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Selecting environmental indicator for use in strategic environmental assessment

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Abstract

The primary aim of carrying out Strategic Environmental Assessment (SEA) is to provide for a high level of environmental protection and to integrate environmental considerations into the planning process. The SEA Directive (2001/42/EC) recommends monitoring to determine the environmental impact of the implementation of plans and programmes. Environmental indicators are a useful tool by which this impact may be measured. However, careful consideration must be given to developing a set of indicators in order to isolate, plan or programme specific impacts. Here, we demonstrate the effectiveness of a workshop-based approach to develop appropriate criteria for selecting environmental indicator for use in SEA. A multi-disciplinary team was used in the approach which consisted of representatives from each of four environmental fields i.e. biodiversity, water, air and climatic factors, together with SEA experts, planning experts, academics and consultants. The team reviewed various sets of criteria, already in existence, for environmental indicator development but not specifically for SEA indicators. The results of this review together with original criteria were applied to the final list agreed upon. Some of the criteria recommended includes, relevance to plan, ability to prioritise, and ability to identify conflict with other plan or SEA objectives.

Keywords: Environmental indicators; Selection criteria; Environmental receptors; SEA

1. Introduction

The use of environmental indicators at the national, regional, local and field level has become a common assessment tool (Bockstaller and Girardin, 2003). There is a growing need to establish appropriate environmental indicators to allow decision makers to make informed judgements

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regarding policies, programs, plans and projects (Cloquell-Ballester et al., 2006). The European Environment Agency's (2005) definition of an indicator is 'a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time. An indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. An indicator is a sign or symptom that makes something known with a reasonable degree of certainty and reveals, gives evidence, and its significance extends beyond what is actually measured to a larger phenomenon of interest.' In other words, indicators are measurable aspects of a project/environment/society that can be used to monitor its progress or direction (www.stats.govt.nz/products-and-services/user-guides/indicator-guidelines). The US Environmental Protection Agency together with the US Geological Survey define an *environmental* indicator to be 'a measurable feature or features that provide managerial and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality'. Consequently, environmental indicators should be measurable, scientifically valid and capable of providing information for management decision-making. In Strategic Environmental Assessment (SEA) environmental indicators may be used to demonstrate the changes in environmental quality resulting from the implementation of plans and programmes. Indicators must provide appropriate information to enable the objectives and targets, of the SEA, to be addressed. In addition, Cloquell-Ballester et al. (2006) suggest that indicators should be validated and accepted beforehand by participants and stakeholders of any impact assessment process. Therefore, it is useful to establish a set of criteria that can be used to select environmental indicators for use in SEA.

A key function of an indicator is to reduce the volume and complexity of information which is required by decision makers. For example, air or water quality indices are generally used as a measure of pollution; they usually imply that the better the air or water quality the less pollution. However, behind these indices are complex data on concentrations of chemicals or particulate matter in the receiving body. In order to make decisions, the decision maker needs to know if the air quality is a threat to human health or agricultural crops or if water is fit to bathe in, drinkable or can sustain a sensitive fish community. It is not necessary for the decision maker to know the detail behind these indices but it is the job of the indicator to relay this complex information in an accurate and understandable manner in order for informed decisions to be taken.

Many sets of indicators exist that have been developed to address specific environmental issues. Some of these include the OECD core set of environmental indicators (OECD, 2004) which consists of about 50 indicators covering issues that reflect the main environmental concerns in OECD countries. These indicators, and many others, are classified using the Pressure-State-Response (PSR) model composed of indicators of environmental pressures (direct and indirect), environmental condition (state) and society's response. In addition, the OECD provide a list of key environmental indicators which is a reduced set of their core indicators that serve communication purposes to inform the general public and provide key signals to policy-makers (OECD, 2004). Furthermore, the European Environment Agency (EEA) have also developed a core set of environmental indicators, 37 in total, which have been developed to provide a manageable and stable basis for indicator based reporting by the EEA, to prioritise improvements in the quality and geographical coverage of data flows and to streamline EEA contributions to other European and global indicator initiatives, such as, EU structural indicators and OECD environmental indicators (EEA, 2005). There is of course substantial overlap between these sets of indicators and each set has slightly different criteria associated with it or it may cover a different geographical area such as worldwide (OECD) or European (EEA), nevertheless all sets are deemed necessary.

