Self Learning Guide for Environmental Impact Assessment

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Abstract — A strong economic activity must go hand in hand with maintaining a healthy, sustainable environment. Helping to maintain this delicate balance requires a consistent and predictable environmental assessment process. It can save time, money and effort to industry, government authorities and citizens. It is important that engineers work on making the environmental assessment process more efficient and effective to help build greater confidence in decision-making planning. On the other hand the environmental background of engineers is not always as good as it should be to handle these problems. Our group has been working for several years on environmental web courses at the "Polytechnic University of Madrid" and in this paper we present an on-line guide for environmental impact assessment that is being tested for students self learning.

Index Terms — Environmental Impact Assessment, Internet, self-learning

INTRODUCTION
In the last years the Polytechnic University of Madrid has devoted great efforts to develop training courses for engineers and postgraduate students aimed at exploiting Internet resources for distance learning seminars and tutorials. One of the most successful on-line courses is Environmental Impact Assessment. The aim of this paper is to present a proposal of the use of the new technologies for distance learning, applied to environmental impact assessment techniques. More specifically, this paper presents a particular experience carried out with engineering students.

The course covers the following issues:
Chapter 1: Reference terms
Chapter 2: inventory Legislation
Chapter 3: Environmental inventory
Chapter 4: Methodology
Chapter 5: Practical issues
Chapter 6: Computer practical sessions

Each chapter introduces different environmental aspects and problems to solve. Some chapters involve the understanding of new concepts, like in Chapter 1. In other chapters, like in Chapter 2, students are taught to search for and analyze relevant information on a given topic in the Internet. Other chapters, such as Chapters 3, 4 and 5, present specific techniques and procedures to carry out certain tasks, for example:
• to detect a list of actions and factors involved in a specific work,
• to weight the environmental factors using different approaches and techniques,
• to establish the list of environmental impacts,
• different ways of assessing environmental impact: qualitative, quantitative or by personal judgement,
• to identify environmental impact prevention measures

The organization of the activities and course assessment requires the use of different teaching techniques and resources depending on the kind of issue presented in each chapter.

One of our objectives has been to present the new concepts in a motivating way, and not in a linear manner like in textbooks, providing hypertextual resources and allowing students to follow their own reading preferences. Other objectives have been to make students reflect on the concepts studied and to assess the students' understanding through questions that students have to answer and send back to the teacher/tutor by e-mail, and through debate forums make the learning process less "individual" than normally happens with distance learning, promoting debates among students.

In this paper we present a practical session included in module 6 of the on-line course. The objectives of the practical session are:

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• To analyze a real case of environmental impact assessment. To carry out the session the students have to download the "Synthesis Document"
• To comment on and improve some aspects of the document.
• To elaborate an environmental impact sheet.
The practical session consists of 7 questions that students have to answer.
The analysis of a "Synthesis Document" of an environmental impact study allows students to know how environmental impact assessment is performed in practice. Subsequently, possibilities to improve the document are analyzed, and the document is used as the basis for students to develop their own impact assessment analysis.

The order to follow in environmental impact assessment studies is very specific. We have developed a "Guide for environmental impact assessment", which consists of the following parts:

• Data collection
• Impact Identification and Assessment
• Impact Prevention and Control
• Communication

GUIDE FOR ENVIRONMENTAL IMPACT ASSESSMENT

Data collection

1. INTRODUCTION
   1.1. Background and justification
   1.2. Objectives
   1.3. Reference scope
   1.4. Legal framework
   1.5. Methodology

2. PROJECT ANALYSIS
   2.1. Project description and analysis
   2.2. Description and analysis of other alternatives.
   2.3. Actions. List of actions
       Construction phase
       Operation phase
       Abandonment or demolition phase

3. INVENTORY
   3.1. Environmental factors. List of factors
   3.2. Weight assigned to the factors

Impact identification and assessment

4. IMPACT IDENTIFICATION
   4.1. Cause-effect matrix between impacting actions and impacted factors. Stepped matrices: secondary and tertiary impacts or effects
   4.2. List of effects: negligible, significant, important
   4.3. Leopold's matrix. Impact classification: personal judgement, qualitative, quantitative and key impacts
   4.4. List of impacts
   4.5. Data sheet for each type of environmental impact

5. IMPACT QUANTIFICATION
   For each alternative:
      5.1. Importance, magnitude and weight matrix. Impact index and judgement for each environmental impact

Impact prevention and correction

6. PLAN OF PREVENTIVE AND CORRECTING MEASURES

7. ENVIRONMENTAL HIERARCHY OF ALTERNATIVES
   7.1. New importance matrix with protecting measures
   7.2. New impact judgement
   7.3. Conclusions
8. ENVIRONMENTAL MONITORING PROGRAM

