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IMPERIA working paper

IMPACT SIGNIFICANCE DETERMINATION IN ENVIRONMENTAL IMPACT ASSESSMENT – LITERATURE REVIEW

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Improving environmental assessment by adopting good practices and tools of multi-criteria decision analysis

LIFE 11ENV/FI/905

Content

1 Introduction

Impact significance determination (ISD) is one of the most important tasks in EIA activity.
The aim of this study is to analyse scientific papers dealing with impact significance and to find answers to following questions

- what does significant impact mean or when the impact is significant?
- what kind of criteria have been developed to ISD?
- what kind of procedures and methods have been suggested for ISD?
- how impact significance can be linked to EIA?
- what are future research needs?

This study is part of the EU funded IMPERIA project (LIFE 11 ENV FI/905) which aims to develop better practices and tools for EIA and SEA projects.

NOTE! This paper is not a scientific paper. The paper is compiled mainly for the internal use of the IMPERIA project in order to get a better overall understanding about the issue of impact significance determination. Most of the texts are directly copied and pasted from the referred articles.

2 Material

The literature search was executed in the Web of Knowledge and the ProQuest databases with command lines. At first, the search gave hundreds of results, but narrowing down the headwords the results became more accurate. Finally, the main headwords were significance determination, significance evaluation, impact, criteria, threshold, guidance and environmental impact assessment. Time period in the analysis was from 1994.

In total 320 articles were found from the ProQuest and 349 articles from the Web of Knowledge with the final command lines. Some of the articles were found from both databases. First, ca. 30 abstracts from the most interesting articles based on the title were reviewed. Second articles, whose abstracts fitted the aim of the literature review the best, were chosen to more detailed analysis. Third, a summary table was made about all the chosen articles (Literature). Also some older interesting articles were identified from the references of the articles. We also made some searches in Google and Google Scholar to ensure that we would also find more practical non-scientific papers and non-published reports but still relevant for our purposes.

Ca. 30 articles which were read and referred were related to 1) general theory, 2) impact significance determination, approaches and methods and 3) case studies.

3 Results

3.1 Concept of significance

There are many different definitions. It is unlikely that universally agreeable definition can be defined.
"Significance" is relativistic and always must be set in a context (Appendix 1, Duinker and Beanlands 1986). The use of statistical tests is recommended when determining the significance for different contexts (Briggs et al. 2013). However, statistical significance does not mean same as the impact significance which also takes into account many other elements than “whether the numbers differ statistically”.

The meaning of the term significance varies depending on the phase of the EIA. Interpretation in the screening phase is related to a selection mechanism; this differs from the meaning of the term in the scoping phase, where it is related to the focus and balancing of the contents of the environmental impact statement (EIS). The meaning is different again in the decision phase. Ultimately, the test of significance comes in real-life conditions during the monitoring phase of the project. In each of these phases, significance is used as a specific criterion, which makes the use of the term a highly context-sensitive task in application. (Kjellerup et al. 1999)

Significance always comprises at least two elements, which must be included in determination or interpretation of significance. On the one hand, significance comprises everything that can be measured in the strict natural scientific sense, by which it is often referred to as *magnitude*, *duration*, or *extension* of the measured phenomenon. On the other hand, there is a link between the natural, scientifically measurable data and the human world. This is sometimes referred to as the social dimension of environmental impacts, and in individual cases often is referred to as *importance* in EISs. (Kjellerup et al. 1999) Also economic and sociocultural characteristics, e.g. quality of life and employment, are relevant in defining the significance (Poder 2006).

”Significance determination in EIA practice makes judgments about what is important, desirable or acceptable. It also interprets degrees of importance.” (Lawrence 2007b)

”The degree of significance depends upon the nature (i.e. type magnitude, intensity, etc.) of impacts and the importance communities place on them.” (Sippe 1999)

”Determining significance is ultimately a judgment call. The significance of a particular issue is determined by a threshold of concern, a priority of that concern, and a probability that a potential environmental impact may cross the threshold of concern.” (Haug et al. 1984)

“Whereas magnitude refers to the difference in environmental quality induced by human action, significance refers to the experts' and stakeholders' judgment on the overall importance of that difference.” (Cloquell-Ballester et al. 2007)

Impact significance is “….a dynamic contextual, and political concept characterized by uncertainty” (Wood 2008, Appendix 2).

“Generally, the significance can be regarded as consisting of three major components: severity of biophysical environmental impacts, socioeconomic variables and probability of adverse effects.” (Poder 2006)

Significance is not absolute and can only be defined in relation to each development and its location. It is for each assessment to determine the assessment criteria and the significance thresholds, using informed and well-reasoned judgment supported by thorough justification for their selection and explanation as to how conclusions about significance for each effect assessed have been derived” (Wood 2008 from IEMA/LI 2002).

The difficulties related to the communication of significance are emphasized by Wood (2008). “Nowhere is this potential for distortion greater than in the language and criteria that are employed to evaluate and communicate the significance of predicted environmental effects”. He also notes that there is lack of research “that critically examines and reflects upon the way in which significance is evaluated and communicated within key EIA documentation.

3.2 General theory and problems

David P. Lawrence has written three articles which form a good basis for understanding the nature and complexity of impact significant determination. *"Impact significance determination – Back to the basics" (2007b)* seeks to help to establish a sound and practical conceptual foundation for formulating and evaluating impact significance determination approaches. The article explores the fundamental attributes of impact significance determination. There is considerable variability how impact significance is treated as the regulatory and applied levels. No consensus has emerged regarding the most appropriate and effective methods or combinations of methods. There is considerable room for improvement in impact significance determination practice. Taken into account the centrality of values, subjectivity, complexity, conflict and uncertainty, absolute good practice ISD standards are unlikely to emerge. Systematic, explicit, open and thoughtfully supported significance judgments are central and critical to effective EIA practice at the regulatory and applied levels.

The variety of techniques and the inconsistency of their use by consultants make the results from ESs difficult to compare. The lack of standardization in the factors considered makes comparison between projects difficult, especially if there is a lack of transparency (Briggs et al. 2013).

Determination of significance occurs throughout the EIA process (notification or referral, screening, scoping, EIS preparation, public review of the EIS, regulator evaluation of EIS and proposal, public evaluation of the project, project decision-making, and follow-up) and is undertaken by different stakeholders at different stages. Our chief concern relates to the determination of significance early in the EIA process as this affects how the EIA subsequently proceeds. (Ross et al. 2006)

Several problems commonly emerge. First, the term 'significance' is used in different contexts. In addition to the traditional meaning in impact assessment (importance for decision making), the term can be used to imply perception of significance or 'issue attention', statistical significance (very likely to be a real effect based on a statistical test) or ecological significance (important to maintain an ecosystem). Also, certain issues or components of the environment (for instance, the presence of a keystone species) might be considered to be significant but of little relevance to the anticipated impacts of the proposed development.

Often the different meanings of the word significant are used indiscriminately in EIA documents and may also be inter-mixed with words with similar meaning such as 'important', 'critical' and 'focal'. A second issue concerns whether a significant impact can be suitably mitigated. This addresses the notion of 'residual impact', the impact post-mitigation or post-development. Certainly, residual impact is what a decision-maker should properly consider when deciding on project approval. However, the decisionmaker must also consider the likelihood and factors that ensure that the mitigation measure proposed will work effectively. (Ross et al. 2006)

A third problem with significance is when there is a mismatch between the method claimed to be used to determine significance and the actual presentation of results in an EIS. For example, it is common in Canada to find EISs indicating that significance is determined by some complex. (Ross et al. 2006)

A final problem with significance concerns the communication of the concept. Why does every EIS lie? In our experience, although it is inevitable that any form of development that triggers the necessity for an EIA is likely to have a significant effect on the environment, not all such effects are wholly mitigatable and manageable. Therefore the conclusion of every EIS that seems to state that: "There are no significant effects from this proposal …" needs to be challenged. (Ross et al. 2006)

Ross et al. recommend that practitioners take a zero tolerance approach to poor quality EIAs and demand the following:

• scoping and terms of reference for EISs that focus attention on significant environmental issues only. Regulators need to be clear here and firm with spurious or ambit claims from public opposition groups;
• clear and consistent methods for articulating the significance of impacts in EISs; and
• focused, objective and scientifically robust EIS. (Ross et al. 2006)

3.3 Approaches

Lawrence (2007) describes three broad approaches to impact significance determination: 1) the technical approach, 2) the collaborative approach and 3) the reasoned argumentation approach. The technical approach breaks significance questions down to their constituent parts and applies a technical procedure to progressively aggregate the relevant impact significance determination considerations. With the collaborative approach interested and affected parties jointly, in interactive forums closely connected to broader constituencies, determine what is acceptable and unacceptable, important and unimportant, and how much importance to attach each concern and potential impact. The reasoned argumentation approach views significance determination as a process of making reasoned judgments, supported by technical and non-technical evidence. No single approach is generally preferable or is always preferable for particular classes of situations. Combinations of approaches have the potential to counterbalance many of the negative tendencies of individual approaches

Gangolells et al. (2011) present an approach to predict impact significance for the construction of residential buildings. A total score for each project is obtained based on the severity of the impacts concerns of interested parties. A three-interval scale was developed: little or no concern to interested parties (=1), secondary concern to all or most interested parties (=3), and primary concern to all or most interested parties (=5). Panel of experts developed 37 indicators and corresponding assessment scales. Most of the indicators were qualitative, because numerical data was not available at the pre-construction phase. Interested parties are classified as internal (direct influence of construction activities on neighbouring communities) or external (community associations, environmentalists, NGOs, the media etc). Two case studies are presented in order to demonstrate the benefits of the improved methodology.

