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The Quality of the Environmental Impact Assessment Process for Public Road Projects: A Case Study in Spain

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Abstract

Environmental impact assessments (EIAs) apply criteria to minimize the negative effects of projects on the environment. However, the EIA process has been criticized by European environmental organizations and governments. One common criticism deals with the fact that the responsibility for creating the environmental impact statement (EIS) normally belongs to the project's promoter; another is the lack of rigor in the criteria for accepting or rejecting these studies. In 1994, the European Commission developed a procedure to evaluate the quality of such studies. In the present research, our objectives were to assess the quality of a sample of EIS documents created from 1990 to 2002 by the Spanish Autonomous Administration of Valencia and to assess the efficiency of the European Review Checklist method. We statistically evaluated 40 EISs, then undertook a qualitative appraisal of the documents. Next, we applied the European Review Checklist to the sample documents to appraise their quality. Based on the results of this analysis, we proposed and applied a new evaluation methodology. We assessed the overall quality by consecutive application of the three methodologies. We report important advantages of using the improved appraisal methodology and discuss the results. We found that combining qualitative analysis with a checklist that supports a more rigorous appraisal methodology improved the reliability of assessments of EIS quality, and that the technical level of the EISs should be improved, along with the accuracy and objectivity of the review tools. Based on these results, we recommend that formal measures be implemented to control and monitor the quality of EISs.

Keywords: Environmental impact assessment; Environmental impact statement; Quality control; Review checklists

Aim of the Research

We analyzed a large, representative sample of environmental impact assessment (EIA) dossiers for existing public road projects in the context of ongoing research by the Valencia Polytechnic University. Our main objective was to evaluate the degree of quality control during the different stages of the EIA process. The research described in this paper dealt with the task of accurately determining EIS quality based on a case study of specific public roads projects in the Valencia region of Spain that evaluated the methodology. We studied EIS quality both qualitatively and using standard quality-assessment tools so as to compare the results and evaluate the effectiveness of the quality control tools recommended by the European Union (EU). The first step in our research was to choose a representative sample of EIA dossiers, which included each road project, EIS, public participation document, and public environmental committee assessment. The Valencian Government provided us with 40 EIA dossiers out of the 100 dossiers that had been created since the relevant Spanish environmental legislation was enacted (in 1990) and ending in 2002. This sample was chosen based on specific parameters such as the year of creation, type of road construction projects, ecological importance of the affected area, and project importance, with the goal of obtaining a diverse sample. We did not restrict the Valencian Government's choices and none of the selected dossiers were refused. The information required for the first part of our research comprised the project description and the EIS. Based on these two documents, we completed our research in four stages:

1. Data collection and statistical analysis of the EISs; qualitative analysis of the EIS.

2. Analysis of a selected official review checklist [1] its application, and the resulting quality.

3. Design of an improved quality assessment methodology to improve the structure, application, and results of the quality-control tool.

4. Comparison of the results from the previous three stages.

Deficiencies in EIS quality Appraisal

Development of the EU's Environmental Impact Assessment Policy has been criticized from the start because of doubts over its application and effectiveness. An EIA is considered effective if the information generated by the EIA contributed to decision-making, if its predictions of the effectiveness of impact-management measures were accurate, and if the proposed mitigation and compensatory measures achieved the approved management objectives [2]. The most important quality-control feature of an EIA is the review stage, which helps to ensure that all information concerning the environmental impacts of an action is adequate before the information is used as a basis for decision-making [3]. The main concerns that have been raised about the EIA process involve the lack of rigour of the EISs, and the transformation of the EIA into a routine bureaucratic "tax" [4]. Moreover, these kinds of studies are inherently complex due to the heterogeneous disciplines they involve [5]. Assessing EIS quality is difficult because the analysis must address three complementary perspectives. First, the EIS is a technical document used to delimit the potential environmental impacts of a project, and combines a range of methodologies. As far as possible, these techniques are quantitative, but some are only descriptive (qualitative). The multidisciplinary approach required by an EIS cannot rely on specifically designed tools for environmental analysis, and must instead borrow these tools from a range of disciplines and adapt them to the unique needs of each specific evaluation. Second, the suitability of existing tools should be analyzed to ensure that these tools

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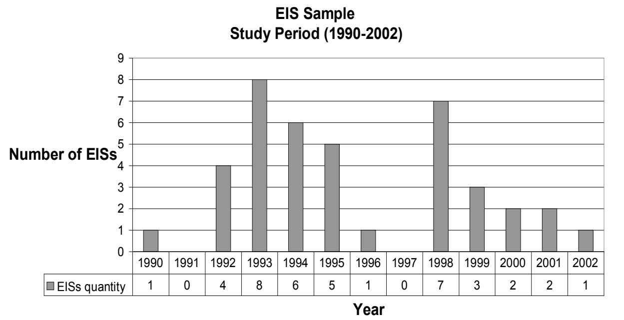
can adequately assess the quality of the EIS. Most tools are similar in terms of their question formats and the methodologies used to assess the quality of the documents. In order to reduce the subjectivity of quality analysis, the assessments are based on the work of a team of experts that must reach consensus on the team's decisions. Third, the optional nature of the quality-control process under EU legislation means that success depends on the commitment of the reviewers. These individuals often have differing needs, constraints, and points of view. Section 4 of the report on the application and effectiveness of the revised EIA Directive 85/337/EEC [6,7] notes that there is little quality control over the content, depth, and adequacy of the environmental information submitted by the developers of the EIS.

Approach to our Research

The suitability of the information to be included in an EIS must be evaluated in the context of the theoretical basis for EIS quality: What should an EIS be, and what deficiencies are involved in this definition? Our research into this definition relied on EU, Spanish, and Valencia EIA legislation; the latter was particularly important given the administrative decentralization of Spain. Starting from this theoretical basis, we obtained 40 EIA dossiers. We then studied the documents in depth to ensure a comprehensive understanding. The first step in our analysis was to characterize the main data in the EISs and perform statistical analysis to support the first stage of our quality appraisal, namely qualitative characterization of the EISs. The qualitative appraisal involved a study of the rational mechanisms behind decision-making, the creation of a quality scale, and subsequent comparison with the results of other methodologies. We analyzed the following main variables (Figure 1): the road network type, the consultancy companies responsible for the EIS, the team members and their credentials, the identification methods and impact-assessment typologies, the proposed alternatives and decision-making options, and the protective, corrective, and compensating measures that were proposed. Analyzing these variables in the context of the ElA legislation provides a qualitative approach to determining the suitability of the different areas included in each EIS (Figure 1).