As described above, of the similarities between the OECD and the EEA core sets of indicators, it is rarely possible to take one set of indicators and use it for another purpose. The reason for this is in the slight differences in the criteria used to establish the lists, which may point to subtle differences in the function of the indicator set. The OECD and EEA indicators could be used in SEA if the assessment was to be carried out on an OECD-wide or European scale. However, to date most are carried out at a more local level and therefore these sets of indicators are inapplicable. However, they do provide ideas of what type of environmental indicators may be available and where the data may be obtained. Table 1 presents examples of sets of criteria used to develop lists of indicators for (i) the EEA core set of environmental indicators, (ii) climate change indicators for Ireland, (iii) biodiversity and (iv) environmental assessment. It is clear that there are many similarities between these sets for example all include 'scientifically valid', 'show trends' and 'understandable' as key criteria. Furthermore, Bockstaller and Girardin (2003) suggest that in order for an environmental indicator to be considered valid it should be scientifically designed, provide relevant information and be useful to the end user.

Donnelly et al. (2006a) reviewed several sets of indicators, available in Ireland, which have been used to determine the environmental impact of the transport sector, the impact of climate change on the environment and key environmental indicators used for reporting the state of the environment. The authors concluded that whereas these documents provided a valuable source of indicators they did not cover all sectors or all environmental receptors required under the SEA Directive, principally because the criteria did not fit SEA purposes. Therefore, it may not always be feasible and straightforward to simply transfer currently available processed data to SEA. This provides evidence for the need to develop environmental indicators specifically for the SEA process which should be accompanied by an associated set of criteria to ensure the indicators are fit for the purpose for which they are intended. The environmental indicators developed should be accompanied by a rigorous validation process such as, the 3S validation methodology, proposed by Cloquell-Ballester et al. (2006). In this method, 3 forms of validation are carried out i.e. self-validation, scientific validation and social validation. The indicators that were ultimately chosen in Donnelly et al. (2006a) were validated by the workshop team i.e. self validation, to ensure appropriateness to the issues in question. Scientific validation was ensured through adoption of previously used indicators and expert judgement. Finally, social validation was ensured by the participation of the many stakeholders which ensured the information being relayed was understandable.

Because of the multifunctional nature of environmental indicators their development and selection has become a relatively complex process (Kurtz et al., 2001). They are expected to reflect a variety of environmental issues, tract or predict change, identify stressors or stressed systems and influence management decisions. This paper is intended to help select successful environmental indicators for use in SEA. The aims of this work are to (i) review criteria for environmental indicator selection already in existence and to determine their transferability to the SEA process, (ii) provide a set of criteria for environmental indicator selection specifically for the SEA process and finally, (iii) present a methodology for evaluating the chosen indicators against the criteria. The result will help optimise the number of environmental indicators required in SEA and focus the baseline data gathering process and the subsequent monitoring of the environment. A workshop-based approach to develop and evaluate the criteria is described.

2. Methodology

2.1. Workshop team

A multi-disciplinary team was used in a workshop-based approach to develop suitable criteria for SEA indicator selection. This method was adopted following the success of a previous

Table 1
Comparison of different sets of criteria used in developing indicators

EEA core set of indicators [a]	Biodiversity [b]	Climate change [c]	Environmental assessment indicators [d]
Policy relevance	Policy relevant and meaningful	Be representative of environmental condition	Be representative
Support EU policies' priority issues	Provide information at policy level		
Progress towards targets	Biodiversity relevant	Show trends over time and be easily interpreted	Be scientifically valid
Quantitative and qualitative targets	Key priorities of biodiversity		
Available and routinely collected data	Scientifically sound	Be responsive to change	Be simple and easy to interpret
Updating of data regularly	Well defined, verifiable, scientific data		
Spatial and temporal coverage	Broad acceptance	Be comparable internationally	Show trends over time
Even coverage and time trends	Include many stakeholders in development		
National scale and representative of data	Affordable monitoring	Be national in scope or applicable to regional environmental issues	Give early warning about irreversible trends where possible
Enables benchmarking	Part of established monitoring system		
Understandability of indicators	Affordable modelling	Have a reference value against which comparisons can be made	Be sensitive to the changes in the environment/economy it is meant to indicate
Clear definitions and presentation	Cause–effect relationships		
Methodologically well founded	Sensitive	Be well founded in technical and scientific terms	Be based on readily available data or be available at a reasonable cost
Appropriate scientific referencing	Sensitive to change to show trends		
EU priority policy issues	Representative of pressure	Be based on international standards	Be based on data adequately documented and of known quality
Ensures indicators prioritise for policy	State and response		
	Small number	Be linked to forecasting and information models	Be capable of being updated at regular intervals
	A small number of indicators is more understandable to the public		
	Aggregation and flexibility	Be high quality, well documented and updated regularly	
	Facilitate aggregation at a range of scales	Be readily available at a reasonable cost	