9. SYNTHESIS DOCUMENT

DATA COLLECTION

The stage of “Data collection” consists of three sections:

- Introduction
- Project Analysis
- Inventory

Introduction

In module 1 students have already learnt how to search for information. In module 2 students have to take into consideration first the European guidelines, second the national legislation, then the regional legislation and finally the local legislation relative to the particular project studied. In addition to the general legislation, specific sectorial regulations are also included: water, natural spaces, waste... Some useful webpages are:

- [http://www.mma.es](http://www.mma.es) Webpage of the Ministry for the Environment, which has links to the webpages of the different autonomous regions and the European Union
- [http://www.mma.es/normativa/legis/index.htm](http://www.mma.es/normativa/legis/index.htm)
- [http://www.eoi.es](http://www.eoi.es) Webpage of the “Fundación EOI”, which provides a direct link to DEMA, a directory of environmental links with environmental information
- [http://www-penelope.drec.unilim.fr/penelope/library/ibs/EsoLib/spieg/indice0.htm](http://www-penelope.drec.unilim.fr/penelope/library/ibs/EsoLib/spieg/indice0.htm) Webpage of a European working group on legislation, bibliography and practical cases of EIA

Module 3 summarizes the methodology to follow.

Project analysis

The basic aspect of “Project Analysis” is to analyze the project, to describe the possible alternatives and to establish the list of actions. Each type of project involves certain particular actions. The steps to follow are:

- Description and analysis of the project
- Description and analysis of the possible alternatives.
- Actions. **List of actions**
  A reference list of actions, including the three phases:
  - Construction phase
  - Operation phase
  - Abandonment or demolition phase

is provided in the Synthesis Document. The analysis of the actions can be performed by levels. On the first level, the different phases are defined. On the second level, the elements. And on the third level, the specific actions are listed depending on the type of project; these actions should be relevant, excluding, localized, quantifiable and identifiable; therefore they should be described depending on their magnitude (m², m³, size, n...), spatial localization, flow, stage, duration (for example, the noise caused by traffic at the operation phase, or the noise caused by materials unloading at the construction phase). The list of actions presented in our document corresponds to level 2.

Inventory

Module 3 covers the aspect of inventory. The sections included in the document are:

- **Environmental factors. List of factors**
- **Weights assigned to factors**
  - The list of factors is similar in all environmental impact studies, but emphasizing those factors which are particularly relevant to the environmental study under analysis. The Synthesis Document provides a good illustration, including factor weighting, which can be used as reference.

IMPACT IDENTIFICATION AND ASSESSMENT

Impact Identification

- Cause-effect matrix between impacting actions and impacted factors. Stepped matrices: secondary, tertiary impacts...
- **List of effects:** negligible, significant, important
- Leopold's matrix. Impact classification: judgement, qualitative, quantitative and key impacts
- **LIST OF IMPACTS**
- **Data sheet for each type of environmental impact**
Impact quantification
For each alternative:

- Importance, weight and magnitude matrix. Impact index and judgement

The first thing to do is to elaborate a matrix, similar to those presented in Module 3, with the impacting actions and the impacted factors, to identify the impacts by means of crosses.

In this particular case, 9 environmental impacts were identified. The Synthesis Document includes the list of the 9 impacts, with the actions and factors, although a detailed description of each impact is not provided. For example, for impact 2, action: 2.1. land use, factor: 2.1.3 recreational activities, the environmental impact is: change in the recreational activities of the land use.

Course assessment question 1
Send a list of the 9 environmental impacts provided in the Synthesis Document, specifying:

- a) impact number
- b) impacting action
- c) impacted factor
- d) phase
- e) name and description of the environmental impact
- f) factor weight

For each of the environmental impacts, an impact data sheet should be developed. Study this model of impact data sheet:

Impact data sheet
Description
Project Alternative Action Factor Factor weight Description of the environmental impact
Type of assessment
Judgement, qualitative, quantitative
Qualitative assessment: Importance
Quantitative assessment: Magnitude
Impact indicators
Transformation functions
a) Indicator value without project
b) Indicator value with project
c) Transformation function for both values
d) Difference
e) Magnitude: Mg
Impact index
Index = Im × Mg × Weight
Judgement
Positive Impact
Correcting measures
Detailed Description
Assessment with correcting measures:
New importance, magnitude and valuation.

Course assessment question 2
Fill-in two data sheets like the ones shown above to assess each impact and explain how magnitude and importance have been calculated.