Joshi and Latif (2004) use conventional matrix method and MCDM method to EIA of water resource management project in Bangladesh.

Wood (2008) has made a desk-top review of the landscape/visual and noise assessment of 30 individual UK EISs. He identified three types of approaches:

1) TYPE 1: Separate sets of criteria are defined for both a) different levels of impact magnitude and b) varying degrees of receptor sensitivity. These criteria are then brought together in a simple matrix to identify relative degrees or categories of impact significance that are summarized using single language terms (e.g. “Major”, “Moderate”, “Minor”) with no further detail provided.
2) TYPE 2: In contrast to the Type 1 approach no appraisal matrix is used and there is no formal attempt to draw together various levels and/or combinations if impacts magnitude and receptor sensitivity. Instead the emphasis is upon providing more detailed definitions of the final impacts significance criteria (Table 1).
3) TYPE 3: This combines elements of Type 1 and Type 2 approaches. Sets of criteria are defined for both impact magnitude and receptor sensitivity and these are then combined in an appraisal matrix to identify relative degrees of impact significance. The matrix is accompanied by ancillary definitions of the resulting final significance categories.

Type 1 is inherently simplistic because it does not take into account that in addition to magnitude and sensitivity there are also other important impact dimensions such as timing, duration, permanence, and likelihood of occurrence. In Type 2 the problem is that the lack of explicit framework for combining varying degrees of sensitivity and magnitude reduce transparency. In the Type 2 some combinations may be not explicitly described. The level of transparency is highest in Type 3 approach where "the reader is potentially in better position to calibrate the language terms used by experts".

Table 1. An example of Type 2 impact significance criteria (Wood 2008).

Major Where the extent of the impact on landscape character is large in scale or magnitude as a result of high sensitivity to change or a high intrinsic value and as a consequence the integrity of that asset will be significantly changed. The impact is of national or regional importance, and will be of long term nature (or very severe short term), irreversible and certain or likely to occur.
Moderate Where the extent of the impact on landscape character is small in scale or magnitude as a result of low sensitivity to change or a low intrinsic value. The impact is of district importance. The impact will be of medium or short-term nature and likely to occur.
Negligible Where the extent of the impact on landscape character is barely noticeable in scale or magnitude as a result of low sensitivity to change or a low intrinsic value. The impact is of local importance. The impact will be of short-term nature and unlikely to occur.

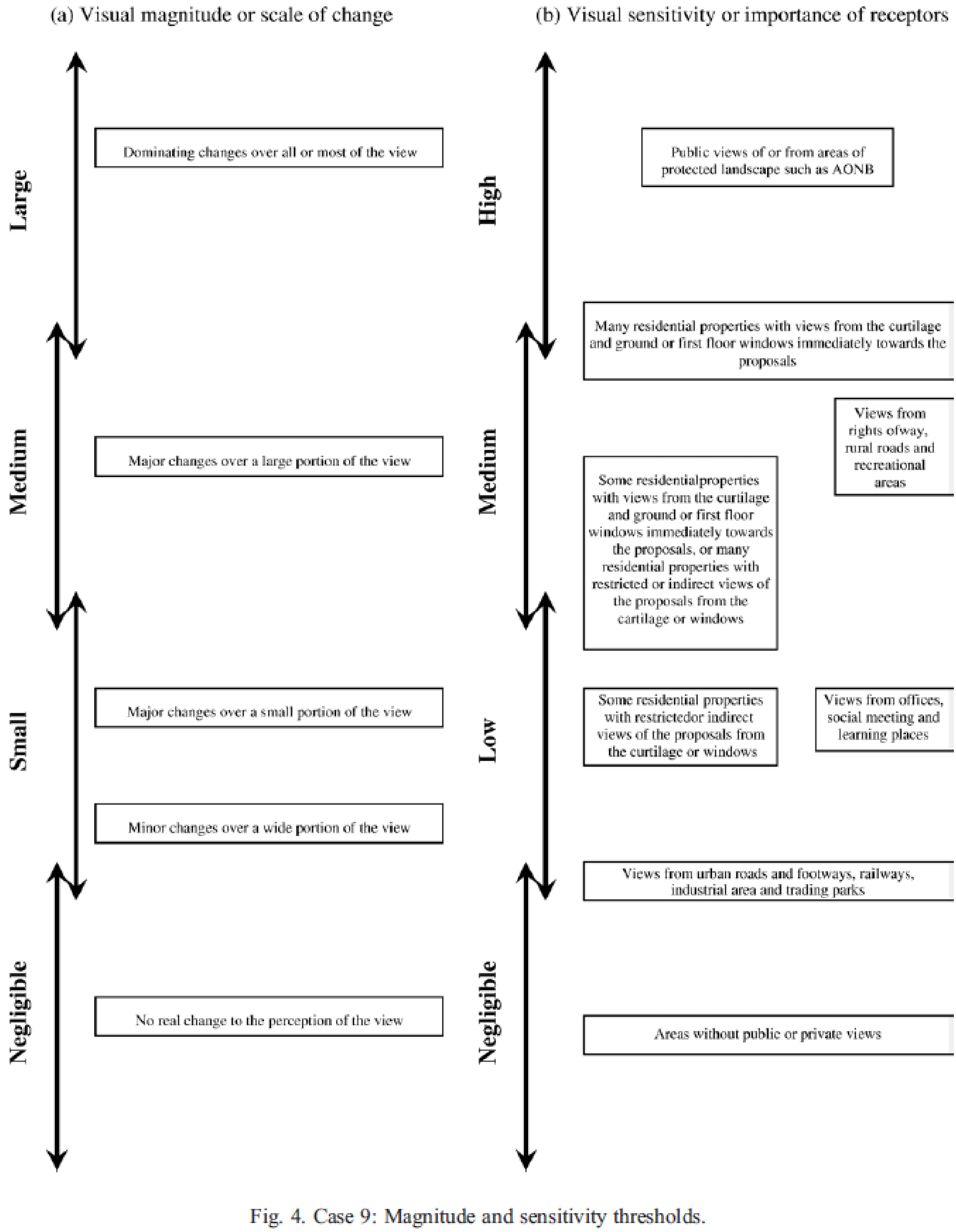

Fig. 4. Case 9: Magnitude and sensitivity thresholds.

Figure 1. Magnitude and sensitivity thresholds in Type 3 approach (Wood 2008).

Thompson (1990) has compiled a review of 24 Methodologies. He presents 6 different approaches for determining impact significance which basic ideas are presented below.

Approach 1, Water Resource Assessment Methodology (WRAM).
This method was originally developed for water resource assessment projects by Solomon, R.C. et. al., 1977[1]. Interdisciplinary team weights the environmental, social and economic components, which may be impacted by the project, by using ranked **pairwise comparison techniques**. There are several ways to do the scaling. The values obtained from scaling for each of the components are called "Alternative Choice Coefficients", which expresses the magnitude of the impact. Weights multiplied by Scales result Aggregate Score and Aggregate Scores summed up result Final Aggregate Scores for each of the alternatives. (Table 2)

Table 2. Approach 1, Water Resource Assessment Methodology (WRAM).

Environmental, Social and Economic Component	Weight	Scale, Alternative Choice Coefficient			Aggregate Scores		
		Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Environmenal							
Env. Component 1							
...	...	...	...	...	...	...	...
Env. Component N							
Social							
Sos. Component 1							
...	...	...	...	...	...	...	...
Sos. Component N							
Economic							
Econ. Component 1							
...	...	...	...	...	...	...	...
Econ. Component N							
			Final Aggregate Score				

Approach 2, Crawford Methodology
This method was originally developed for highway route planning purposes by Crawford, et. al., 1973[2]. This method uses extensively a **Delphi techniques**, which is a method where expert panels make their estimates in several rounds. After each round the results are presented for other panels. On this way the estimates are expected to become closer to each other in each new round and finally reach the "correct" estimates. (Table 3).

The presentation of this method in the publication is not detailed enough. Most likely the weighting and scaling of the impacts is otherwise similar in this method than in the Approach 1 exempt the weight multiplied by magnitude of impact is further multiplied by **probability**. The end result of the analysis is magnitude, which is certain percentage of the maximum impact.