Main Project Data

Type of Project	Road construction
Developer	Valencia Autonomous Government
Study Period	1990 - 2002
Sample size	40 projects and 40 EISs
Total number of EISs issued during study period	100
No. of expert teams	27
Number of experts per team (range)	1/15
Number of experts per team (median)	4.5
EISs contracted per team (range)	1-5
Total number of professional degrees	20
Construction budget (range, in Euros)	631 063 - 56 018 213
Total construction budget for sample EISs (Euros)	350 785 679
Construction budget (median, Euros)	8 769 642
Mitigation measures budget (range, Euros)	36 548 - 5 630 017
Mitigation measures budget (median, Euros)	591 982
Length of road affected by the project (range, m)	580 - 21 000
Length of road affected by the project (median, m)	6.599
Length of EISs (range, pages)	19 - 171
Total length of EISs (pages)	3 264
Length of EISs (median, pages)	81.6
Total length of projects (pages)	18 532

Figure 1: Data obtained for the EIS samples and for the main project.

Standard EIS Quality tools in the EU

Several similar tools have been developed to support EIS reviews in the EU: the Review Package [8], the Review Checklist [1], and the EIS Review [9].

The Review Package [10] contains a set of 52 hierarchically arranged questions at three levels: four review areas are each divided into review categories, and each category is divided into sub-categories. The reviewer begins by rating the quality of the responses to each question in a given sub-category using a standard six-point scale, then moves upwards to the next level (the category), and once again applies the assessment scale. The reviewer then repeats this process at the highest level (the review area). At this level, reviewers are expected to use personal judgment and the assessment should not be based on simple averaging of the assessments for the sub-categories or categories. The method promotes objectivity in the review process by recommending separate review of the EIS by two independent reviewers, who should then discuss their ratings and reconcile any differences before presenting a joint conclusion.

The Review Checklist [1] is arranged into eight review areas:

1. Project description.
2. Outline of alternatives.
3. Environment description.
4. Description of the mitigation measures.
5. Description of the impacts.
6. Non-technical summary.
7. Difficulties in compiling the information.
8. General approach.

Areas 1 to 7 match those requested in Annex III of Directive 85/337/EEC [11], which governs the writing of the EIS. Area 8, the general approach, has been added to allow reviewers to check the organization information and presentation in each EIS. As with the Review Package, specific questions (82 in all) are provided for each area to identify the kind of information that must be provided by the EIS and to determine whether there are omissions or shortcomings in the information. The Review Checklist includes a three-point ranking scale for each question:

1. Complete: All information relevant to the decision-making process is available.
2. Acceptable: The information presented is incomplete, but the omissions do not prevent the decision-making process.
3. Inadequate: The information contains major omissions that would interfere with the decision-making process.

The Review Checklist also suggests an overall five-point quality scale for the EIS: Excellent, Good, Satisfactory, Inadequate, and Deficient. It does not, however, propose how to link the two scales. Finally, the EIS Review [9] is arranged into seven areas with a total of 143 questions. When reviewing a single EIS, the EIS Review method suggests two possible answers to each question: "Yes" if the information provided is sufficient for decision-making and "No" if it is not. When the EIS Review is used to produce an overall rating, the reviewer uses a five-point ranking system that ranges from A ("Full provision of information with no gaps or weaknesses") to E ("Very poor provision of information with major gaps"). The EIS Review states that to provide an overall grade, the reviewer aggregates the rankings for the individual review questions in each of the seven areas, then aggregates these seven composite rankings to provide an overall grade. This aggregation requires subjective judgment (i.e., again, the aggregate values are not calculated as a simple average), and the EIS review provides the following example for one area with 10 review questions: If 9 are graded B and 1 is graded A, an overall grade of B is considered reasonable. In contrast, if 9 had been graded B and 1 had been graded E, then an overall grade of D would be appropriate.

Selection of the Checklist to be used in our Research

Of the three checklists described in the previous section, the ones that have been studied most are the Review Package and the Review Checklist. In a performance evaluation of the EIA process [12], researchers from EU Member States were asked to evaluate EISs using both tools. The overall level of agreement between the two checklists was 76%. There was no agreement about which instrument was easier to use; most preferred the Review Package, probably because it was more familiar. However, most believed that the Review Checklist was more easily adaptable to different contexts, and some found that its wording, coverage, and emphasis were better than those of the Review Package. However, the Review Checklist was criticized for being too detailed and time-consuming to use. In the present research, we chose the Review Checklist because we felt that its wording and emphasis were superior and it provided a wider range of questions than the Review Package, thereby improving its coverage. Its organization into areas exactly matched the organization prescribed by European and Spanish EIA legislation. Finally, although the EI Review included more questions (143 vs. 82), it had been studied less and was published after our research had already been underway for 1 year.

Methodology

Stage 1: Qualitative appraisal

Our first level of research qualitatively appraised the 40 EISs in our sample. To do so, we used traditional qualitative decision-making processes [13,14] that focused on rational decision theory [15,16]. The tools that we required were profound knowledge of the EIA dossiers and the identification of variables, factors, and alternatives through an iterative process of testing and refining a sequence of tentative formulations to reach the final EIS quality appraisal. We improved the identification of all the factors by evaluating their completeness, consistency, and relationship to subjective judgments. The decision-making method we applied to arrive at the final result was the "individual decision in an established group" approach of Jelassi and others [17], in which an expert reviewer makes the final decision, although all reviewers take part in the decision-making process. In this paper, all such reviews involved only the two authors of the present paper. Once the necessary data was obtained and analyzed, and the iterative process produced a quality result that served as the basis for comparison in subsequent stages of our research, we chose the same final quality scale for each EIS, whatever tool was applied: the five rankings provided by the Review Checklist (from Excellent to Deficient).