Qualitative assessment: Importance
The table shows one way of assessing importance. The features are defined in RD 1131 /1988.

<table>
<thead>
<tr>
<th>TYPE OF ASSESSMENT</th>
<th>SIGN</th>
<th>EFFECT (EF)</th>
<th>EXTENSION (EX)</th>
<th>INTENSITY (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficial Impact</td>
<td>+</td>
<td>Direct</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Harmful Impact</td>
<td>-</td>
<td>Indirect (secondary, tertiary...)</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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Influence area | Degree of destruction
---|---
Punctual | Low | 1
Partial | Medium | 2
Large | High | 4
Total | Very high | 8
Critical | Total | 12

DURATION (DU) | REVERSIBILITY (RV)
---|---
Duration of the effect | Natural resources
Brief | Short term | 1
Temporal | Medium term | 2
Permanent | Irreversible | 4

ACCUMULATION (S/A/S) | PERIODICITY (PR)
---|---
Temporal resources | | |
Simple | Discontinuous | 1
Cumulative | Periodic | 2
Synergic | Continuous | 4

MOMENT (MO) | RECUPERABILITY (RC)
---|---
Time to manifest | Human resources
Long term | Immediately recoverable | 1
Medium term | Recoverable in the medium term | 2
Immediate | Mitigating | 4
Critical | Irrecoverable | 8

**Course assessment question 3**

Calculate the importance of the environmental impact using the formula:

\[ \text{Im} = \text{Sign} \left( \text{EF} + \text{EX} + \text{I} + \text{DU} + \text{RV} + \text{S/A/S} + \text{PR} + \text{MO} + \text{RC} \right) \]

Try to differentiate the importance of each alternative

1) Which formula would you use if you wanted impact importance to be a number ranging between 0 and 1? Observe that it should be: Importance = \((\text{Im} – \text{Minimum}) / (\text{Maximum} – \text{Minimum})\)

2) Which formula would you use if you wanted impact importance to be a number ranging between 0.4 and 0.7?

3) Which formula would you use if you wanted impact importance to be a number ranging between 0 and 0.7?

4) Which formula would you use if you wanted impact importance to be a number ranging between 0.4 and 1?

5) Write down the values found in the impact data sheet.

6) The following table shows another way of assessing importance:

<table>
<thead>
<tr>
<th>SIGN</th>
<th>EXTENSION (EX)</th>
<th>INTENSITY (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficial Impact</td>
<td>+</td>
<td>Degree of destruction</td>
</tr>
<tr>
<td>Harmful Impact</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Influence area</th>
<th>Degree of destruction</th>
</tr>
</thead>
</table>
Punctual | Low | 1
Partial | Medium | 2
Large | High | 4

DURATION (DU) | REVERSIBILITY (RV)
---|---
Duration of the effect | Natural resources
Temporal | Reversible | 1
Permanent | Irreversible | 3

ACCUMULATION (S/A/S) | RECOVERABILITY (RC)
---|---
Temporal resources | Human resources
Simple | Recoverable | 1
Cumulative | Irrecoverable | 3
Synergic | 5

Recalculate impact importance using the formula:

\[ \text{Im} = \text{Sign} \left( \text{S/A/S} + \text{I} + \text{EX} + \text{DU} + \text{RV} + \text{RC} \right) \]

with Importance = \(0.3(\text{Im} – \text{Minimum})/(\text{Maximum} - \text{Minimum}) + 0.7\)

**Quantitative assessment: Magnitude**

**Impact Indicators**

It is necessary to analyze present situation, future situation without project and future situation with project or alternative

The magnitude indicators of an environmental impact consist of two components, the magnitude of the project action and the environmental quality of the factor.

To analyze the magnitude of the environmental impact “Vegetation loss” the magnitude indicator will be the number of hectares of the affected area, which is affected by a quality index. In general for similar environmental impacts the expression of the magnitude is:
\[ I = \sum_{i} \frac{\text{Superficie afectada}_i \cdot \text{Valor de calidad}_i}{\text{Superficie ámbito}_i \cdot \text{Valor de calidad}_i} \times 100 \]

**Course assessment question 4**

Let's suppose that in alternative 1 the crop and bush land area is 255 ha, with a quality value of 0.3, and that the road affects 60 ha, whereas on the other side of the park the area is 7.5 ha, with a quality value of 0.7, and the road affects 0.54.

Let's suppose that in alternative 2 the area of the crop and bush land is 190 ha, with a quality value of 0.3, and that the road affects 28.1 ha, whereas on the other side of the park the area is 20 ha, with a quality value of 0.7, and the road affects 5.1 ha.

- Which will then be the value of indicator I?