[1] Solomon, R.C., Colbert, B.K., Hansen, W. J., Richardson, S. E.,Canter, L. And Valachos, E. C. (1977) Water Resource Assessment Methodology (WRAM) Impact Assessment and Alternative Evaluation. Technical Report No. Y-77-1 Vicksburg, Mississippi, U.S. Armu Corps of Engineers.

[2] Crawford, A. B., (1973). Impact Analysis Using Differential Weighted Eveluation Criteria, in Multiple Criteria Decision Making. Cochrane, J. L. and Zeleny, M. (eds). Columbia, SC: University of South Carolina Press.

Table 3. Approach 2, Crawford Methodology.

Components or Impacts	Relative Weights	Consequence			Propability			Magnitude of Impact			% of Maximum		
		Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
Component/ Impact X													
componen/Impact Y													
etc.	…	…	…	…	…	…	…	…	…	…	…	…	…

Approach 3, Project Appraisal for Development Control (PADC) methodology
This method (Clark et. al., 1983[3]) makes a choice between five polarities (adverse/beneficial, …) for each of the impacts. The significance of the impacts could be determined based on the sum the numbers in each polarity. This would give a same weight for each polarity. However, in the document it is not explained how the polarities are suggested to be used to analyze significance. (Table 4)

Table 4. Approach 3, Project Appraisal for Development Control (PADC) methodology.

Alternative 1

Impacts	Adverse/Beneficial	Short-term/long-term	Reversible/Irreversible	Direct/Indirect	Local/Strategic	Significance
Impact X						
Impact Y						
Impact Z						
etc						

Alternative 2

Impacts	Adverse/Beneficial	Short-term/long-term	Reversible/Irreversible	Direct/Indirect	Local/Strategic	Significance
Impact X						
Impact Y						
Impact Z						
etc.						

Alternative 3

…

Approach 4, The Leopold Matrix
This methodology is based on the Leopold Matrix (Leopold et al., 1971)[4], which has existing environmental conditions, which might be affected by actions, as rows and actions, which cause environmental impacts, as columns. (See Table 5)

In the matrix the number of actions listed in columns is 100. The number of environmental factors listed in rows is 88. This provides a total of 8,800 interactions. In practice, however, only a few of the

[3] Clark, B. D., Chapman, K., Bisset, R., Wathern, P. and Barrett, M. (1983). A Manual for the Assessment of Major Development Proposals. PADC Aberdeen University. London: HMSO.

[4] Leopold, L. R., Clark, F. A., Henshaw, B. R. And Balsey, J. R. (1971). A Procedure for Evaluating Environmental Impact. U.S. Geological Survey Circular 645 and http://eps.berkeley.edu/people/lunaleopold/(118)%20A%20Procedure%20for%20Evaluating%20Environmental%20Impact.pdf and http://ponce.sdsu.edu/the_leopold_matrix.html

interactions would be likely to involve impacts of such magnitude and importance to warrant detailed treatment. The number of interactions for a typical project is between 25 and 50 of which about dozen actions are usually significant according to Leopold et. al.

Each shell in the matrix is divided into two parts. In the upper part it is presented relative magnitude (scale 1 – 10) of the impact and in the lower part the relative importance of the impacts (scale 1 – 10).

The analysis concentrates in the shells where significant magnitudes and importance are marked (high numbers in both). The significant impacts must be well reasoned in the text. The method does not give any numerical figure for significance and leaves room for judgment of the analyst. Separate matrixes are prepared for each of the project implementation alternatives.

Table 5. Approach 4, The Leopold Matrix.

Environmental parameter	Activity			
	1	2	...	100
1	9 / 8		9 / 6	2 / 1
2	6 / 4	10 / 7		5 / 3
3		1 / 3	1 / 3	2 / 1
...		2 / 1	8 / 2	
88	4 / 4	9 / 9		

magnitude / importance

Leopold Matrix approach was used in Guidebook for Evaluating Mining Project EIAs of Environmental Law Alliance Worldwide (ELAW). [5]

Approach 5, The Fischer and Davis methodology

In this methodology (Fischer and Davis, 1973)[6] the impacts of each project alternative are assigned + or – sign indicating positive or negative impact, degree of impact indicating the magnitude of the impact and if the impact is short term or long-term impact. For further analysis are taken only the impacts, which have highest impact scores. (See Table 6)

The analysis is not taken further in numerical level. This leaves room for judgment of the analyst.

[5] http://www.elaw.org/files/mining-eia-guidebook/Full-Guidebook.pdf

[6] Fischer, D. W., and Davis, G. S. (1973). An approach to assessing environmental impacts. Journal of Environmental Management 1, 207 – 227 and http://books.google.fi/books?id=7MYOAAAAQAAJ&pg=PA332&lpg=PA332&dq=Fischer+Davis+environmental+impacts+Journal&source=bl&ots=4j25GYajYo&sig=XX10WKlfHmVCoSFnmcELgpkwCsU&hl=fi&sa=X&ei=pWuoUfjOBoOz4ASo2ICYBw&redir_esc=y#v=onepage&q=Fischer%20Davis%20environmental%20impacts%20Journal&f=false

Table 6. Approach 5, The Fischer and Davis methodology.

Alternative 1

Impacts	Environment Compatibility Matrix			→	Impacts	Decision Matrix		
	Benefit +/Cost -	Degree of Impat, 1-5	Short/long term			Benefit +/Cost -	Degree of Impat, 1-5	Short/long term
Impact X	+	4	l		Impact X	+	4	l
Impact Y	-	2	s		Impact Y			
Impact Z	-	5	s		Impact Z	-	5	s
Impact A	+	3	l		Impact A			
Impact B	-	1	s		Impact B			
etc.	…	…	…		etc.	…	…	…

Alternative 2

Impacts	Environment Compatibility Matrix			→	Impacts	Decision Matrix		
	Benefit +/Cost -	Degree of Impat, 1-5	Short/long term			Benefit +/Cost -	Degree of Impat, 1-5	Short/long term
Impact X	+	3	l		Impact X			
Impact Y	-	4	s		Impact Y	-	4	s
Impact Z	-	5	s		Impact Z	-	5	s
Impact A	+	4	l		Impact A	+	4	l
Impact B	-	2	s		Impact B			
etc.	…	…	…		etc.	…	…	…

Alternative 3

…

Approach 6, Loran methodology

This methodology presented by Loran 1975[7] uses a matrix with 234 project activities and 27 environmental features. Each combination of activity and environmental feature are scaled according to forecasted severity of impact from 0 to 5 by interdisciplinary team. The result is recorded using a computer algorithm and a primitive aggregation of impacts is achieved by "clustering" of highly rated impacts. The method serves in identifying the critical environmental areas. Further processing of numbers is not done and the method leaves room for the own judgment of the analyst. (See Table 7)

[7] Loran, B. (1975). Quantitative assessment of environmental impact. Journal of Environmental Systems 5, 247 – 256.

Table 7. Approach 6, Loran methodology.

Environmental Feature	Project Activity					
	1	2	3	…	233	234
1	1	0	2	1		
2	0	5	0	0	0	2
3	1	0	5	1	5	0
4	4	1	1	4		
…	…	…	…	…	…	…
26	0	2	1	0	2	0
27	3	0	0	5	0	5

Environmental Feature	Project Activity					
	10	44	65	3	230	78
3	1	0	2	1		
12	4	4	0	0	0	2
4	4	5	5	5	4	0
22	3	4	1	3	4	
26	…	…	…	1	…	…
5	0	2	1	0	2	0
27	3	0	0	5	0	5

Antunes et al. (2001) presents a new methodology for impact assessment—SIAM (Spatial Impact Assessment Methodology) —which is based on the assumption that the importance of environmental impacts is dependent, among other things, on the spatial distribution of the effects and of the affected environment. The information generated by the use of Geographical Information Systems (GIS) in impact identification and prediction stages of Environmental Impact Assessment (EIA) is used in the assessment of impact significance by the computation of a set of impact indices. For each environmental component (e.g., air pollution, water resources, biological resources), impact indices are calculated based on the spatial distribution of impacts. A case study of impact evaluation of a proposed highway in Central Portugal illustrates the application of the methodology and shows its capabilities to be adapted to the particular characteristics of a given EIA problem.

3.3.1 MCDA supported approaches

We found three papers where MCDA was used to support impact significance determination.

Cloquell-Ballester et al. (2007) propose **a MCDA supported methodology for the evaluation of environmental impact significance** using expert judgments. Core to this methodology is the use of two multi-criteria techniques and sensitivity analysis. This systematic procedure focuses on ensuring robustness in the judgments exposed and on promoting public participation. Two main phases are impact identification and significance assessment. The phases of the method are presented in Appendix 5.

The methodology proposed gives the expert the protagonist role in the decision and offers him/her two sets of information of great value. Firstly, the variation of allocations of significance values as a function of the variations in the parameters employed in the techniques (sensitivity analysis), and secondly, a comparison between allocation of results (comparative analysis) using conceptually different MCDA techniques, namely compensatory (sum-based) and non-compensatory (outranking-based) techniques.