Stage 2: Review checklist appraisal

We selected the Review Checklist to evaluate the sample EISs based on the questions in each of its eight areas, with three possible grades (complete, acceptable, and inadequate). Once all questions for an area had been answered, we obtained a final quality rating using the same five grades used in Stage 1. To consolidate the results at the level of individual questions into an overall grade for the EIS, we used the same decision-making approach as in Stage 1 of the research and the "individual decision in an established group" method of Jelassi and others [17]. As in Stage 1, no other tools were required.

Stage 3: Analysis of the Review Checklist patterns, and design and use of an improved methodology

During this stage, we analyzed the Review Checklist results to determine whether its structure could be improved, even though its questions were well developed and covered the main aspects of EISs and its qualitative scale did an adequate job of defining the EIS suitability for each question. At this point, the Review Checklist provided no guidance on how to reach a final EIS rating; that is, there was no method reviewers could follow to objectively and consistently summarize the question results to produce the final assessment. Our goals in improving the methodology were to facilitate expert analysis and to reduce the subjectivity and uncertainty that arise during the hierarchical grading process. In addition, we needed tools for defining EIS quality that could support the consensus approach that produces the final decision. In this stage, we retained the two qualitative scales used by the Review Checklist. However, we needed to develop a means to link the two since it is difficult to transform a three-point scale (for the questions) into a five-point scale (for the final decision). In addition, we felt that a quantitative ranking would do a better job of synthesizing multiple grades than its qualitative equivalent because it reduces the burden on working memory as well as the subjectivity when goals and values differ among reviewers and also reduces the tendency to change the conclusion to reflect previous decisions [18]. On the other hand, it is not appropriate to base a decision only on a quantitative (mathematical) model because social, economic, and cultural aspects of the decision must also to be taken into account [19]. Our proposed improvements to the original model had to deal with this dichotomy between qualitative and quantitative options. The first step was to make the process hierarchical so we could define the principal levels and clarify the main phases on which to focus [20,21]. The Review Checklist was clearly arranged in three main levels (question, area, and overall EIS) and the task was to design a standardized method that linked all three levels. We proposed transforming the three-point qualitative assignment at the question level into a quantitative grade by assigning a value of 1 to "complete", 0.5 to "acceptable", and 0 to "inadequate". This approach generates an "obtained value" assigned by each expert reviewer that can be compared with a "potential value" that represents the maximum possible score for each question (i.e., a value of 1). The decision-making process to grade the suitability of the EIS for each question and produce the obtained values was also carried out with the aforementioned "individual decision in an established group" method to provide a basis for comparison. The sums of the obtained values and of the potential values for the questions in each area equal the corresponding obtained value and potential value at the area level (Figure 2). Following this approach, the sum of the obtained values and potential values for all eight areas would result in a final obtained value and potential value at the EIS level, and the quality appraisal would be complete. Using this approach, it is not possible to directly compare the results between two EISs because the relative weights placed on each question or area may differ; that is, the two EISs are not homogeneous. This suggests that it is necessary to include a means of assigning a relative importance to each question or area.

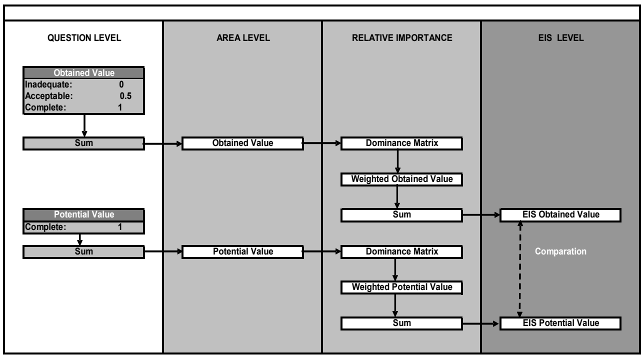


Figure 2: EIS quality appraisal: application of the weighting methodology.

Therefore, in order to allow a more objective comparison between EISs in our research sample, increase the objectivity of the final results, and obtain a convergence of judgments, we introduced a dominance matrix [22,23] and applied it to the obtained and potential values for each area, as shown in Figure 2.

We developed a dominance matrix that contains the weights for each of the eight areas of the EIA report to assess their relative importance in each document based on the type of project (e.g., public roads) being assessed. The dominance matrix is square (i.e., one row and one column for each of the eight areas being evaluated). The rows represent the dominant factor, and each dominant factor is compared with the seven other factors (the dominated factors). If factor 1 in the dominant row is more important than factor 2 in the dominated column, factor 1 receives a weight equal to 1 and factor 2 receives a weight of 0. Thus, cell (1,2) of the matrix will hold a weight value of 1, and cell (2,1) will hold a weight value of 0 because these two cells are complementary. However, because few factors are completely unimportant in comparison with other factors (i.e., there should be few values of 0 in the matrix), it is more accurate to assign values between 0 and 1 to each pair of factors, as shown in Figure 3. In our research, we assigned the weighting factors to each area using the "individual decision in an established group" method [17]. Once the dominance matrix is completed, the sum of the weight values for each row indicates the most dominant factors (i.e., the ones with the highest values). However, the scale obtained in this way is ordinal and cannot be used for algebraic operations. We thus transform this scale into a numerical one such as 0 to 10 or 0 to 100 by assigning a value of 10 or 100 (respectively) to the maximum value; the remaining relative values are expressed as proportions of this maximum value. The numerical scale obtained in this way corresponds to the relative weights of each EIS area. In the present research, we chose a scale of 0 to 10. To demonstrate this approach, we have provided the results for EIS sample 36-2000 in Figure 3.

