

The Rapid Impact Assessment Matrix (RIAM) – A New Tool for Environmental Impact Assessment

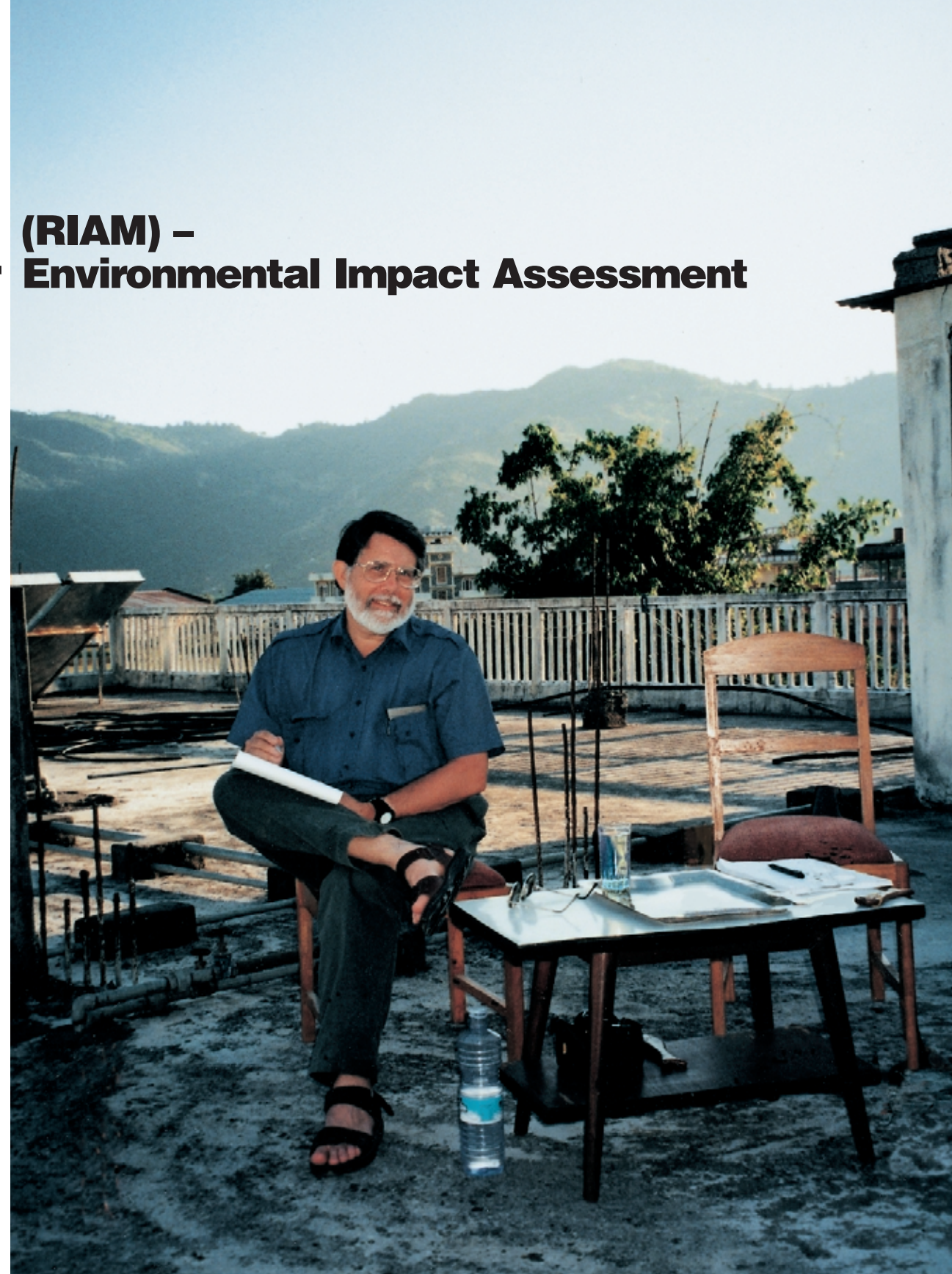
Christopher M.R. Pastakia

VKI, Agern Alle 11, DK-2970 Hørsholm, Denmark
e-mail: cmp@vki.dk

Abstract Environmental Impact Assessment (EIA) has progressed from the consideration of pollution assessment, through the wider range of ecological assessment, and has now become a 'holistic' EIA.

Although the quality of data analysis for EIA has improved over the years, the judgements made in an EIA are essentially subjective. Although these subjective conclusions can provide a suitable basis for EIA, the problem lies in recording the transparency of the assessment. EIA evaluations need to be re-assessed with the passage of time, and the data contained therein should be open to scrutiny and revision, as new data become available. Wholly subjective and descriptive systems are not capable of such revision, dependent as they are on the expertise and experience of the original assessors and on the quality of the descriptive record left behind.