The first notable outcome from the use of the methodology when applied to the case study, was that the different experts who participated, showed their satisfaction with the facility to fully preserve their autonomy in decision-making, as the methodology did not aim to grant the final decision to numerical values resulting from the multi-criteria techniques, rather the expert was given the last word. The second positive comment from the experts was centered on the easiness with which a consensual decision had been reached, primarily because the methodology provided a panoramic vision of the evaluation which helped systematic and tractable argumentation of the decisions.

Electre TRI provides more information (both pessimistic and optimistic assignation) than the sum-based techniques in complicated situations (fuzziness and imbalance. One of the disadvantages of the use of Electre TRI is the large number of parameters it requires. (Cloquell-Ballester et al. 2007)

Authors give two possible reasons why different multi-criteria techniques in the determination of the significance have been scarce. On the one hand, the environmental expert does not wish to be (and must not be) substituted when it comes to expressing his/her judgment of an impact, and is thus wary of any tool that may restrict his/her freedom when making the decision. On the other hand, the environmental expert knows that there does not yet exist a universal and indisputable multi-criteria technique, discouraging its application to real-life problems.

Boteva et al. (2004) have developed **a GIS based multi-criteria approach to evaluate the nature conservation significance** of the joint influence of the five criteria. Criteria were combined by decision rule. The ratings from a pairwise comparison matrix (criteria ranging from 1/9 to 9) were used to calculate a best-fit set of weights. Each criterion map was multiplied by its weight and summed to generate a final map of the conservation score for every vegetation unit. Authors list several limitations like: 1) The evaluation system uses scientific data but the assessment of the significance of criteria doesn´t. There are two stages at which subjective assessments are made: the scoring of different criteria and the relative weights of the criteria for the MCE analysis. 2) The threat component should be given much higher weight and should be treated as a separate criterion in the evaluation. 3) When dealing with interactions between ecosystems and humans, the history of the human-induced changes should be taken into account for understanding the components and dynamics of current biodiversity and application of conservation and management measures for biodiversity.

Noh and Lee (2003) propose a systematic and easy-to-use method for the determination of significance factor (for Life Cycle Analysis) of an impact category. MCDA methods including the Analytic Hierarchy Process (AHP), the rank order centroid method, and the fuzzy method were evaluated for this purpose. Time, area, irreversibility and scientific uncertainty were chosen as criteria. A total of eight impact categories were considered, e.g. global warming and acidification. The rank-order centroid method was considered a practical method for the determination of significance factor because it is easier and simpler to use than AHP and the fuzzy method. See Appendix 4.

In Netherlands a systematic approach (**Citizen Value Assessment**, CVA, Stolp et al. 2002) to find out citizens' and opinions about the impacts and their importance have been applied in many projects. CVA is a useful addition to the EIA process because it adds information that has been systematically collected, which represents the way citizens assess the qualities of the environment, and which provides a systematic comparison of alternatives from the citizens' perspective. The authors state that what is even more important than the application of the CVA instrument itself, is the explicit recognition by politicians of the relevance of systematic information on citizen values as a data source for decision-making.

Rapid Impact Assessment Matrix (RIAM) is a tool for organizing, analyzing and presenting the results of holistic EIA. RIAM was originally developed to compare the impact of alternative procedures in a single project. Kuitunen et al. (2008) used RIAM to compare the environmental and social impact of 142 projects, plans and programs realized within the same geographical area. The five criteria used in the analysis were: A1) Importance of impact (local, outside local context, regional, national, international), A2) Magnitude of change and effect (major disadvantage to major positive impact). Assessment of the direction of impact depends on from whose point of view it is evaluated. B1) Permanence of the impact causing activity, B2) Reversibility of impact, and B3) Accumulation of impact (cumulative or synergetistic, non-cumulative impact).

The basic formula for the RIAM is:

A1*A2 = AT

B1+B2+B3=BT

AT*BT=ES (Environmental Scores)

The results revealed that RIAM method could be used for comparison and ranking of separate and distinct projects, plans, programs and policies, based on their negative or positive impacts.

3.4 Criteria

Different authors have defined different sets of criteria taking into account their case specific characteristics. Determining the significance of impacts can be considered a multiple criteria problem. A good synthesis of the state-of-the-art in the development of significance criteria is presented by Bevan (2009, Figure 2).

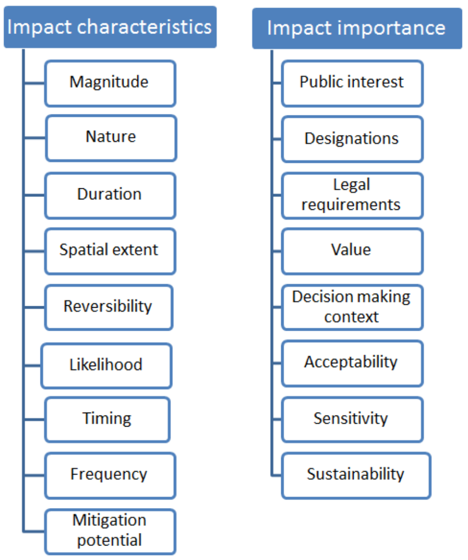

Figure 2. Potential criteria for impact significance determination based on Bevan's (2009) work.

Duinker and Beanlands (1986) state that any exercise in judging the significance of an environmental impact should thoroughly consider (a) the importance of the environmental attribute in question to project decision makers, (b) the distribution of change in time and space, (c) the magnitude of change, and (d) the reliability with which change has been predicted or measured.

Andrews et al. (1977) set forth a number of criteria that should be incorporated into a context for determining the significance of environmental impacts. These criteria include: (1) magnitude of the impact, (2) spatial extent of the impact, (3) duration of the impact, (4) probability of occurrence of the impact, (5) confidence in the impact prediction, (6) the existence of "set values" (e.g., air or water quality standards) and (7) the controversy surrounding the development proposal.

Cloquell-Ballester et al. (2007) suggest that in addition to impact magnitude several other impact characteristics, such as extension, accumulation, synergism, duration, reversibility, mitigation, periodicity, controversy, should be taken into account.

Scolozzi and Geneletti (2012) present an approach for assessing impacts on habitats on a local scale. The results provide insight into future habitat loss and fragmentation caused by land-use changes. A rule-based approach (maximum rule) was applied, meaning that different species or habitat types have equal importance. If-then rules for classification of the overall ecological value considering the qualitative assessment of connectivity and habitat as described below:

- IF Functioning for one selected species AND (Functioning OR Fairly functioning for another species) THEN High.
- IF Fairly functioning for at least two species OR Functioning for only one species THEN Medium.
- IF Farily functioning for only one species THEN Low
- OTHERWISE Negligible.

Boteva et al. (2004) have defined criteria for the evaluation of conservation significance. From a list of 12 criteria used in 17 different conservation schemes, four out of five most commonly used criteria were applied with the addition of replaceability: diversity, rarity, naturalness, threat of human interference and replaceability. They emphasize that the quantity and quality of available data should be taken into account in the selection of the criteria.

Canter and Canty (1993) present three questions which can be used in the impact significance determination:

1) Is the environmental component legally recognized as important?
2) Is the environmental component politically or publicly recognized as significant?
3) Is the environmental component professionally judged to be important?

Significance based on institutional recognition means that the importance of an EQ (Environmental Quality) resource or attribute is acknowledged in the laws, adopted plans, and other policy statement of public agencies or private groups. Significance based on public recognition means that some segment of the general public recognizes the importance of an EQ resource or attribute. Public recognition may take the form of controversy, support, conflict or opposition and may be expressed formally or informally. Significance based on technical recognition means that the importance of an EQ resource or attribute is based on scientific or technical knowledge or judgments of critical resource characteristic.

3.5 Subjectivity

Subjectivity can be an area of contention in EcIA; it is looked upon both favorably and unfavorably, but is inherent within the determination of significance. Since there is no widespread agreement on a definition of significance it becomes a collective judgment of the stakeholders in each case—this usually makes subjectivity inescapable. Additionally, subjectivity arises from the value placed on the receptor (species or habitat) of an impact; it is dependent on the value society places on it. There is concern that developers and consultants can use subjectivity to scale impacts down in order to increase the likelihood of achieving planning permission (Briggs et al. 2013).

Another problem that follows on from the previous point is that often an entirely subjective approach to significance is used. An important procedural component in any EIA is to ensure that the reporting of significance criteria follows a standardised approach across all environmental parameters, a template that is easily understood by stakeholders and decision-makers. It is rare that proponents explicitly define the measure by which significance is judged in an EIS. There is a real risk in this circumstance for every impact to be significant (in the sense that it is included in an EIS, therefore it is implicit that it must be significant) or for none of the impacts to be distinguished as significant (because the proponent makes no attempt to determine the significance of individual impacts). (Ross et al. 2006)

The goals of EIA are often viewed as securing a prediction of the future, as institutionalizing environmental awareness among bureaucrats, or as a tool for social learning. Wilkins (2003) suggests EIA as a system for promoting the development of values that foster greater social responsibility and has the capacity to increase the importance of long-term environmental considerations in decision-making. Wilkins regards subjectivity as one of the positive attributes of the EIA process that should be encouraged in order to promote sustainability and to inspire confidence in EIA. The influence of personal value systems and beliefs is unavoidable when creating an expert evaluation and interpretation. Subjectivity and values play an inevitable role in the development of positions taken in an assessment, the scoping of assessment boundaries, the data to be examined and the assumptions used in an assessment's methodology. Even the terms ''environment'' and ''impact'' are subjective concepts, which are socially defined and created as a result of the interchange of views and perspectives of a variety of societal actors.