workshop used to develop a methodology for indicator selection for use in SEA (Donnelly et al., 2006a,b). It was decided, for this workshop, to have a greater input from SEA practitioners — in particular planners from local authorities as the majority of SEAs conducted in Ireland to date have been for local area plans. The team (Table 2) consisted of representatives from each of four environmental fields i.e. biodiversity, water, air and climatic factors, together with SEA experts and practitioners, planning experts, academics, representatives from local authorities, various environmental agencies and consultants in the environmental field.

It was felt that the environment agencies and services would provide information on what was required from an SEA as these are the groups involved in providing advice and guidance to the SEA practitioners. Whereas the contribution made by the planners from the local authorities and the environmental consultants was in the form of practical experience of what was and was not feasible on the ground. The academics provided expertise on the development of indicators and the various environmental receptors. In addition, they provided guidance on the feasibility of the indicators chosen and whether or not there was supporting data available. Finally, the representatives form the European Environment Agency and the EU COST Action had previous experience in developing indicators for environmental reporting (EEA) and SEA indicators for the transport sector (COST). A key outcome from a similar workshop was that development of indicators benefited from the involvement of as many stakeholders as possible, data providers and groups with similar interests (Donnelly et al., 2006a).

A total of 28 delegates participated in the workshop. There were 8 jurisdictions represented at the workshop i.e. Ireland, Scotland, England, Wales, Northern Ireland, Italy, Denmark and France. The team reviewed sets of criteria (Table 1), already in existence, to determine whether or not they could be used for environmental indicator selection for SEA even though they were not specifically designed for this purpose. The reason for choosing the particular criteria presented in Table 1 was because they were (a) specific to a particular theme of the workshop, (b) already established and used in environmental assessment or (c) previously employed in the development of general environmental indicators.

2.2. Workshop format

The workshop (http://coe.epa.ie/SEA/) was held over 2 days. The morning sessions consisted of oral presentations from agencies such as the Environment Agency, UK, the Scottish Environment Protection Agency and the Irish Environmental Protection Agency on various aspects of indicator use and misuse with emphasis on SEA. In addition, there were presentations dealing with data issues for indicators and specific case studies on landscape indicators, biodiversity indicators and SEA indicators used in a docklands area in Dublin. Finally, the use of SEA indicators in the transport sector was presented.

Notes to Table 1:

Coloe (2000) and Lehane et al. (2002) do not have an established methodology for selecting criteria for indicator choice. Rather they are based on sets of indicators that were already established for other purposes.

[a] Source: EEA core set of indicators (2005).

[b] Source: Convention on Biological Diversity (2003).

[c] Source: Sweeney et al. (2002).

[d] Source: European Commission (1998) A handbook on environmental assessment of regional development plans and EU structural funds programmes.

Following the presentations on each day, the delegates were divided into 4 Working Groups (WGs) pertaining to 4 environmental receptors, as follows; biodiversity, water, air and climatic factors. Each WG worked on developing criteria for SEA indicators that they had developed in a previous workshop (Donnelly et al., 2006a). Each WG had a chairperson and a rapporteur to report back at regular intervals for discussion with all participants on any issues or concerns raised. Each WG was provided with 4 lists of currently available criteria (EEA core set of indicators, climate change, biodiversity, and environmental assessment indicators) (Table 1) for indicator selection as a starting point for developing criteria specifically for selecting SEA indicators. In addition, the participants were asked to consider the following list of questions when developing their criteria;

How important is the indicator for the environment?
How relevant to the problem is the indicator and how well will it describe the trends from year to year?
How much effort and money must be used to retrieve the data?
How big is the uncertainty of the calculations?
How good is the indicator to provide a basis for actions and plans?
How well will the indicator perform to provide a basis for comparison across time and between different geographical areas?