In each EIS, the relative importance of an area depends on the project type, the surrounding environment, and other factors. By applying the numerical relative importance value obtained from the dominance matrix to each EIS area's values obtained by applying the Review Checklist approach; we obtained weighted obtained values for each area. The sum of all weighted obtained values for the eight areas provides the EIS final score. Similarly, by applying the numerical relative importance value obtained from the dominance matrix to the potential values obtained using the Review Checklist approach, which represent the maximum possible score, we obtained weighted potential values; the sum of all weighted potential values provides the potential EIS score. The final step in the process is to match the final EIS score to the proportional scale used for the potential EIS score, which is the EIS final quality scale suggested by the Review Checklist (i.e., Poor, Inadequate, Satisfactory, Good, and Excellent). In this way, we obtain a final quality using the improved Review Checklist methodology. An example of this process is provided for EIS sample 36-2000 in Figure 4.

Research Results

Stage 1: Qualitative appraisal

We identified 27 different expert teams in our sample of EISs: 20 consultancy firms had written 50% of the documents, and 7 had written the remainder. This latter group included 5 companies that had each written 3 to 5 reports (50% of the sample). Because the number of consultancy firms was so high, we feel confident that our results can be generalized and that the few companies that wrote multiple reports did not bias our results to any large extent. In each of the 40 samples, the same company hired to design the project was responsible for writing the EIA report. The teams included professionals with 20 different academic degrees, but in 15 of the documents (37.5%), the professional degree was not mentioned; thus, we only assessed this parameter for 25 documents. Civil Engineering was the most common professional degree; it appeared in 21 of the 25 documents (84% of the analyzed sample). The project description was the area most neglected by the experts. Deficiencies such as poor identification of the location, the lack of a map and other drawings, insufficient technical and construction details for the project, and unsuitable map scales in relation to the desired representation were common. The outline of alternatives was missing from a high percentage of the EISs (40% of the total). Of the 24

AREA LEVEL

EIA REPORT 36-2000: RELATIVE IMPORTANCE OF AREAS

Review Areas
1 Project Description
2 Outline of Alternatives
3 Environment Description
4 Description of the Mitigation Measures
5 Description of Impacts
6 Non-Technical Summary
7 Difficulties in compiling information
8 General Approach

M (1.2) + M (2.1) = 1

DOMINANCE MATRIX

	1	2	3	4	5	6	7	8	Ordinal	Score 1-10
1		0.5	0.6	0.4	0.4	0.9	0.8	1	4.6	8.8
2	0.5		0.6	0.4	0.5	0.9	0.8	1	4.7	9
3	0.4	0.4		0.4	0.4	0.8	0.7	0.9	4	7.7
4	0.6	0.6	0.6		0.6	1	0.8	1	5.2	10
5	0.6	0.5	0.6	0.4		0.9	0.8	1	4.8	9.2
6	0.1	0.1	0.2	0	0.1		0.3	0.8	1.6	3
7	0.2	0.2	0.3	0.2	0.2	0.7		1	2.8	5.4
8	0	0	0.1	0	0	0.2	0		0.3	0.5

Review Area's relative importance score

4	Description of the Mitigation Measures	10
5	Description of Impacts	9.2
2	Outline of Alternatives	9
1	Project Description	8.8
3	Environment Description	7.7
7	Difficulties in compiling information	5.4
6	Non-Technical Summary	3
8	General Approach	0.5

Figure 3: Example of the relative importance methodology applied at the area level in the form of a dominance matrix.

EIS level

EIS 36-2000

	A Obtained Value	B Potential Value
PROJECT DESCRIPTION	4	17
OUTLINE OF ALTERNATIVES	2	3
ENVIRONMENT DESCRIPTION	4	8
DESCRIPTION OF MITIGATION MEASURES	7	11
DESCRIPTION OF IMPACTS	10.5	18
NON-TECHNICAL SUMMARY	4	5
DIFFICULTIES IN COMPILING INFORMATION	0	2
GENERAL APPROACH	5	12
Total	36.5	76

A Weighted Obtained Value	C Dominance Matrix Results	AXC	B Weighted Potential Value	D Dominance Matrix Results	BXD
4	8.8	35.2	17	8.8	149.6
2	9	18	3	9	27
4	7.7	30.8	8	7.7	61.6
7	10	70	11	10	110
10.5	9.2	96.6	18	9.2	165.6
4	3	12	5	3	15
0	5.4	0	2	5.4	10.8
5	0.5	2.5	12	0.5	6
		265.1			545.6

Grading scale	
0-109.1	Poor
109.2-218.2	Inadequate
218.3-327.3	Satisfactory
327.4-436.4	Good
436.5-545.6	Excellent

"Satisfactory Score"

Figure 4: Example of the relative importance methodology applied at the area level: results of the EIS quality appraisal using the dominance matrix in Figure 3.

EISs that did include this important area,the description was too brief: only 13 (32.5% of the total sample) were longer than 2 pages, and 27 reports (67.5%) did not include maps or drawings as complementary information. The environment description was one of the best areas in the sample EISs. Nonetheless, the written content often reflected a simplistic approach to the affected environment's distinctive qualities. Many parameters were not related to other key factors; for instance, the fauna of an area is not independent, but is strongly related to the flora, geology, climatic conditions, anthropogenic pressures, and other factors. The team responsible for writing the EIS is often driven by the project's promoters to make predictions based on irrelevant or incomplete data sets (Munn 1979). In our sample, no EIS accurately delimited the affected ecosystem; the environmental description was often incorrect and provided insufficient information about the location being discussed. The existence of scale-dependent changes suggests that the choice of scale may significantly affect the accuracy of an EIA study [24]. This can prevent the writers from reaching a well-balanced analysis of interactions between the environment and the project's impacts based on the approach prescribed by the legislation that is currently in force. A description of the mitigation measures and monitoring program was included in every EIS in our sample. However, this was not based on a thorough previous study, and therefore the proposed mitigation measures remained too general and questionable in their effectiveness. Furthermore, the mitigation measures assigned no confidence intervals to their results, leading to considerable uncertainty in what the actual results might be. An effective and detailed monitoring program was lacking in most EISs in our sample, so we must assume that this work is done during the construction of the project. Obviously, this means that there were significant information gaps in decision-making. In terms of the description of impacts, most of the sample documents were not delimited in time and space, and were based on weak previous studies. Again, no confidence intervals were provided for the impact assessment, and there was evidence of a lack of rigorous study of the relevant variables. The methodology used to assess environmental impacts revealed the use of matrices that showed the relationships between causes and effects, with a wide range of different variables, in 15 out of 40 reports (37.5%). Only 5 of the 40 EISs (12.5%) combined these matrices with qualitative observations, and only 5 more included a qualitative analysis. The remaining 15 EISs used specific methods such as the Leopold matrix [25] or the Gomez Orea matrix (Gomez [26]; 8 EISs, 20%), which are widely used in EIS design, as well as impact indicators or a combination of the abovementioned methods. The last three areas of the Review Checklist (the non-technical summary, difficulties in compiling the information, and general approach) were generally acceptable.