4 Examples of good practice for IMPERIA

Following examples of good practices have been found from literature:

- For any particular EIA, the development of criteria for judging impact significance should take place very early in the planning stages of the assessment. These criteria provide the foundation upon which the investigators can design and undertake biophysical studies. (Duinker & Beanlands 1986)
- A summary table which covers the initial significance, justification for the level of significance, proposed mitigation measures and the residual significance (Briggs et al. 2013).
- The use of statistical tests in the determination of significance (Briggs et al. 2013).
- Post-monitoring and feedback, more effective streamlining and implementing of legislation or guidance (Briggs et al. 2013).
- As part of Environmental Impact Statements a summary table which cover the initial significance, justification for the level of significance, proposed mitigation measures and the residual significance (Briggs et al. 2013).
- GIS combined with MCE analysis can be useful when evaluating the conservation significance of a large number of sites (e.g. Boteva et al. 2004).
- Using Input–output analysis as part of conventional EIA in order to calculate the indirect effects (Lenzen etc. 2003).
- The use of Electre TRI instead of Weighted Sum or Corrected Sum for supporting impact significance assessments (Cloquell-Ballester et al. 2006).
- Three levels of significance: 1) significant and not mitigable, 2) significant but mitigable and 3) insignificant (Canter and Canty 1993).
- A flow chart describing different tasks and option in ISA both in scoping and EIS phase.
- Better focus on determining significance and criteria in the screening phase of the project (Kjellerup 1999). Ross et al. (2006) also claim that "significant" should be defined at early stage of EIA.

- Regarding to Poder (2006), assessment criteria should be clearly defined, the assessment process transparent, and the description of the impacts comprehensive enough.

In addition, Lawrence (2007c) presents an extensive table about the examples of general good practices. He lists 16 criteria for each he gives 2-7 examples. The criteria covers e.g. integration knowledge, managing uncertainties, facilitating learning and conflict resolution (see Appendix 3: table 10). Lawrence also presents a table where he lists challenges of determination of significance and how to manage them (see Appendix 3: table 11).

5 Conclusions and recommendations

Significance determination in EIA practice makes judgments about what is important, desirable or acceptable (Sippe 1999, Stamps 1997). It also interprets degrees of importance (Lawrence 2007b). ISD can be defined narrowly or broadly. The broad definition includes positive and negative impacts, direct and indirect social and economic effects, all forms of significance, interpretations from multiple perspectives including what people consider important. (Lawrence 2007b)

The links between significance determination and decision making should be clearly identified and substantiated, especially regarding how significance determinations shape and direct EIA process. **Systematic, explicit, open and thoughtfully supported significance judgments are central and critical to effective EIA practice at the regulatory and applied levels** (Lawrence 2007b).

There is considerabale variability how impact significance is treated as the regulatory and applied levels (Lawrence 2007b). No consensus has emerged regarding the most appropriate and effective methods or combinations of methods. **There is considerable room for improvement in impact significance determination practice.** Taken into account the centrality of values, subjectivity, complexity, conflict and uncertainty, absolute good practice ISD standards are unlikely to emerge. When significant environmental impacts can be identified in advance, corresponding on-site measures can be implemented (Gangolells et al. 2011).

The general weaknesses of EIA seem to be (1) ill-defined and unsystematically adopted assessment criteria and (2) lack of a clear scheme for adopting the results of EIA and ERA. A tiered assessment scheme with the more precisely defined criteria could provide a rational basis for aspects assessment while avoiding the abovementioned drawbacks. **Limited transparency and reproducibility of the assessment process serves as a common shortcoming** (Poder 2006). Further attention should be devoted to the use and effectiveness of procedural and substantive objectives in EIA practice (Lawrence 2007b).

Applied research that addresses the relative effectiveness of alternative significance determination approaches and approach combinations in multiple settings could further enhance EIA practice. Combinations of approaches have the potential to counterbalance many of the negative tendencies of individual approaches. (Lawrence 2007a) **It is of fundamental importance to choose methods appropriate to the project, environmental context and impact under consideration and to adapt them according to the local decision-making circumstances.** Subjectivity is an inherent and necessary feature of significance determinations, and rather than trying to diminish it is essential to incorporate and make explicit the multiple values upon which judgements are made. (Bevan 2009)

The development of a list of universal attributes of the significance; the definition of the indicators and value functions for the evaluation of the attributes which allow for this, in an attempt to increase the rigour of the allocation; investigation on the definition of the Electre TRI parameters with the purpose of defining those intervals, more appropriate for each type of project; and the development of specific methods to facilitate consensus control between stakeholders with the aim of enabling effective participation in the determination of the significance. (Cloquell-Ballester et al. 2007)

Significance determination tends to be more effective if value-full, non-technical but technically supported, adaptive, focused on issues and decision-making, and open. Significance determination properties can help guide practice, especially if their roles in practice are systematically assessed. (Lawrence 2007b) For a sustainability approach, all impacts need to be considered to a similar extent whether bio-physical, social or economic, and given equal weighting, determinations will need to be objective-led, encompass positive and negative impacts, provide consistent and comparable judgements, become more inclusive, acknowledge uncertainty and adopt the precautionary principle. (Bevan 2009) If a number of proposals fall in the same area, it may not be necessary to conduct case-by-case hybrid EIAs including indirect effects calculated using input–output analysis because the regional impacts might be very similar. In this situation, an integrated regional systems model has been suggested as being the most appropriate assessment tool. (Lenzen et al. 2003)

The proposed changes to the scope and orientation of impact significance determinations can assist EIA practitioners in ensuring that impact significance determination approaches reflect the broadened and re-oriented scope of emerging EIA requirements and practices. The "learning curve" associated with impact significance determination practice can be further accelerated with additional conceptual and methodological refinements and testing, by more sharing of experiences, with further applied case studies, research and follow-up studies, by refining and adapting relevant EIA requirements and guidelines, by means of further good practice guidance, and with a concerted effort to better match contextual characteristics and significance determination methods and processes. (Lawrence 2007c)

Extensive practical guidance for practitioners, focusing extensively on significance can only help to improve practice. There is a need to establish a theoretical consensus over the purpose of EIA and the means, by which it is to achieve this. (Bevan 2009) **Consultants considered the guidance to be beneficial, but there is a clear message that a balance has to be struck between guidance and hindrance.** (Ross et al. 2006) We do not have to overly complicate EIA — a good dose of common sense in EIA can go a long way towards meeting all demands (Ross et al. 2006).

Literature

Andrews, R.N.L. & Cromwell, P. & Enk, G.A. & Farnworth, E.G. & Hibbs, J.R. & Sharp, V.L. 1977. *Substantive guidance for environmental impact assessment: an exploratory study*. Institute of Ecology, Washington DC. 79 s.

Antunes, P. & Santos, R. & Jordão, L. 2001. *The application of Geographical Information Systems to determine environmental impact significance*. Environmental Impact Assessment Review, vol. 21:6. S. 511-535. ISSN 0195-9255.

Bevan, J.P. 2009. *Determining significance in environmental impact assessment: A review of impacts upon the socio-economic and water environments*. School of Environmental Sciences, University of East Anglia, University Plain, Norwich. 79 s.

Boteva, D. & Griffiths, G.& Dimopoulos, P. 2004. *Evaluation and mapping of the conservation significance of* habitats using GIS: an example from Crete, Greece. Journal for Nature Conservation, vol. 12. S. 237-250. ISSN 1617-1381.

Briggs, S. & Hudson, M.D. 2013. *Determination of significance in Ecological Impact Assessment: Past change, current practice and future improvements*. Environmental Impact Assessment Review, vol. 38. S. 16-25. ISSN 195-9255.

Canter, L.W. & Canty G.A. 1993. *Impact significance determination –basic considerations and a sequenced approach*. Environmental Impact Assessment 13:275-297.

Cloquell-Ballester, VA. & Monterde-Diaz, R. & Cloquell-Ballester, VA. & Santamarina-Siurana, MC. 2007. *Systematic comparative and sensitivity analyses of additive and outranking techniques for supporting impact significance assessments*. Environmental Impact Assessment Review, vol. 27:1. S. 62-83. ISSN 0195-9255.

Duinker, P.N. & Beanlands, G.E. 1986. *The Significance of Environmental Impacts: an Exploration of the Concept*. Environmental Management, vol. 10:1. S. 1-10. ISSN 0364-152X.