There were 3 practical workshop sessions. The first session required each WG to review objectives, targets and indicators for a national, regional and local plan, that they had developed in a previous workshop. While doing this, the participants were requested to take note of the criteria they used in choosing these parameters and to record if there were different criteria required for different plan levels. The aim of this task was to identify any indicators that were unclear and/or unnecessary and to establish whether or not any new indicators should be added to the previously recorded list.

Table 2
List of organisations and groups represented in each Working Group at the Workshop

Biodiversity	Water
Countryside Council of Wales	Environmental Protection Agency (Ireland)
National Parks and Wildlife Service (Ireland)	Northern Ireland Loughs Authority
Academic representatives specialising in biodiversity	Academic representatives specialising in either surface water or planning
Environment Agency, UK	Consultant with experience in impact assessment
Consultant with experience in biodiversity	Dublin Docklands Development Authority
	Department of the Marine
	Local authority
Climatic factors	**Air**
Environmental Protection Agency (Ireland)	Environmental Protection Agency (Ireland)
Environment and Heritage Service, Northern Ireland	Environment and Heritage Service, Northern Ireland
Academic representatives specialising in either climate change or SEA	Academic representatives specialising in air quality
Consultant with experience in impact assessment	Environment Agency, UK.
Scottish Environment Protection Agency	European Environment Agency
Representative form European COST Action	Local authority
Local authority	

Overall, the choice and range of indicators made was considered suitable to determine the environmental impact of the plans in question. Some slight adjustments and refinements were made, in particular to the wording of targets and indicators, which emphasised the need to revisit these parameters throughout the duration of the plan as more knowledge and experience is gained and more data becomes available. Some issues were raised in relation to availability of baseline data at a local level and how to deal with and take account of cumulative impacts.

The second session, required the WG's to establish the criteria for their particular environmental receptor with which the SEA indicators would ideally be selected. In addition, the participants were requested to identify potential data sets to support the indicators and also to identify data gaps. There were group discussions following sessions 1 and 2 to explore difficulties and challenges before moving to the subsequent session. These discussions provided a forum for opposing views to be aired and a compromise to be reached in a democratic fashion. The main conflict of interest arose between the planners and the environmental scientists or protectors of the environment (Prendergast and Donnelly, 2006). The planners saw development as the priority whereas the environmental protectors viewed protection of the environment as the key concern. Therefore, a consensus was reached before moving on to the final session.

It was decided to use a "face to face" technique for decision making as opposed to other multicriteria decision systems such as internet based Delphi panels. The reasons for this were: (a) because in our opinion it is a better way to communicate and explain detailed ideas and opinions, (b) it is a good forum for interactive discussion and allows trains of thought to be continuous rather than stopping and starting as with other forms of communication such as the internet and (c) having all stakeholders in the one place also allowed for people to openly discuss issues with individuals over coffee or at breaks. In addition everyone can hear what others are saying as it is being relayed and were encouraged to participate in the debate and this may spark new questions and ideas. Overall, the authors preferred this approach and did not see the need for anonymity. The Delphi technique is certainly one way of reaching consensus but is not always suited to the task at stake. This was an interactive process.

Finally, in the third session all participants of the WGs gathered for a group discussion to synthesise the 4 sets of criteria (water, air, biodiversity and climatic factors) developed by the individual WGs culminating in a final list agreed upon by the entire group (Table 3).

Table 3
List of criteria for SEA indicator selection

Criteria	Brief description
Policy relevant	Consistent with significant legislation already in existence.
Cover a range of environmental receptors	The data gathered should provide information that extends beyond that which is being measured.
Relevant to the plan	Plan specific environmental impacts should be detectable.
Shows trends	Responsive to change, measurable, capable of being updated regularly, demonstrates progress towards a target.
Understandable	Ability to communicate information to a level appropriate for making policy decisions and to the general public.
Well founded in technical and scientific terms	Data should be supported by sound collection methodologies, clearly defined, easily reproduced, and cost effective.
Prioritise key issues and provide early warning	Identifies areas most at risk of damage. Provide early warning of potential problems before it is too late.
Adaptable	Emphasis can change at different stages of the plan.
Identify conflict	With plan objectives in order that alternatives may be explored.

