**LEOPOLD MATRIX**

**Introduction:**

One of the major forms of matrices used in EIAs is Leopold Interaction Matrix. The Leopold matrix (LM) was developed in 1971, in response to the Environmental Policy Act of 1969. The LM provides a system for the analysis and numerical weighting of probable impacts. The analysis does not produce an overall quantitative rating; instead, it portrays many value judgments. A primary purpose is to ensure that the impact of alternative actions is evaluated and considered in project planning.

**Structure of the Matrix:**

Leopold Matrix, designed by Leopold in 1971, consists of a list of 100 project activities on the horizontal axis, and about 88 environmental /social aspects on the vertical axis. Environmental factors must correspond to all those that could be affected by the development of the activity in the project area and the area of influence.

The cells of the matrix are divided by a diagonal line. The top division is used to describe the magnitude of the impact upon specific sector(s) of the environment. The term "magnitude" is used here in the sense of degree, extensiveness, or scale. The bottom division is used to describe the "importance," i.e., the significance of the proposed actions on the specific environmental characteristics and conditions. Unlike magnitude of impact, which can be readily evaluated on the basis of facts, the importance of impact is generally based on a value judgment [of the evaluator]. The numerical values of magnitude (quantitative) and importance (qualitative) reflect the best estimates of the impact of each action.

* If a cell has no division, it means that the activity has no impact on the environmental aspect.
* Once all the impacts have been identified and rated, a detailed narrative must be written to describe and justify the impact significance (FAO, 1996).

Project activity

Environmental Aspects

Magnitude (1-10)

Significance (1-10)

The outcome of the Environmental Impact Statement (EIS) is a section of Summary and Recommendations. This section of the report explains:

* the relative merits of the proposed actions,
* the rationale behind the final choice of actions, and
* The plan for achieving the stated objectives.

**PROCEDURE**

The assessment of environmental impact is the next to last in a series of steps described below (Fig. 1):

1. A statement of the major objective sought by the proposed project.
2. Analysis of the technological possibilites for achieving the objective.
3. A statement of one or more proposed actions, including alternatives, which may cause environmental impact.
4. The characteristics and conditions of the environment prior to initiation of actions.
5. The engineering proposals for actions, including analysis of monetary benefits and costs.
6. An analysis of the environmental impacts of the proposed actions.
7. An assessment of the impacts of the proposed actions on the [characteristics and conditions of the] environment.
8. Summary and recommendations.

The last item (H) of the Environmental Impact Statement (EIS) is a section of Summary and Recommendations. This section of the report explains:

1. the relative merits of the proposed actions,
2. the rationale behind the final choice of actions, and
3. the plan for achieving the stated objectives

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The analysis is performed with the Leopold Matrix (LM) (Leopold et al., 1971). This matrix has: (1) on the horizontal axis, the actions which cause environmental impact, and (2) on the vertical axis, the existing environmental conditions which may be affected by those actions. This provides a format for comprehensive review of the interactions between proposed [anthropogenic] actions and environmental factors [characteristics and conditions].

The number of actions listed on the horizontal axis is 100. The number of environmental factors [characteristics and conditions] listed on the vertical axis is 88. This provides a total of **8,800 interactions**. In practice, however, only a few of the interactions would be likely to involve impacts of such magnitude and importance to warrant detailed treatment.

Not all the actions and factors apply to every project proposal; in some cases, other actions and factors not considered here may be warranted. According to Leopold et al. (1971), **the number of interactions for a typical project is** **between 25 and 50.**

The most efficient way to use the matrix is to check each significant action (listed on the horizontal axis). Generally, only about a dozen actions will be significant. **Each action checked is evaluated in terms of magnitude of effect on environmental characteristics and conditions** (listed on the vertical axis). A slash (/) is placed diagonally from upper right to lower left across each block where significant interaction is expected. The discussion in the text should indicate whether the assessment is on short-term or long-term impacts.

The most important blocks marked are evaluated individually, and a number between 1 and 10 is placed in the upper left-hand corner to indicate the relative magnitude of the impact (1 represents the least magnitude, and 10 the greatest). Likewise, a number between 1 and 10 is placed in the lower right-hand corner to indicate the relative importance of the impact (again, 1 represents the least magnitude and 10 the greatest).

The next step is to evaluate the numbers which have been placed in the slashed boxes. **It is convenient to construct a reduced matrix which consists only of those actions and environmental characteristics which have been identified as interacting.** Special note may be taken of boxes with high numbers. The high or low numbers on any one box indicates the degree of impact of the applicable action on the given characteristic of the environment. **The assignment of magnitude and importance numbers is based, to the extent possible, on factual data rather than on the evaluator's preference.**

The rating scheme requires the evaluator to quantify his/her judgment regarding the probable impacts. The scheme allows the reviewers to systematically follow the evaluator's line of reasoning, to aid in identifying points of agreement and disagreement. **In fact, the matrix is the abstract for the text of the environmental impact assessment.**

**Concluding remarks:**

**Merit:**

* The Leopold matrix provides a simple way to summarize and rank environmental impacts, and to focus on those that are considered to be greatest.
* The advantage of the matrix format is its reminder of the full range of actions, factors, and related impacts. As far as possible, the assignment of magnitude is based on factual information. However, the assignment of importance may leave some room for the subjective opinion of the evaluator. This separation of fact from opinion is an asset of the Leopold matrix.

**Demerit:**

* It does not explicitly describe spatial and temporal effects of the environmental activity. It merely gives the magnitude and significance of the interaction.
* It tends to be too simplified when we require a comprehensive analysis of the impacts on the project area. A numerical value of the magnitude and impact is not sufficient for a contractor to the impact their activities are having and why they should overcome it.
* They cannot explain the linkages between two environmental aspects. In other words, it does not describe secondary and tertiary impacts.

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