Gangolells, M. & Casals, M. & Gassó, S. & Forcada, N. &Roca, X. & Fuertes, A. 2011. *Assessing concerns of interested parties when predicting the significance of environmental impacts related to the construction process of residential buildings*. Building and Environment, vol. 46:5. S. 1023-1037. ISSN 0360-1323.

Haug, P.T. & Burwell, R.W. & Stein, A. & Bandurski, B.L. 1984. *Determining the significance of environmental issues under the National Environmental Policy Act*. Journal of Environmental Management, vol. 18:1. S. 15-24. ISSN 0301-4797.

Joshi, H. & Latif, M.A. 2004. *Environmental impact assessment of water resource projects with matrix and multi-criteria decision-making methods: A case study*. Journal of Environmental Systems, vol. 30:3. S. 207-231. ISSN 0047-2433.

Kjellerup, U. 1999. *Significance determination: A rational reconstruction of decisions*. Environmental Impact Assessment Review, vol. 19:1. S. 3-19. ISSN 0195-9255.

Kuitunen, M., Jalava, K. and Hirvonen, K. 2008. *Testing the usability of the Rapid Impacts Assessment matrix (RIAM) method for comparison of EIA and SEA results*. Environmental Impact Assessment Review 28:312-320.

Lawrence, D.P. 2007a. *Impact significance determination – Designing an approach*. Environmental Impact Assessment Review, vol. 27:8. S. 730-754. ISSN 0195-9255.

Lawrence, D.P. 2007b. *Impact significance determination – Back to basics*. Environmental Impact Assessment Review, vol. 27:8. S. 775-769. ISSN 0195-9255.

Lawrence, D.P. 2007c. *Impact significance determination – Pushing the boundaries*. Environmental Impact Assessment Review, vol. 27:8. S. 770-788. ISSN 0195-9255.

Lenzen, M. & Murray, S.A. & Korte, B. & Dey, C.J. 2003. *Environmental impact assessment including indirect effects – a case study using input-output analysis*. Environmental Impact Assessment Review, vol. 23:3. S. 263-282. ISSN 0195-9255.

Noh, J. & Lee, K.M. 2003. *Application of Multiattribute Decision-Making Methods for the Determination of Relative Significance Factor of Impact Categories*. Environmental Management, vol. 31:5. S. 633-641. ISSN 0364-152X

Põder, T. 2006. *Evaluation of Environmental Aspects Significance in ISO 14001*. Environmental Management, vol. 37:5. S. 732-743. ISSN 0364-152X

Ross, W.A. & Morrison-Saunders, A. & Marshall, R. 2006*. Improving quality - Common sense in environmental impact assessment: it is not as common as it should be*. Impact Assessment and Project Appraisal, vol. 24:1. S. 3-10. ISSN 1461-5517.

Scolozzi, R. & Geneletti, D. 2012. *A multi-scale qualitative approach to assess the impact of urbanization on natural habitats and their connectivity*. Environmental Impact Assessment Review, vol. 36. S. 9-22. ISSN 0195-9255.

Sippe, R. 1999. *Criteria and standards for assessing significant impacts*. Handbook of Environmental Impact Assessment, vol. 1 – Environmental Impact Assessment: Process, Methods and Potential. Petts, J. (ed.). S. 74-92.

Stamps, III AE. 1997. *A paradigm for distinguishing significant from non-significant visual impacts: theory , implementation, case histories*. Environmental Impact Assessment Review, vol. 17:4. S. 249-293. ISSN 0195-9255.

Stolp, A. & Groen, W. & van Vliet, J. & Vanclay, F. 2002. *Citizen values assessment: incorporating citizens' value judgements in environmental impact assessment*. Impact Assessment and Project Appraisal, vol. 20:1. S. 11-23. ISSN 1461-5517.

Thompson, M.A 1990. *Determining Impact Significance in EIA: a review of 24 Methodologies*. Journal of Environmental Management 30: 235 -250.

Wilkins, H. 2003. *The need for subjectivity in EIA: discourse as a tool for sustainable development*. Environmental Impact Assessment Review 23 (2003) 401–414.

Wood, G. 2008. *Thresholds and criteria for evaluating and communicating impact significance in environmental statements: 'See no evil, hear no evil, speak no evil'?*. Environmental Impact Assessment Review, vol. 28:1. S. 22-38. ISSN 0195-9255.

APPENDIX 1

Table 8. Criteria used to rate impacts in the environmental impact assessment of exploratory hydrocarbon drilling in the Davis Strait region (Duinker et al. 1986).

Major impact

Affects an entire population or species in sufficient magnitude to cause a decline in abundance and/or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return that population or species, or any population or species dependent upon it, to its former level within several generations. May also affect a subsistence or commercial resource use to the degree that the well-being of the user is affected over a long term.

Moderate impact

Affects a portion of a population and may bring about a change in abundance and/or distribution over one or more generation, but does not threaten the integrity of that population or any population dependent upon it. A short-term effect upon the well-being of resource users may also constitute a moderate impact.

Minor impact

Affects a specific group of localized individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself.

Negligible

Any impacts below the minor category are considered negligible.

Source: Imperial Oil Limited and others (1978).

APPENDIX 2

Table 9. Significance evaluation and uncertainty at key stages in the EIA process (Wood 2008, Adopted from Hildén 1997).

Table 1
Significance evaluation and uncertainty at key stages in the EIA process

EIA process stage	Purpose of ignificance evaluation	Minor impacts considered significant	Major impacts considered non-significant	Sources of uncertainty
Screening	Identification of development proposals requiring formal EIA	• Competent authority loses credibility. • Costs to the developer of initiating an unnecessary EIA	• Controversy and conflict • Legal challenge • EIA occurs at a later phase of project planning	• Project design, technical processes and timing • Environmental and social receptors potentially affected
Scoping	Preliminary identification of impacts and issues requiring assessment	• Assessment resources subsequently wasted • Voluminous and unwieldy EIS	• Bias to focus of the subsequent assessment • Loss of trust, credibility and reduced legitimacy of the EIA	• Knowledge/understanding of the existing environment • Relevance/availability of environmental information • Future baseline conditions • Detailed project design • Divergence of opinion rekey impacts and valued environmental components • Likelihood of impact occurrence
Impact prediction and EIS production	Feedback to project design for change and/or mitigation. Identification, evaluation and communication of key impacts for the competent authority and the public	• Unnecessary mitigation raises project costs • Causes damage to the public profile of the project and increases opposition • "Overreaction" and possible rejection of feasible projects	• Biased assessment • Loss of credibility for proponent and competent authority • If detected later in the process: – project delays – mitigation "retrofitted" – future legal procedures – project stopped	• Measurement error in assessing baseline conditions • Estimating future baseline changes without the project • Accuracy and/or suitability of predictive methods used • Uncertainty over mitigation performance/ effectiveness • Lexical uncertainty in communication/ interpretation of impact significance
Monitoring/audit and impact management	Evaluation of impact predictions and mitigation effectiveness. Identify further mitigation requirements and focus management resources	• Attempt to mitigate environmental changes that are not related to the project or are costly to correct	• Loss of credibility for proponent and competent authority • Failure to recognise early warning signals • Costly rehabilitation	• Measurement error • Uncertainty in identifying impacts attributable to the project

Source: Adapted from Hilden (1997).

APPENDIX 3

Table 10. Examples of general good practices – impact significance determination (Lawrence 2007c)

Criteria	Examples of Practices
Focused/efficient	• Focus efforts and resources on matters critical and relevant to decision-making. • Focus on key sustainability requirements and cumulative effects. • Focus on major community issues and tradeoffs. • Consider insights and lessons from comparable projects and environments in focusing significance determinations.
Consistent/unbiased	• Guard against advocacy and bias. • EIA guidelines (generic and project-specific) should explicitly and consistently address impact significance. • Ensure that comparable situations are treated in a comparable manner. • Ensure that alternatives are treated consistently. • Apply thresholds, criteria and significance determination procedures consistently.
Clear/explicit/understandable	• Clearly describe all procedures. The explanation of the approach should be straight-forward and non-technical. • Distinguish among impact magnitude, impact likelihood, environmental significance and impact significance. • Address significance with and without mitigation and enhancement. • Address significance of positive and negative effects. • Address significance of individual and cumulative effects. • Explicitly integrate public and agency concerns and preferences. • Distinguish, where appropriate, significance of impacts for various project phases, for various study areas, and for various time horizons. • Use illustrative materials where can facilitate understanding. • Make use of explicit criteria and decision aids whenever practical and appropriate.
Comprehensive/systematic/traceable	• Ensure a coherent, transparent and orderly procedure for integrating impact characteristics, environmental characteristics, contextual factors, institutional requirements and objectives, and the perspectives and concerns of interested and affected parties. • Ensure that the significance of positive, cumulative, and socio-economic effects are addressed. • Ensure that other parties can independently reconstruct how judgments were derived from relevant inputs. • Address significance for each EIA activity, with appropriate adjustments to reflect character of each activity.
Logical/substantiated/reasoned	• Text should be concise and thoughtfully reasoned. • Substantiate all methods and assumptions. • Interpretations and conclusions should flow logically from support materials. • Fully substantiate all thresholds, criteria, scaling levels and indicators. • Ensure that judgments are supported by qualitative and quantitative data, clear evidence, logical deduction and reasoned arguments. • Ensure that the attribution of significance is made in a rational, defensible and problem-relevant way.
Integrates knowledge	• Build on knowledge base established through EIA quality and effectiveness analyses (e.g., good practice principles). • Ensure that full use is made of technical and scientific knowledge. • Ensure that full use is made community and traditional knowledge. • Integrate lessons and insights from good practice significance determination procedures.