3. Criteria for indicator selection

Each WG established a set of criteria for the indicators developed for their particular environmental receptor and a synthesis of these 4 sets was prepared. Table 3 presents the final list of criteria for SEA indicator selection agreed upon at the workshop. Continuing evaluation of the indicators against these criteria will be an important basis for future quality assurance of the set. These criteria may also be used in future to decide whether new indicators should be added to the list or existing ones deleted. The following is the list of criteria decided upon at the workshop to help identify appropriate environmental indicators to ensure a rigorous and robust SEA.

1. Be policy relevant
   This criterion ensures the indicator is consistent with significant environmental policy goals/ standards/commitments already in existence at different levels of planning. For example, indicators pertaining to objectives and targets set out in legislation such as the Convention on Biodiversity (CBD) on a global scale, the Water Framework Directive (WFD) on a European scale, Biodiversity Action Plans (BAPs) on a local scale and various other national and local standards should, as far as possible, be incorporated into the SEA objectives, targets and indicators. The indicator(s) chosen should inform decision making to allow action to occur and where appropriate should provide opportunities for policy change.
2. Cover a range of environmental receptors
   The indicator should be broadly applicable to different stressors and situations. In this instance an indicator should respond to a broad range of environmental conditions related to the impact being evaluated on an appropriate time frame and geographic scale. Where possible, the indicator should be reflective of a wider system, for example, the presence or absence of key invertebrate species in waterways gives an indication of the quality of the water and the biodiversity of the system. Therefore, by gathering data for a particular issue the significance of the information collected extends beyond what is actually measured to a larger phenomenon of interest. This will obviously help reduce costs and duplication of effort while at the same time ensure maximum use of resources.
3. Be relevant to the plan in question
   The indicator should be relevant to the plan, i.e. responds to changes imposed by the plan in question. It is important to be able to isolate the impact of the proposed plan on the indicator from external and non-related impacts. For example, it would be pointless to use 'greenhouse gas concentrations in the atmosphere' or 'the number of vehicles on a particular stretch of roadway' as environmental indicators of a development plan if it was not possible to isolate the contribution of the plan to these indicators.
4. Show trends
   This criterion ensures the data for the indicator has been collected over a sufficient period of time to allow trends to be detected and analysed. The indicator should be responsive to change (small changes in the indicator should show measurable results) and measurable (should be quantified simply using standard methodology with a known degree of performance and precision). In addition, it should be capable of being updated regularly (ideally be part of an existing monitoring network, there should be minimal time lag between collecting and reporting of data, to ensure that indicators are reporting current trends) and should demonstrate progress towards a target (for example, it should be obvious that 'up' is desirable and 'down' is not). The indicator should also show trends on an appropriate geographic and temporal scale consistent with the objective and should be reproducible, within defined and acceptable limits

for data collection over time and space. The indicator should be able to discriminate meaningful differences in environmental condition with a high degree of resolution and should ideally respond quickly and noticeably to the impact being evaluated in order for trends to be determined.

