable des Côtes Européennes) Project. http://www.deduce.eu/; accessed 11/9/09.

scope of this paper. However, the full document containing such information can be accessed online through the CES webpage (http://ces.caib.es).

4. Discussion

The overall structure (i.e. number of indicators, ranking, general sustainability categories) of the Balearic Indicator System is similar to other initiatives that have involved stakeholders in indicator development [47,48,50]. However, at a more detailed scale, these systems differ with respect to the local environment within which they are designed to operate. For example, Fontalvo-Herazo et al. [47] found a proportionately large number of indicators in their socio-cultural category which they attributed to the local reality. Essentially, these differences among indicator systems reflect the fact that there is no universal way to implement ICZM because every situation is different and ICZM is generally implemented at the local level [20,22]. Furthermore, ICZM objectives and associated indicators are all interrelated and often span more than one category (e.g. the extent of land and sea protected areas is a governance indicator but could also me classified as environmental). A concentration of indicators in the socio-economic and governance categories of indicator systems reflect the reality that sustainability problems tend to be generated by human activities, necessitating decision-making that is based on associated indicators. The Balearics are an insular environment, meaning that, as mentioned previously, space and natural resources are particularly scarce. They are also a mature tourism destination, resulting in the fact that coastal sustainability is highly contingent upon sustainable tourism. These local realities are reflected in the resulting indicators and the balance among the different categories.

As highlighted a number of times, a focus on generating a list of indicators with a probable chance of being implemented necessitated some compromises from the scientific perspective. In this context, the following subsections discuss the implementation status of the indicator system and highlight the methodological limitations of the study.

4.1. Implementation status

The *Dictamen* was published as a book in Spanish, English and Catalan at the end of 2008 and presented in an official ‘‘launch’’ which was attended, among others, by the President of the Government of the Balearic Islands, members of all the Insular Councils, the director of IBESTAT and members of the general public. At this meeting, the Government, IBESTAT and the Insular Councils expressed a commitment to following through with the implementation of the system and proposed the initiation of a pilot study on the island of Menorca, which has established experience in implementing indicator systems. In March 2009, members of the original Technical Committee of the project met with the Insular Council of Menorca and IBESTAT to discuss the initiation of the pilot study. This study is underway with the leadership of IBESTAT in collaboration with OceanBit (the research entity responsible for the continuation of the ICZM project, which employs some of the original IMEDEA scientists and CES chief economist from the original Technical Committee), and Menorca's Socio-environmental Observatory (OBSAM). The work so far has been focused on the measurement of the 17 indicators with high viability scores and high levels of importance. The indicators will be presented in two ways. First, in the form of a technical document, intended for practitioners and decision-makers requiring in depth information and analysis. This document will allow the people responsible for implementing the system to pass on their reflections and experiences to those who may be responsible for measuring them in the future. Second, in a more simplistic, visually attractive format for communicating the information to other stakeholders and the general public. This will be available online through the IBESTAT website and, if resources permit, could be published in book format annually.

The ultimate success of this project, which would be the implementation of the indicators system and their influence over decision-making in the Balearic Islands, is still uncertain due to a lack of human and financial resources. To date, the agencies involved have been working on the system voluntarily with no additional technical and financial support. As a result of this, progress has been slow and sustained implementation might not be feasible. Efforts are currently underway at the government level to designate legislative status to the indicator system, thus incorporating it into IBESTAT's legal mandate and annual budget. This will be an important step which reflects McKenna et al.'s conclusion that unless agreements reached through participation become part of statutory management practice, the participation will have been ineffective [22]. Having said this, progress thus far, from scientific project to the *Dictamen* with active support from local government agencies, may be considered a success story of science-policy communication in itself.

As mentioned previously, although other entities were consulted, this project involved a partnership between only two institutions. The fact that the project was funded by the Government of the Balearic Islands implies their involvement as well, but only with respect to their general support of the overall goal of implementing ICZM in the Islands. In order to be deemed truly participatory, additional entities, including the general public, resource users, private sector, and NGOs should have been involved more significantly in the indicator development process. However, once again, this raises the issue of finding a balance between what can be done realistically and what should be done idealistically. The socio-political structure of the Balearic society is such that the chosen approach of working with one representative, legal entity of participatory democracy that has a direct influence on government policy, was considered the most practical approach. Jentoft [2] supports this approach when he stresses that environmental politics, which can be conflicting, but may be converted into cooperation through participatory democracy in ICZM. Participation with too many stakeholders increases the potential for conflict [51] and can be an expensive, inefficient and time consuming process [22]. Involving more entities in the process could have generated political, logistical and bureaucratic obstacles that may have hindered the project from being completed in a reasonable amount of time, if ever. Having said this, it will be important to continually adjust the system to include more stakeholder opinions over time.