Figure 5 summarizes our qualitative appraisal of the 40 sample EISs.

Stage 2: Appraisal of the Review Checklist

The results in this stage of our research (Figure 6) indicate that half of the documents included in the sample (20 EISs) were rated either deficient or inadequate: 4 (10% of the sample) were deficient and 16 (40%) were inadequate. The remaining 20 EISs were at least satisfactory: 15 (37.5%) were satisfactory and 5 (12.5%) were good. No EIS was rated excellent.

Stage 3: Appraisal of the improved Review Checklist methodology

We then applied our improved Review Checklist and rated the sample EISs at the question level (Figure 7), area level (Figure 8), and EIS level (Figure 9).

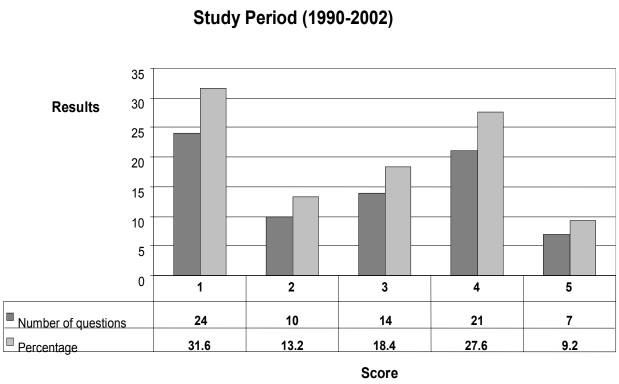
The results revealed that 27 of the 40 EISs (67.5%) were deficient or inadequate and that only 13 (32.5%) were satisfactory or good (Figure 9). No EIS obtained an excellent score, and only 1 obtained a good score.

Qualitative appraisal.	Study Period (1990-2002)		Period 1 (1990-1992)		Period 2 (1993-1996)		Period 3 (1998-2002)	
	EISs	%	EISs	%	EISs	%	EISs	%
Deficient	3	7.5	2	40	1	5	0	0
Inadequate	15	37.5	3	60	8	40	4	26.7
Satisfactory	14	35	0	0	8	40	6	40
Good	8	20	0	0	3	15	5	33.3
Excellent	0	0	0	0	0	0	0	0
	40	100	5	100	20	100	15	100

Figure 5: Results of the qualitative appraisal process.

Review Checklist appraisal.	Study Period (1990-2002)		Period 1 (1990-1992)		Period 2 (1993-1996)		Period 3 (1998-2002)	
	EISs	%	EISs	%	EISs	%	EISs	%
Deficient	4	10	2	40	1	5	1	6.7
Inadequate	16	40	3	60	10	50	3	20
Satisfactory	15	37.5	0	0	8	40	7	46.6
Good	5	12.5	0	0	1	5	4	26.7
Excellent	0	0	0	0	0	0	0	0
	40	100	5	100	20	100	15	100

Figure 6: Results of the Review Checklist appraisal process.



Score	Suitability Interval (%)	
1	(0 - 10)	Not Suitable
2	(10.1 - 25)	
3	(25.1 - 50)	
4	(50.1 - 75)	Suitable
5	(75.1 - 100)	

Figure 7: Results of the appraisal process using the improved Review Checklist at the question level and definition of the suitability intervals used to assign a score between 1 and 5.

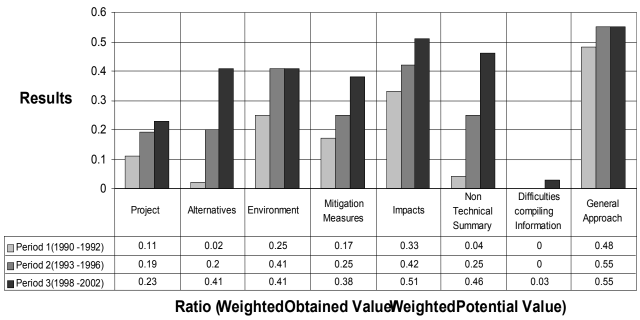


Figure 8: Results of the appraisal process using the improvedReview Checklist at the area level: changes between 1990 and 2002 across three periods.

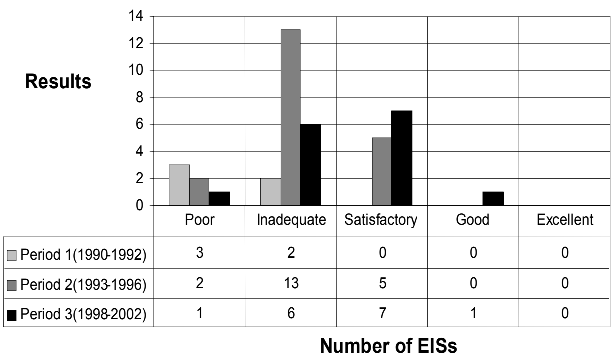


Figure 9: Final results of the appraisal process using the improvedReview Checklist for three study periods.

Stage 4: Comparison of the results from the first three stages

In this stage, we compared the results of our qualitative appraisal, of the Review Checklist, and of the improved Review Checklist. In general (Figure 10), the qualitative appraisal was most forgiving, and gave the largest number of satisfactory or good results; in contrast, the improved Review Checklist provided a much more rigorous assessment, and rated more reports as inadequate or deficient. The original Review Checklist fell somewhere in between these two methods.