5. Be easily understandable to decision makers and the public
The indicator should have the ability to convey information to a level appropriate for making policy decisions and to the general public. For example, a water quality index may be composed of several chemical and biological parameters, but what is important to the decision-maker or the general public is whether the water in question is suitable for drinking or bathing or whether or not it can sustain a population of fish. It is not necessary for them to know the technical detail behind the indicator but whether the quality is good or bad and whether the trend is improving or getting worse over time. This is important to enable informed decisions to be made. The indicator should be simple and clear, and sufficiently non-technical to be understandable with brief explanation. It should also lend itself to effective display and presentation. Documentation should be available on how the indicator was constructed to enable greater understanding of the meaning of the indicator. Interpretative notes should be provided for all indicators.
6. Be well founded in technical and scientific terms
The data supporting the indicators should be adequately backed up by sound collection methodologies, data management systems and quality assurance procedures to ensure the indicator is accurately represented. The data should be clearly defined, verifiable, scientifically acceptable and easy to reproduce. Scientific validity ensures data can be compared with reference conditions or other sites. In addition to being scientifically valid the indicators application should be practical (cost effective and not technically complex). Interpretation of measurements should accurately distinguish between natural variability and anthropogenically driven impacts. Practical issues that require consideration include monitoring costs, availability of experienced personnel, the practical application of the technology and the environmental impact of the monitoring system used. In order to be cost effective a large amount of information should be supplied in comparison to cost and effort which may be related to the availability of experienced personnel.
7. Prioritise key issues and provide early warning
Indicators are useful tools for prioritising which environmental information is most useful to inform decision making. Tracking the progress of a suite of environmental indicators should highlight the areas at greatest risk of damage, thereby identifying priority issues that may require a greater amount of attention, where there is an important emerging issue, indicators should be developed to monitor that issue. For example, a regional forestry plan may have a significant detrimental impact on soils (due to the use of heavy machinery at planting and logging) and surface waters (due to lowering of the water-table and excess suspended solids in runoff during certain operations). But there may be no significant adverse effect on human health or climate. Therefore, a greater amount of resources should be put into finding and monitoring suitable indicators for soil and water, than on other environmental receptors, to demonstrate these impacts. In addition, indicators can provide an early warning of potential problems, such as a change in environmental condition, for example, a decrease in water quality due to increased development may indicate that a higher level of wastewater treatment is needed. Providing an early warning mechanism allows time for action to be taken before irreparable damage occurs.
8. Be adaptable
Even monitoring requires monitoring. The initial list of indicators decided upon should be monitored to ensure it is measuring what it is intended to measure or achieving what it is

intended to achieve. At different stages of a plan the same indicator may be paramount or may become redundant, for example, air quality in the sense of dust particles (PM_{10}) may be a very important measure of environmental impact during the construction of a roads programme but when this phase is finished traffic emissions may take over as the most important contributor of emissions to air. Therefore, the list of indicators need to be updated to reflect this change indicating the iterative nature of the process (Kurtz et al., 2001).

9. Identify conflict between plan objectives and SEA objectives
   There will inevitably be some conflict between development and environmental protection unless the plan in question is a conservation plan such as a biodiversity action plan. Environmental indicators in the SEA process should be able to identify this conflict at an early stage in order that a compromise may be reached before it is too late. For example, if a proposed transport plan is going to impact negatively on an area designated for conservation by creating a road, an indicator could be developed that allows a certain amount of land to be used that would not significantly impact on the designated area. However, if the plan would breech this threshold an alternative route would have to be considered. In this instance the environmental indicator would suggest that the plan objective would have to be amended to avoid significant damage to the designated site and alternatives [to or within plan objective] be explored.

These criteria were established to ensure the environmental indicators would meet the needs of SEA. In addition, by standardising the selection criteria the indicator selection process should be more streamlined, costs should be reduced, duplication of effort should be minimised and consistency ensured, thereby increasing the potential for cross SEA comparison (ITFM, 1994).

3.1. Evaluation of indicators against criteria

In order to evaluate the SEA indicators, developed by each WG, against the established criteria a matrix format can be employed. The environmental indicators are listed on the vertical axis and the criteria on the horizontal axis. Table 4 presents 2 examples of potential environmental indicators of biodiversity, air, water and climatic factors, derived during the workshop. These are subdivided into examples of a general indicator, which may be used across different levels of plans and a specific indicator, which was developed at the workshop for a specific plan. Information is recorded in the cells relating to each indicator and each criterion. This allows the practitioner to evaluate, at a glance, which criteria are covered by particular indicators thus enabling any gaps to be quickly identified. If an indicator fails to meet the majority of the criteria it may be discarded but only after some consideration to identify why the indicator was chosen in the first place. For example, an indicator may only meet the criterion ‘relevant to the plan’ and depending on the importance of the indicator (to the SEA) this may be enough to ensure its continued inclusion in the list. Some indicators, such as ‘insurance claims due to flooding’ does not satisfy the majority of the criteria but is extremely important in relation to climate change which is predicted to cause increased frequency of extreme weather events such as flooding. Therefore, information on insurance claims due to flooding is important especially if a proposed plan includes development close to an existing floodplain. These examples highlight the importance of local knowledge of the plan in evaluating environmental indicators.