As mentioned previously, the level of public participation in this project is best classified by rung 6 of Arnstein's [58] 8 rung ladder of public participation (partnership). The partnership differs from Arnstein's classification in that there are no real "power holders" since neither organization has decision-making power at the political level. However, both have distinctive types of influence over decision-makers. IMEDEA, as a respected academic entity that can help convince the government that the indicators are scientifically viable and CES, with the formal, designated role of providing advice to the government. This partnership is innovative in that it can not be pigeonholed into a classic top-down or bottom-up categorization. Rather, its relevance is more strategic with respect to how it might help science to influence change at the policy level. Such strategic partnerships, between entities that can influence decision-makers but, unlike decision-makers, may have the ability to be more objective in their opinions, could be useful in future indicator development initiatives.

4.2. Methodological limitations

The methodological limitations of this study may be considered as part of the inevitable trade-off between the needs of science and decision-makers mentioned in the introductory section. McCool and Stankey [12, p. 304] write that "the indicator selection process is as much political and value-based as it is scientific, more iterative than linear, less private than public." Had this system responded solely to scientific needs, the emphasis may have been less on practicality and societal needs, and more on developing new methods and generating more data. Instead, a significant proportion of time and resources was dedicated to meetings and discussions, conducting extensive reviews of the literature, and identifying existing data.

There is an element of "scientific risk" involved in this approach in that the resulting list may lend itself to criticism from the scientific community due to its relative simplicity. The system does not incorporate emerging scientific developments such as system dynamics or composite measures. An additional scientific component missing from this work, and many indicator systems, is the identification of thresholds and natural ranges of variability. Where these elements are undeniably valid, at this stage in the process, they could defeat one of the main objectives of this initiative, which is to ensure implementation. Implementation is a step by step process which might never begin if it is too complicated from the outset. Additional research will need to be carried out to incorporate more advanced scientific methods and scientific rigour into the current system but could be counterproductive at this stage. If small steps are taken at first, such as the identification and the measurement of high priority indicators requiring few resources, the process can gain momentum once the entities involved start seeing positive results from their participation. In addition, if decision-makers feel that scientists are taking their opinions into account from the beginning, they may be more amenable to following their advice in the future. Conversely, scientists will have a better idea of the capacity of decision-makers to work with more complex measurements and systems.

5. Conclusions

This article highlights some important questions about the efficiency of science for addressing sustainability problems. Why does science often fail to result in change at the societal level? How can the needs of science and decision-makers be calibrated? Does the structure of the academic system, where the majority of science is generated, limit the applicability of science? In order to maintain prestige and, in many cases, employment, academics are encouraged to advance scientific theory, develop new methodologies and conduct original research. This must be published as articles in peer-reviewed journals which, in the majority of cases are only read, debated and understood by other academics in their field of study. Efforts to step off the "academic band-wagon" and engage in practical or society driven science may go unnoticed, be deemed "weak" and criticized by the more traditional academic community. Essentially, many scientists are not provided with incentives to focus their research on management issues [26]. Fortunately, this reality has not gone unnoticed by the scientific community resulting in an increasing number of academics working in government agencies aimed at generating science-based policy, more initiatives both within and outside academia that focus on stakeholder and public participation, and more interdisciplinary, problem orientated science [24].

Rosenström and Kyllönen [48] reflect that the success of the participatory process depends on what you set out to achieve. The objective of this project was to develop a system of indicators that is scientifically viable and comparable internationally yet relevant to the local scale and to ensure its implementation. Bearing in mind the fact that this represents a first step towards establishing an indicator system for ICZM in the Islands, so far, it may be considered a success. There is no doubt that the partnership and process by which the system was developed, coupled with its relative simplicity have helped to progress the implementation thus far. This is reflected in the support the project received at the governance level and the continued involvement of the original partners. Continuation of the initiative will be contingent upon the commitment (financial and personal) and collaboration of the government, CES and OceanBit. Coordination and communication with other entities will also be necessary for the full implementation of the system in all the Islands meaning that the participatory process will continue to play a critical role in ensuring its long-term success. Sustained commitment after the completion of technical activities is critical to the maintaining implementation of initiatives related to solving sustainability problems, which are constantly evolving.

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