Figures 11 and 12 summarize the level of agreement between the three assessment tools. The level of agreement between the three methods was generally poor: the methods provided the same rating for only 7 of the 40 EISs (Figure 11). Agreement was better, but still low, between pairs of methods: the Review Checklist and Qualitative Appraisal agreed in only 20 of 40 cases (50%), and the best agreement was between the original and improved versions of the Review Checklist (23 out of 40, 57.5%).

Study Period (1990-2002)	Qualitative Appraisal		Review Checklist application		Improved Review Checklist application	
	EISs	%	EISs	%	EISs	%
Deficient	3	7.5	4	10	6	15
Inadequate	15	37.5	16	40	21	52.5
Satisfactory	14	35	15	37.5	12	30
Good	8	20	5	12.5	1	2.5
Excellent	0	0	0	0	0	0
	40	100	40	100	40	100

Figure 10: Comparison of the results obtained by means of qualitative appraisal, the Review Checklist, and the improved Review Checklist.

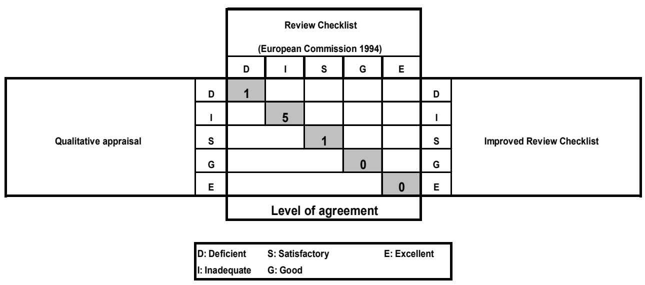


Figure 11: Comparison of the level of agreement between the three appraisal tools. Numbers indicate the number of EISs that received the same rating using all three tools.

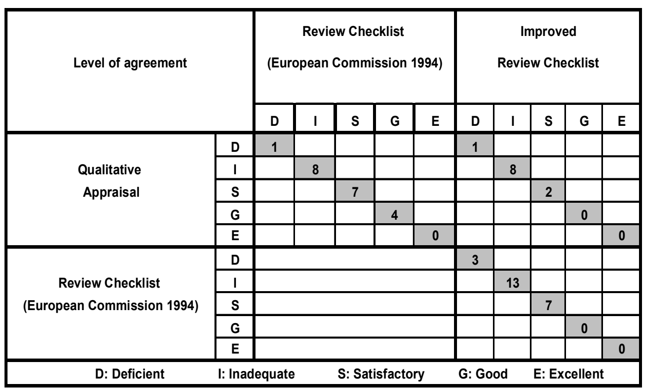


Figure 12: Detailed comparison of the level of agreement between pairs of tools. Numbers indicate the number of EISs that received the same rating using each pair of tools.

EISs quality results evolution depending on applying tool		Review Checklist (European Commission 1994)					Improved Review Checklist				
		D	I	S	G	E	D	I	S	G	E
Qualitative Appraisal	D	1	2	0	0	0	1	2	0	0	0
	I	3	8	4	0	0	5	8	2	0	0
	S	0	6	7	1	0	0	11	2	1	0
	G	0	0	4	4	0	0	0	8	0	0
	E	0	0	0	0	0	0	0	0	0	0
Review Checklist (European Commission 1994)	D						3	1	0	0	0
	I						3	13	0	0	0
	S						0	7	7	1	0
	G						0	0	5	0	0
	E						0	0	0	0	0

D: Deficient I: Inadequate S: Satisfactory G: Good E: Excellent

Figure 13: Changes in the EIS quality results of the qualitative appraisal after applying the Review Checklist and the improved Review Checklist, and changes in the results of the Review Checklist appraisal after applying the improved Review Checklist. Numbers in shaded cells represent identical results for the two tools; numbers in white cells represent the number of EISs that changed to that category.

It is also important to consider how the ratings changed between pairs of methods (Figure 13). For example, the qualitative appraisal agreed with the original Review Checklist in 20 of the 40 cases, but using this Review Checklist improved the rating of 7 EISs, and decreased the rating of 13 EISs. In contrast, the improved Review Checklist agreed with the qualitative appraisal in only 11 cases, improved the rating for only 5 EISs, and decreased the rating in 19 cases.