In order to reduce the amount of information required in the matrix each criterion is designated a set of abbreviations which must be clearly defined in the legend of the table. These

Table 4
Indicators vs. criteria matrix with examples from biodiversity, air, water and climatic factors

Indicator		Policy relevant	Range of environmental receptors	Relevant to the plan	Show trends	Understandable	Well founded	Provide early warning	Adaptable	Identify potential conflict
1	Biodiversity Number of sites with habitat enhancement (G)	Y	Y	Y	L; R; N; TN; ST; LT	E; D	Y; A	Y	Y	Y
2	Number of incidences of fly-tipping and illegal dumping per capita (S)	Y	Y	Y	L; R; N; TN; ST; LT	E; D	Y; NA	Y	Y	Y
3	Air Number of exceedences of air quality limits (G)	Y	Y	Y	L; R; N; TA; ST; LT	E; D	Y; A	Y	Y	Y
4	% of new dwellings with natural gas/renewables (S)	Y	Y	Y	L; TN; ST; LT	E; D	Y; A	N	Y	Y
5	Water Minimise culverting of watercourses (G)	Y	Y	Y	L; LT; TN;	E; D	Y; A	Y	Y	Y
6	All river stretches above Q3 must be maintained and river stretches at Q1 and 2 must reach at least Q3 within the period of the plan (S)	Y	Y	Y	L; LT; TA	E; D	Y; A	N	Y	Y
7	Climatic factors Insurance claims due to flooding (G)	N	N	Y	L; TN; ST; LT	E; D	Y; A	N	Y	N
8	% dwellings constructed from different materials in 2015 and 2020 (S)	Y	Y	Y	L; TN; ST; LT	E; D	Y; A	N	Y	N

(G) = general indicator; (S) = specific indicator. Policy relevant: Y = yes; N = no. Range of environmental receptors: Y = yes; N = no. Relevant to the plan: Y = yes; N = no. Show trends: ST = short term effect; LT = long term effect; L = local; R = regional; N = national; TA = has target(s) associated with it; TN = does not have associated target(s). Understandable: E = easily understandable: D = easy to display. Well founded in technical and scientific terms: Y = data and underlying methodology is quality assured; N = data and underlying methodology is not quality: A = data available at reasonable cost; NA = data not available at reasonable cost. Provide early warning: Y = yes; N = no: Adaptable: Y = yes; N = no. Identify potential conflict: Y = yes; N = no.

abbreviations should be adapted to suit each set of SEA indicators for a particular plan or programme, for example, if a national transport plan is being developed it may be more useful to examine traffic trends on a daily or weekly basis than on an annual basis. The matrix should be kept as simple as possible while still remaining useful, the level of detail will depend on the type of SEA in question. The list below gives examples of potential abbreviations which could be tailored to a particular plan or programme.

1. Policy relevant: Y = yes; N = no.
2. Range of environmental receptors: Y = yes; N = no.
3. Relevant to the plan: Y = yes; N = no.
4. Show trends: S = short term effect; L = long term effect; C = continuous; W = weekly; 2W = every 2 weeks; M = monthly; 6M = 6 monthly; A = annually; 2A = every 2 years; 3A, 4A etc.; L = local; R = regional; N = national; TA = has target(s) associated with it; TN = does not have associated target(s).
5. Understandable: E = easily understandable: D = easy to display.
6. Well founded in technical and scientific terms: Y = data and underlying methodology is quality assured; N = data and underlying methodology is not quality; A = data Available at reasonable Cost; NA = data not available at reasonable cost.
7. Prioritise key issues: Y = yes = can potentially provide an early warning; N = no = cannot potentially provide an early warning;
8. Adaptable: Y = yes; N = no.
9. Identify conflict: Y = yes; N = no.

Examples of one general and one specific indicator for each environmental receptor are presented in Table 4.