Criteria	Examples of Practices
Manages uncertainties	• Be explicit regarding level of confidence in significance judgments. • Ensure that the significance determination process is conducive to identifying and managing uncertainties. • Identify significant knowledge gaps and relevance to significance determination. • Use, as appropriate, uncertainty as a significance criterion, as a rationale for elevating scaling levels or as a trigger for mitigation, enhancement, monitoring or project rejection. • Explicitly consider the implications of information loss as focus and summarize. • Recognize action limits and uncertainties, especially regarding mitigation and enhancement effectiveness. • Integrate, as appropriate the Precautionary Principle into significance determinations. • Where uncertain, seek to minimize the consequences of being wrong regarding both impact prediction and mitigation/enhancement effectiveness.
Effective/decision-making support	• Ensure consistent with EIA and environmental regulatory requirements. • Link to international standards, conventions and guidelines. • Link to national and territorial policies and standards. • Assess in terms of compliance with land claims agreements and treaty rights.
Open/inclusive/involves public	• Define significance broadly. Burden of proof should be on those seeking to define more narrowly. • Ensure the involvement of technical specialists. •Ensure the direct, early and ongoing involvement of interested and affected parties. • Ensure that consultation methods appropriate to the characteristics and needs of each interested and affected party. • Consider public and agency concerns and preferences. • Ensure that the approach facilitates the involvement of all interested and affected parties.
Collective/collaborative/facilitates learning/facilitates conflict resolution	• Address impact significance from multiple perspectives. • Collaboratively design and adapt impact significance approach. • Ensure that significance determination approach is conducive to collaboration with interested and affected parties. • Ensure early, effective and frequent links to the broader public. • Ensure that membership in interactive forums reflect the full range of interests and values associated with the proposed action. • Make effective use of alternative dispute resolution, where appropriate. • Provide procedural assistance and training to participants, as appropriate.
Democratic/empowering/facilitates public support	• Employ simple to use and widely supported criteria, thresholds and decision rules. • Intensity and extent of public controversy can be a useful significance criterion. • Focus on what people consider is significant, in either a positive or negative sense. • Make a concerted effort to support rather than inhibit local and regional democratic decision-making.
Appropriate to context/real/genuine	• Place within the context of local and regional issues, conditions and challenges. • Link judgments to local perceptions, and to local and regional ecological, social, economic and political problems and challenges. • Place within the context of historical, current and emerging conditions. • Ensure that the significance determination methods and procedures are appropriate to the culture and to the social, ecological, economic, legal and political setting. • Take into account regulatory framework including relevant historical decisions.

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Criteria	Examples of Practices
Appropriate participant roles	• Ensure that the roles of all parties in the significance determination process are clear and substantiated. • Make effective use of fully qualified specialists, with adequate local and regional experience and knowledge.
Adaptive/innovative	• Focus on those environmental components most susceptible to change and on likelihood and ability to enhance capacity to adapt to and manage change. • Ensure that process for determining significance can adapt to varying roles in the process. • Immediately seek to correct and resolve misinformation and misunderstandings. • Ensure that the significance determination process can be adapted to changing circumstances. • Hedge away from large losses and give greater weight to vulnerability. • Adapt approach to characteristics and needs of each interested and affected party.
Value-full/ethical/favours most vulnerable	• Focus on major values and value tradeoffs. • Ensure that the value basis for all judgments can be readily understood. • Devote particular attention to the most vulnerable environmental components and segments of society. • Provide measures to offset procedural inequities. • Take into account the interests, values and concerns of each interested and affected party. • Make a particular effort to involve those most directly affected, most vulnerable to change and least likely to be able to participate in the process.
Substantive/facilitates environmental enhancements/sustainable	• Ensure that the approach is conducive to the realization of substantive objectives. • Distinguish between ecological and socio-economic importance. • Place within the context of corporate and institutional social and environmental sustainability policies and objectives. • Analyze and interpret impact significance for each valued socio-economic and ecological component. • Ensure that the significance determination approach culminates in a judgment about project acceptability from a sustainability perspective.

Table 11. Good practices – addressing significance determination challenges (Lawrence 2007c)

How to select a significance determination approach or approach combination

- Select approach or approach combination best suited to context.
- Adapt to context jointly with interested and affected parties.
- Ensure approach consistent with procedural and substantive objectives.
- Ensure good general practices and approach—specific good practices.
- Adapt to changing circumstances and preferences.

How to adapt the approach to fit the context

- Determine relevant project characteristics (e.g., components, time horizons, study areas).
- Review documents, web sites, oral histories and newspapers to identify historical and current issues, concerns and perspectives.
- Review documents to provide a sense of historical, current and likely future physical, ecological, social, cultural, economic, political and legal–administrative conditions and interactions.
- Review available submissions from interested and affected parties to identify major perspectives, issues, concerns and preferences.
- Consider pertinent laws, policies, treaty rights, agreements, values and interests.
- Consider relationships to other past, present and reasonably foreseeable future actions.
- Hold scoping sessions with general public and with a cross-section of interested and affected parties.
- Interview community leaders and most directly affected groups and individuals.
- Attempt to derive approach or approach combination most consistent with context.
- Design, refine, apply and adapt approach jointly with interested and affected parties.

How to evaluate impact significance determinations in EIA documents and procedures

- Review whether explicit and broad procedural and substantive significance determination objectives.
- Assess whether appropriate to local and regional context.
- Determine if reflects perspectives and positions of all major parties.
- Review if clearly defined, substantiated and applied thresholds, criteria and procedures.
- Determine if consistent with good general practices.
- Determine if consistent with approach good practices.
- Determine if consistent with procedural and substantive objectives.
- Determine if consistent with good practices for determining significance of positive, cumulative effects, socio-economic effects, the application of the Precautionary Principle and sustainability.
- Review adequacy of explanations for differences in conclusions regarding impact significance between documents and interpretations of other parties.

How to deal with tradeoffs among study areas (e.g., local, regional, national) in impact significance determinations

- Aim to achieve net benefits at each scale.
- Identify impacts that are locally, regionally and nationally significant. Manage at each level.
- Distinguish significance of impacts for various study areas and time horizons without ranking study areas or time horizons.
- Recognize that many interactions of impacts across study areas and time horizons. Consider implications for impact significance determinations.
- Make particular effort to prevent and offset adverse impacts and to provide lasting benefits at local and regional scale because larger scales inherent in project purpose and more severe impacts tend to be concentrated at local and regional scales.

What to do when there are multiple conflicting perspectives regarding which impacts are more significant and why

- All parties should provide full and succinct substantiation for significance judgments.
- Identify and explore nature of and reasons for perspective differences.
- Identify and explore validity of significance judgments by each party.
- Explore potential use of forums (including alternative dispute resolution) to see if parties can reach consensus regarding impact significance and how best to manage.
- Consider use of independent peer review to evaluate impact significance procedures and arguments by various parties (could include recommendations for resolution).
- Explore overlaps and gaps to determine potential for identifying middle ground positions that could be acceptable to all parties.
- Make difficult decisions regarding impact significance and substantiate basis for judgments.

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What to do when public perceptions regarding what is significant are inconsistent with technical and scientific predictions and interpretations of impact magnitude, likehood and significance

- Review basis for all predictions (with or without peer review).
- Review basis and scope of all significance determination thresholds, criteria and decision rules (with or without peer review).
- Explore with each party rationale for interpretations.
- Clear up any misunderstandings and misconceptions.
- Review against experience with comparable projects in comparable environments.
- Initiate forums for parties to attempt to resolve perspective differences (with or without alternative dispute resolution).
- Ensure adequate allowance for uncertainties and potential repercussions of uncertainties.
- Explore whether concerns can be addressed through additional impact management.
- Allow for monitoring and management of perception-related impacts.

How to integrate significance interpretations into impact management

- Use mitigation and enhancement potential and/or reversibility as significance criteria.
- Focus mitigation and enhancement measures on potentially significant impacts. Where practical, apply to all adverse impacts.
- Examine potential for significant effects from mitigation and enhancement.
- Address significance of impacts, with and without mitigation, for both individual and cumulative effects.
- Monitor potentially significant impacts. Test accuracy of impact predictions and reliability of impact management measures.
- Take into consideration uncertainties regarding likelihood of significant impacts and the effectiveness of mitigation and enhancement.
- Monitoring should include, where practical, explicit significance thresholds and criteria, and explicit procedures to be enacted when monitoring detects potentially significant impacts.
- Roles of each party in determining and managing potentially significant impacts should be clearly defined.