Discussion

Our results confirm the need to improve the design of EISs. We found persistent deficiencies in terms of a lack of vital information, some of which is compulsory under European Commission EIA legislation. For instance, reasons for selecting an alternative were missing in 40% of the EISs, an evaluation of net environmental impacts that accounted for the proposed mitigation measures was missing in 80% of reports, and a comparison of present and future scenarios with and without a project was missing in 100% of the reports, among other deficiencies. The Alternatives area of the report was similarly deficient. Although EIA legislation requires a study of the alternatives in every EIS, the authors of these reports showed a strong tendency to recommend the option being studied. This offers little opportunity to partially or totally modify the initial proposal. This is to be expected when the lack of a study of alternatives results in a failure to question the project promoter's original choices. Considering alternatives should be the first phase of project design and management [2], and is therefore one of the most important aspects of the whole planning process, but this step becomes difficult when promoters have not considered any alternatives. In terms of comparing present and future scenarios, it is important to note that the value of these scenarios lies not in their capacity to predict the future, but rather in their ability to provide insights into the present. In our study, not a single EIS included field sampling to characterize the baseline descriptions of the study area, and no reports assigned confidence intervals to both the impact evaluation and the mitigation measures. Analyses of impacts tended to be based primarily on weak previous studies. Much too often, the reviewers rely on their own values to decide what is important in the EIS and what considerations should be accounted for in the process [27]. In many cases, a qualitative analysis can be as accurate as a quantitative one if it is based on adequate previous studies. However, this was not the case for most of our sample documents. Professional impact assessors must effectively account for the subjectivity present in any decision, but must also objectively present all the facts to the decision-maker to achieve an effective, socially acceptable, well-informed decision-making process [28]. It is important to highlight the heterogeneity of professional qualifications (e.g., academic degrees) we observed in the relatively homogeneous projects (public roads) in our sample. The importance of including some professionals (such as landscape designers, chemical engineers, and industrial engineers) was not obvious in many cases, since these professionals appeared to provide limited contributions to the effectiveness of the EISs. We found no correlation between some of the analyzed variables, including the number of experts in the project developer's team and their credentials, the budget for materials and execution, the sensitivity of the ecosystem, and the difficulties in identifying impacts. This leads us to believe that the selection of the number and type of experts depends on their availability to the professional consultancy firm responsible for the project rather than on a conscious choice to select the most appropriate specialists for each project. Explanations of the social or logistical factors that define the project's requirements were also lacking, and this information is clearly important to acknowledge the needs of the public that should participate in the EIA process. Neither was any information provided on social attitudes (approval or aversion) towards the project. It could also be crucial to define the surrounding area that would be affected by a project, and to consider possible synergies between proposed projects and completed or proposed nearby projects, yet none of the reviewed samples contemplated this step. Finally, consultants must account for the difficulty of avoiding subjectivity, particularly under pressure from project proponents to provide favorable assessments [29]. In our research, this problem was exacerbated by the fact that the consultants chosen to design the project were always the same group required to write the EIS, so the objectivity of these reports is likely to be compromised. Our results clearly suggest that the value and efficiency of the EISs must be guaranteed by means of a more effective approach in order to prevent these assessments from becoming nothing more than a bureaucratic formality for the project's promoters. Unfortunately, current European and Spanish EIA legislation only specify the areas that an EIS must include, but provide no methodology that EIS writers must follow and no specific guidelines for the best decision-making methodology. Several EIS technical guidelines exist; for example, an official guide has been developed by Spain's Environment Ministry [30] that covers different techniques for studying each environmental aspect (e.g., water, soil, air, noise), but not the different methodologies for analysing and evaluating project impacts and their relationships and not the baseline conditions under which each method should be selected. In our research sample, 7 consultancy firms wrote more than one EIS, and each used exactly the same method to identify impacts for every EIS they designed. In most cases, they used the same technique for impact appraisal despite differences in baseline conditions, factors, and variables. The profile of the professionals participating in the team of expert reviewers in each case varied; thus, rather than requiring the professionals to choose the approach, EIS regulations should prescribe standard guidelines for writing an EIS and choosing the best decision-making alternative (Figure 14).

The results of our comparison of the three quality tools confirm the results of previous studies: at least half of the EIS samples had unacceptable quality no matter which tool was applied. The results of our comparison showed that using tools such as the original and improved versions of the Review Checklist constrains the process of quality appraisal and promotes rational decision-making by ordering the factors, alternatives, and options into a hierarchical system that supports the team in reaching a final decision; this standardization of

Redacting team Code	Improved Review Checklist application results	EIS Code	Professional team members	Impacts Identification Methodology	Impacts Evaluation Methodology
N	Inadequate	25-1996	2	1	8
	Inadequate	23-1995	6	1	5
	Inadequate	35-1999	8	1	6
M	Satisfactory	22-1995	No mention	1	9
	Satisfactory	39-2001	15	1	12
C	Deficient	3-1992	No mention	1	10
	Inadequate	8-1993	No mention	1	10
	Inadequate	11-1993	No mention	1	10
	Deficient	19-1994	No mention	1	1
I	Inadequate	10-1993	6	1	7
	Deficient	14-1994	4	1	7
	Inadequate	15-1994	6	1	7
	Inadequate	21-1995	1	1	7
	Inadequate	30-1998	1	1	4
B	Inadequate	2-1992	No mention	2	11
	Inadequate	17-1994	6	2	8
	Satisfactory	18-1994	6	2	8
K	Inadequate	17-1994	6	2	8
	Satisfactory	18-1994	6	2	8
E	Deficient	5-1992	3	1	3
	Inadequate	16-1994	3	2	3
	Satisfactory	24-1995	8	2	3

Figure 14: Summary of the impact identification and evaluation methodologies used by seven of the teams responsible for writing the EISs.

1. Qualitative observations; 2. Qualitative and quantitative analysis; 3.Leopold matrix; 4.Impact indicators; 5.Leopold and Gomez Orea matrices; 6.3 variables, interaction cause-effect matrix; 7.5 variables, interaction cause-effect matrix; 8.6 variables, interaction cause-effect matrix; 9.10 variables, interaction cause-effect matrix; 10.12 variables, interaction cause-effect matrix; 11.6 variables, interaction cause-effect matrix plus Batelle method; 12.14 variable, Leopold matrix.

the evaluation methodology constrains the results so that the result provided by a purely qualitative appraisal are more closely reflected in the results produced by the more rigorous approach. Specifically, the Review Checklist (and particularly the improved Review Checklist) typically produced a worse quality assessment. However, we found the opposite result in our evaluation of EIS 27-1998; this document was rated satisfactory by the qualitative appraisal and the Review Checklist, but was rated well by the improved Review Checklist. In this case, the document obtained the best rating among the 40 EISs in terms of its descriptions of the impacts and of the mitigation measures, the second-best score for the environment description, and the fourth-best score for its outline of alternatives. Nevertheless, this document lacked relevant information such as an evaluation of the net environmental impact that accounted for the mitigation measures and a comparative study of present and future scenarios, with and without the project; as well, the Project Description area also lacked relevant data. The use of a checklist tool such as the improved Review Checklist that provides a more objective quality appraisal methodology adjusts the appraised quality to the needs of the decision-making, and this explains the progressive worsening of quality results by applying the more rigorous original and improved Review Checklist. Another important point is that using the improved Review Checklist seemed to be helpful in discriminating between intermediate levels such as inadequate and satisfactory, where reviewers have more difficulty in accurately assessing the quality of the EIS; the best and worst EISs are obvious to skilled experts, but assessing quality becomes more difficult when there are many variables to take into account and the resulting appraisal becomes more intermediate. When we compared the qualitative analysis with the Review Checklist, this adjustment affected 20 EISs (50% of the sample); when we compared the qualitative analysis with the improved Review Checklist, the quality of 29 of the EISs (72.5% of the sample) changed. Even when we compared the original and improved versions of the Review Checklist, 17 of the documents (42.5%) changed ratings; negative adjustments occurred in 13 (32.5%), 24 (60%), and 14 (35%) of these comparisons, respectively, and this reflects improvements in the appraisal process by applying more rigorous guidelines (i.e., the two checklists).