Most of the indicators were found to be policy relevant, cover a range of environmental receptors, were relevant to the plan, understandable, were well founded, adaptable and could identify potential conflict with plan objectives. The degree to which they showed trends and provided an early warning mechanism varied which reflected the different level of plan used in the exercise.

4. Discussion and conclusions

There remains little published material on the successful use of environmental indicators in SEA which partly reflects the challenges surrounding identifying suitable indicators and the lack of long term established SEA monitoring programmes to date. Therefore, much of the work on environmental indicators, for SEA, remains in the theoretical stage. The major output from this workshop was the final list of criteria arrived at for selecting environmental indicators for use in the SEA process. This is an important development in the whole area of environmental indicators as they are crucial for the monitoring stage of SEA, an area which is only currently evolving but an area of great importance as it will ultimately demonstrate the impact of the proposed plan on the environment. The need for a list of criteria arose following the development of a methodology (Donnelly et al., 2006b) designed to help SEA practitioners decide upon a set of environmental indicators for a proposed plan. The next step was to refine this potential list of indicators to a more focused, practical and useable set through the application of a set of selection criteria. However, it is the end user who will ultimately decide if the environmental indicator is acceptable helped by the criteria and based on the objectives of the SEA (Kurtz et al., 2001).

The multidisciplinary nature of the participants in the workshop ensured as many stakeholders as possible were involved in the criteria development process allowing a broad base from which expertise could be drawn and differing viewpoints to be incorporated. It also ensured validation of the indicators by consensus of experts and end users which is a minimum requirement recommended for indicator validation (Bockstaller and Girardin, 2003). The value of having participants with a planning background and others with an environmental background on the same team was highlighted. It was generally felt that this was desirable in most aspects of SEA given the fact that the SEA and planning processes should be carried out in tandem. In addition, where difference of opinions arose consensus was reached quickly.

Having examined various sets of criteria used to develop environmental indicators for different end uses it was considered that unless the indicators meet these criteria they would be unlikely to fulfil their prime functions of measuring the impact on the environment. The criteria chosen should help the user to decide whether new indicators need to be added to the list or existing ones deleted (EEA, 2005). However, Noss (1990) stated, in relation to biodiversity indicators, that no single indicator will possess all of the desirable criteria therefore a set of complementary indictors is required. This is true for all sets of indicators and in order to reduce the number of potential indicators to a more useable list and thus ensure that the most pertinent environmental issues for SEA are properly addressed, it is important to set criteria before a final list of indicators is agreed upon.

In general, it was considered that all the criteria established were necessary but there was some confusion over the meaning of some of the wording initially used, such as ‘flexible’, ‘covers a range of issues’ and ‘limits conflict’ so clearer definitions were established. In light of this, ‘flexible’ was changed to ‘adaptable’, ‘covers a range of issues’ was changed to ‘covers a range of environmental receptors’ and ‘limits conflict’ was changed to ‘identify potential conflict’. Cumulative or combination effects need to be examined in the criteria. This could also help establish possible links between a particular plan and other plans and programmes with potential impacts — negative or positive.

Evaluating a set of indicators against the chosen criteria proved useful to (i) ensure all selection criteria were addressed by at least some of the indicators, (ii) identify indicators that could not be supported by available data and (iii) highlight indicators that were irrelevant. In practice, this will result in an optimum set of environmental indicators for a particular SEA which will lead to an efficient monitoring programme, reduced costs and maximised use of resources.

4.1. Conclusions

(i) It was not possible to use a set of criteria already in existence to select environmental indicators for SEA purposes.
(ii) The multidisciplinary approach adopted facilitated the views of as many stakeholders as possible to contribute to the development of the criteria. This in turn ensured less bias in the decision making process.
(iii) It is important to set criteria before a final list of indicators is agreed upon to ensure the most pertinent environmental issues for SEA are properly addressed.
(iv) The result will help optimise the number of environmental indicators required in SEA and focus the baseline data gathering process and the subsequent monitoring of the environment.

(v) It was felt that all criteria were necessary but that clear definitions should accompany each.
(vi) Evaluating the indicators against the criteria using a matrix format proved useful to ensure all criteria were accounted for in the list of indicators.
(vii) The final set of criteria was based on criteria widely used elsewhere, both nationally and internationally, while at the same time accommodating SEA needs and requirements.

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