APPENDIX 4

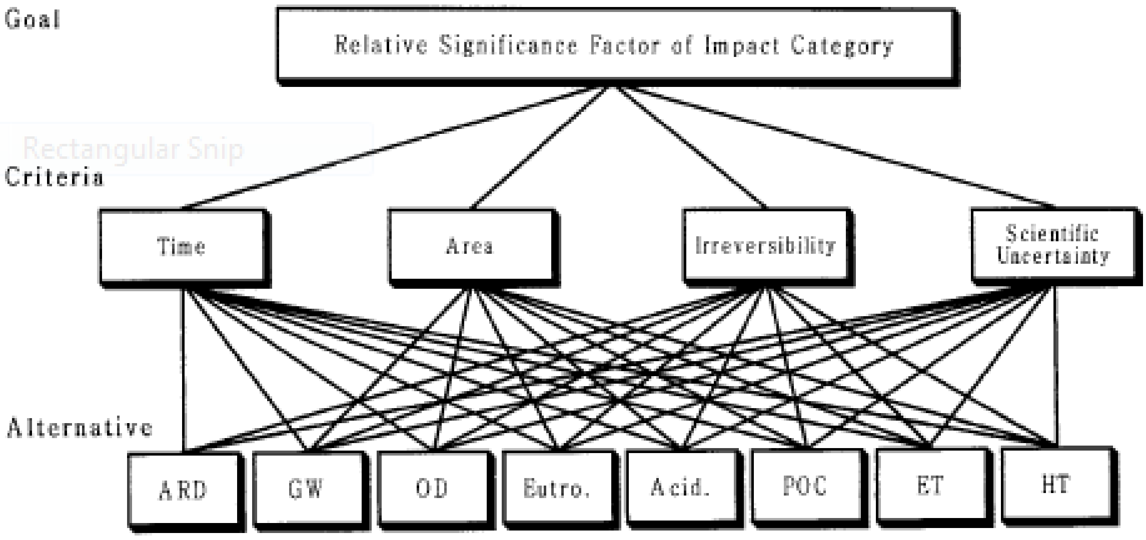

Figure 1. Structure of the hierarchy for the determination of f_i.

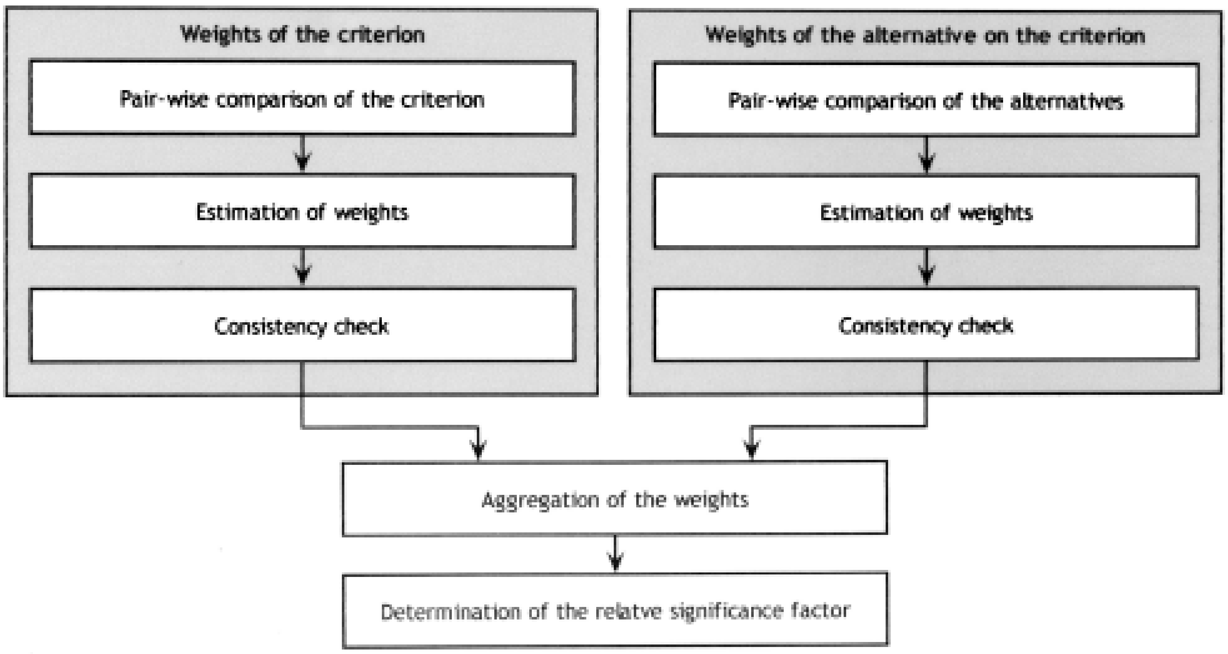

Figure 2. Steps for the determination of f_i based on the AHP.

Figure 3. Analytic Hierarchy Process (Noh and Lee 2003).

APPENDIX 5

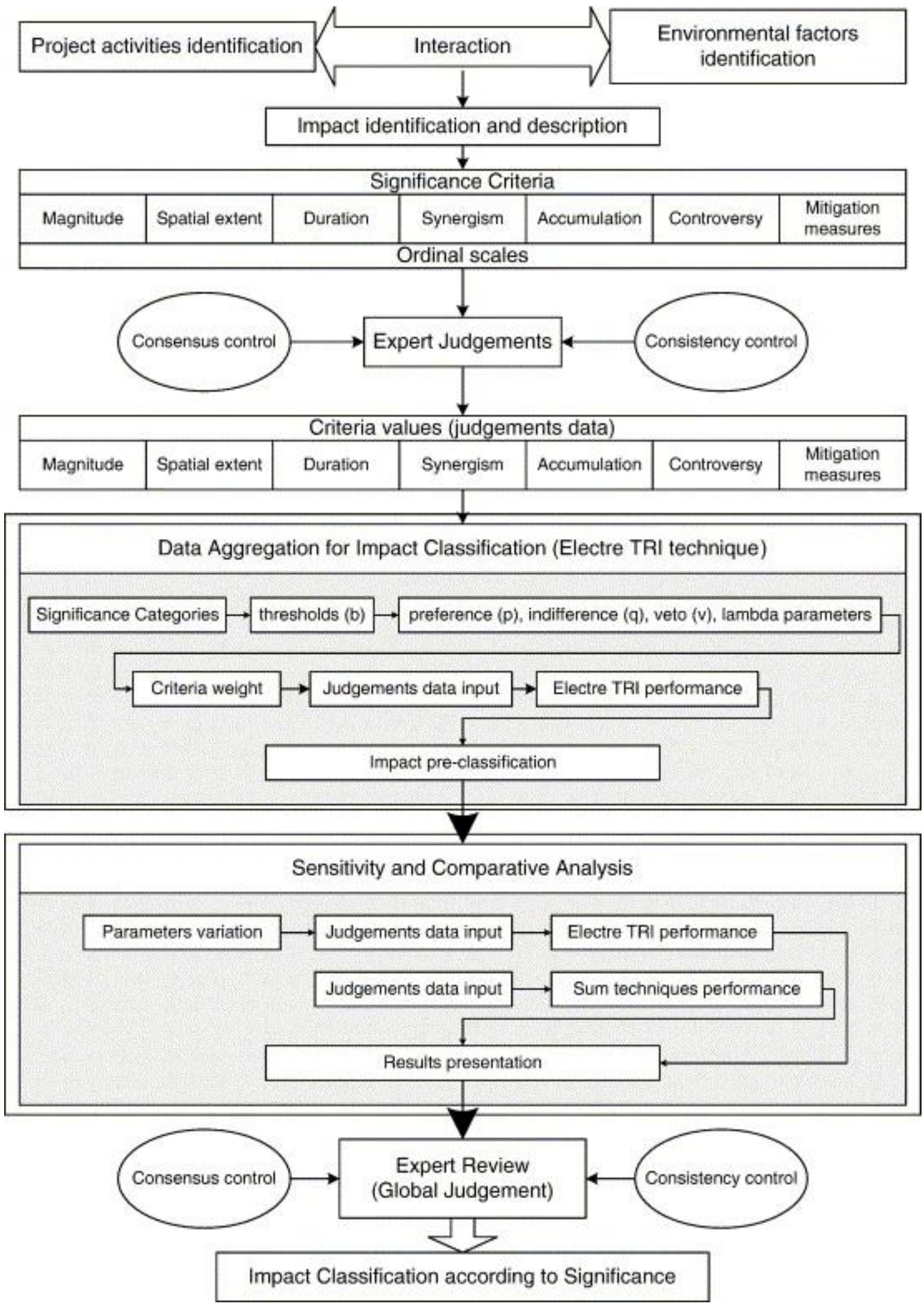

Figure 4. Phases of the MCDA supported methodology (Cloquell-Ballester et al. 2007).