The improved Review Checklist complements the qualitative methodology by adding a quantitative approach based on careful theoretical analysis of how the tool functions. As a result, it facilitates application of the original checklist by reviewers, and provides a rational and scientific (i.e., more objective) way of linking three levels (question, area, and EIS) that were formerly disconnected; such rationalization improves the rigor of the original Review Checklist, which itself improves upon the relatively unstructured qualitative analysis. Our results also demonstrate that the combination of qualitative analysis with a well-balanced checklist and a supporting rational (quantitative) methodology can improve the accuracy of the results by facilitating the work of expert reviewers and minimizing the effect of subjectivity. We achieved this result by linking the three levels of the assessment through a quantitative ranking system combined with a method of specifying the relative importance (i.e., the weight) of each area. Although the weights assigned to each area are somewhat subjective, this approach minimizes the subjectivity that arises when summarizing results from a lower level in the hierarchy (e.g., questions) to produce a composite result for a higher level in the hierarchy (e.g., areas). This permits more consistent comparisons, and enhances the decision-support potential of the method. Although the Review Checklist improves on the purely qualitative appraisal, it has significant disadvantages in terms of the subjectivity in applying the quality criteria and in correlating the results among the different levels of the evaluation. Consequently, the lack of specific methodology makes it difficult to obtain reliable assessments of the quality of an EIS. This means that each reviewer may choose a different approach to defining an overall quality and thus, that the differences among reviewers increase the subjectivity of the assessment. The improved Review Checklist minimizes this subjectivity by standardizing the approach used to summarize individual assessments (e.g., questions) to obtain a score for the next level in the hierarchy (e.g., areas).

The use of a standard methodology is important because:

- The quality appraisal compiles both quantifiable and qualitative variables; the qualitative factors are responsible for the subjectivity. The different levels of experience among experts also influence the accuracy of their final conclusions. Other factors add uncertainty to quality assessment, such as the pressure on the team, the authority of a specific team member, a lack of determination, and stress, among others [31,32].
- Each expert uses their own particular criteria throughout the process to reach a conclusion about the quality of the EIS. Consensus must be achieved for every question and area, then for the EIS as a whole. At every step, the number of variables to deal with grows and decision-making becomes more complex, making consensus more complicated to reach as the process advances [33]. The harder the agreement becomes to reach, the more controversy is to be expected and the more persuasion is required.
- The composition of review teams varies from one to several experts, and many methods are used to reach a final decision on EIS quality, but there are important differences depending on the approach that is taken (e.g., individual decision in an established group vs. hierarchical decision; Jelassi and others [17]); such a diversity of methods makes it difficult to compare the results between teams because teams may have used

incompatible methodologies that cannot be compared easily or at all.

Recommendations

European, Spanish, and Valencian environmental legislation prescribes the key information that an EIA must address in each EIS area. Nonetheless, the results of various quality assessments of EISs published in the EU and the results of our own research have demonstrated significant deficiencies in both the quantity and quality of the information provided by writers of EISs. To improve the quality of EISs, the developers should apply one of the available decision-support tools, including the Review Checklist described in this paper, to confirm that the information they have included in the report is both sufficient and suitable. Tools such as the Review Checklist are useful instruments that focus and organize the efforts of reviewers into a hierarchical system that facilitates the qualitative appraisals. Once the reviewer obtains a precise description of the environment and project, as well as the social, economic, cultural, logistical, and other important factors that affect it, such tools help to both identify the best alternative for the context of the project and to support this recommendation in an accurate, technically adequate, easily understood document. The questions provided for each area of the assessment provide a rational, methodical approach but make it difficult to determine the final EIS quality because there is no legislated methodology for consolidating the question results into area results and the area results into an overall EIS quality. These checklists do not account for the essential differences between different work scopes, the quality of the affected ecosystems, or the magnitude and importance of the impacts; unfortunately, all this information is needed to compare alternatives. The methodology discussed in the present paper offers solutions for these deficiencies: the quantitative approach makes interpretation more objective and provides a hierarchical structure that facilitates integration of the results at one level to provide a composite evaluation for the next level. The use of a dominance matrix to rank the importance of each area of the assessment accounts for the fact that different areas have different importance and should thus have different weightings in reaching a decision. Therefore, we recommend including an approach similar to the one described in this paper in the description of any decision-support tool. Finally, we recommend that both governments and project developers should systematize the use and application of these tools to control and improve the quality of EIS content. This would provide obvious benefits to everyone involved in the EIA process.

Conclusions

Our study examined a large sample of EISs that covered a wide range of road network infrastructure projects promoted by the government of Valencia. We detected many deficiencies in the design, content, and quality of these EISs. These deficiencies appear to be inherent in the writing and review process, mainly due to a lack of precision in the methodology demanded by the relevant laws and regulations rather than due to a lack of professionalism among those involved in the process. We developed an improved methodology for quality analysis that facilitates the reviewer's work and provides greater objectivity in the results. This new methodology is compatible with traditional quality assessment techniques used in the EU, such as the Review Checklist [1]. Some experts consider it almost impossible to standardize and homogenize impact identification and evaluation methods, and consider it impossible to eliminate all subjectivity from an EIA [27,34,35]. However, environmental science includes many branches whose expertise can be applied to making such assessments more rigorous. The aim should be to avoid a fragmented environmental vision that results from a failure to integrate this expertise. EISs must become more effective planning tools that can contribute to environmental sustainability, and the approach discussed in this paper can help them achieve this goal.

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