**Transformation functions**

This is an indicator expressed as a percentage. To calculate the magnitude a transformation function is applied. To simplify it, first let's take as transformation function a straight line passing through the origin (for 0 affected area, 0 impact) and through point (100, 1), because if \( I = 100 \) the impact will be maximum with a value of 1.

You have to calculate the following values:

a) Indicator value without project
b) Indicator value with project
c) The transformation function is applied to both values
d) And then the difference is calculated
e) Magnitude: \( Mg \)

To simplify it, let's consider that the indicator value without project is 0.

1) Which will be the value of the magnitude of this impact for each alternative?
2) Now let's consider that the indicator value without project is 10, and with project it is 40. Draw on squared paper a transformation function that is not a straight line but concave, and that passes through the points given. Which will then be the value of the magnitude?
3) Now draw a convex function and calculate the magnitude.

The transformation functions most suitable for assessing the specific environmental impact under study are chosen, depending on whether the impact values are low, medium or high. In case of doubt, use a straight line.

Write down the magnitudes in the impact data sheet.

**Impact index**

\[ \text{Index} = \text{Im} \times \text{Mg} \times \text{Weight} \]

In order to calculate the impact index, multiply importance by magnitude and by weight. Write down the impact indices for each alternative in the impact data sheet.

**Judgement**

Positive impact

According to the legislation, some judgement should be given. Give your judgement on the environmental impact under study for each alternative.

**PREVENTION, CORRECTING AND COMPENSATING MEASURES**

The prevention, correcting and compensating measures that may be used to reduce the environmental impact are described in detail. The “Synthesis Document” provides a detailed description of this type of assessment, and in BOE 17 march, pages 10852 and 10856 you have information available on this respect.

Let's see some examples:

**Prevention measures**
To prevent environmental impact
Examples:

- To correct the environmental management of the works
- To use of silent pavement
- To signal the perimeter of the works, outcrops, protected areas...

**Correcting measures**
To correct environmental impact
Examples:

- Anti-noise screening
• Disposal, collection, conservation and supply of soil. Re-vegetation
• Landscape recovery and integration
• Water retention tanks, infiltration systems
• Transplanting trees of special value

**Compensating measures**
“*To give something or to provide some kind of benefit in compensation for the damage, disturbance or troubles caused*”. (Dictionary).

Examples:
• To build a pond for amphibians
• To restore an element of cultural interest

In each impact data sheet write down which measures can be improved.

**Monitoring program**
The “Synthesis Document” provides an example of the monitoring program, and page 10857 of the BOE presents the regulations on this issue.

**Environmental monitoring program**


**Objective:** To check the fulfillment of the prevention, correcting and compensating measures.

**Stages:**
1) Draft of the program
2) Implementation

1) List of environmental impacts and prevention and compensating measures to control
2) Determine the data: indicators.
3) Define sampling frequency, control sites, sampling method, admissible threshold, alert levels, campaigns...

**record file**
4) Needs of personnel, costs, laboratories...
5) Length of the program

II) Data sampling and results
1) Analysis: impacts, value and identification, thresholds, efficiency of the measures
2) Control method
3) Elaboration of reports

It is convenient to structure each aspect of the environmental monitoring program creating a new data sheet.

**Course assessment question 5**
Elaborate a data sheet on how to monitor some of the correcting measures you propose, using as a model the following data sheet:

<table>
<thead>
<tr>
<th>OBJECTIVE</th>
<th>IMPACT</th>
<th>INDICATOR OR INDICATORS</th>
<th>PHASES OF THE WORKS</th>
<th>ALERT THRESHOLD</th>
<th>ADMISSIBLE THRESHOLD</th>
<th>AGENDA / FREQUENCY</th>
<th>DESCRIPTION OF THE CAMPAIGN OR SAMPLING METHOD</th>
<th>CHECKING POINTS</th>
<th>TECHNICAL REQUIREMENTS</th>
<th>URGENT MEASURES</th>
<th>COST / BUDGET</th>
<th>COMMENTS</th>
</tr>
</thead>
</table>

Now, re-calculate impact importance and magnitude taking into account the prevention, correcting and compensating measures.

**Course assessment question 7**
Write down your comments on the “Document” analyzed
1) Which are the positive points?
2) What can be improved?
3) Comment on the results published in the BOE
CONCLUSION
This paper presents a teaching experience that allows to provide on-line theoretical and practical learning on environmental impact assessment. The students' and teachers' response to this experience has been highly positive, so that we expect to develop further similar activities. The practical session presented in this paper permits students to analyze a real-case environmental impact study, which in itself is an interesting learning experience.

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REFERENCES