The paper outlines the processes involved in a new method for EIA: the Rapid Impact Assessment Matrix (RIAM). This method seeks to overcome the problems of recording subjective judgements by defining the criteria and scales against which these judgements are to be made; and by placing the results in a simple matrix that allows for a permanent record of the arguments in the judgement process.



Introduction Environmental Impact Assessment (EIA) is a tool used in planning development strategies and projects, and its use has been adopted into planning regulations in a number of countries, and by a number of regional groupings and multilateral agencies (CEQ, 1978; CEU, 1985, 1997; World Bank, 1988; DANIDA, 1994; EBRD, 1996).

EIA has progressed from the consideration of pollution assessment, through the wider range of ecological assessment, and now is required to consider all aspects affected by any proposed development or development strategy: the 'holistic' EIA. The depth of investigation now required of EIA has meant that the assessors are constrained by a lack of time (for detailed quantitative data collection and analysis) and by an uncertainty brought about by the need to make subjective judgements on such acquired data. This subjectivity can provide a competent analysis of the probable changes and effects, but suffers in that it is neither reproducible nor transparent.

It is necessary to ensure some degree of transparency and objectivity in the qualitative assessment and evaluation of the impacts on projects (in particular development projects where data may be scarce and implementation may take a number of years). EIA evaluations need to be re-assessed with the passage of time, and the data contained therein should be open to scrutiny and revision, as new data becomes available. Wholly subjective and descriptive systems are not capable of such revision, dependent as they are on the expertise and experience of the original assessors and on the quality of the descriptive record left behind.

The shortcomings in existing EIA methods The historical development of EIA shows that a number of attempts have been made to improve the quality of the EIA analysis by seeking to improve the accuracy of the judgement, resulting in a number of formats being developed for analysis in EIA (Wathern, 1988; Bisset, 1988). These have in some cases provided an improvement to the analysis but have not improved the quality of transparency of argument, neither addressed the problem of keeping an adequate record of the EIA.

In any EIA the judgements will be subjective, either in whole or in part. This is a consequence of many factors: the lack or inadequacy of baseline data, the time frame provided for data acquisition and analysis, the terms of reference provided for the EIA, and the capacity of the assessors to cover a wide range of issues. Even where quantitative environmental data is available, the overall use of this data requires a subjective judgement of the possible impact, its spatial scale and potential magnitude. It is this forecasting of events that underpins the subjectivity of the analysis.

Subjectivity in itself is not a bar to the use or reliance of EIA, as comparison of alternative systems is a valid system for decision making, provided that such comparisons are made on an equal basis. The problem with subjective judgements relies in their lack of transparency and in the value of historic, written record.

The pattern of the final EIA report has been widely developed into Environmental Impact Statements (EIS) that consist of the description of

the project, methods used in the EIA, the conclusions of the assessment, together with supporting evidence and data. Most EISs will contain a non-technical summary of the conclusions to assist decision makers, and often it is this summary alone that forms the basis on which decisions are made (Glasson *et al.*, 1994).

Where EIA is a mandatory requirement, and is often carried out by (or on behalf of) the developer, it is necessary for the competent planning and regulatory authorities to be able to evaluate the assessment, and to be satisfied that the technical conclusions are sound. It is difficult to evaluate EISs, as they are generally voluminous, with a considerable inclusion of data, and no real account of the process of argument by which judgements were arrived at. This lack of transparent record reduces the effectiveness of the EIA, and with time often leads to a requirement for a new assessment to be made, or for development decisions to be made on inadequately understood and evaluated assessments.

Possible solutions to improve EIA The problem of recording the arguments that lead to a conclusion in a subjective judgement can be addressed by defining precisely how that judgement has been made. For the subjectivity of judgement to become transparent, it will be necessary to define very carefully how the analysis should be carried out, and the criteria against which judgements are made. This requires that the criteria for judgement can be identified and accepted in all forms of EIA.

Many of the criteria used at present to determine an impact that may occur as a result of a development strategy or project, are well known and accepted by most workers in the field of EIA. It is always necessary to consider: the area likely to be affected, the degree or magnitude of the impact, whether the change is permanent or temporary in nature, whether the affect may be reversed, whether an impact may, with other effects, be synergistic, and whether there is any likelihood for a cumulative effect to develop over time.

All these criteria form areas of judgement common to most EIAs today, yet the assessors develop the scales for describing their judgements of the impacts against each of these criteria on an 'ad hoc' basis. If, however, these criteria and scales are laid down prior to the analysis, and are common to all EIAs, then a system of understanding of the arguments by which conclusions are arrived at can be recorded.

The process of selecting components for an EIA which are then assessed against criteria is known as 'scoping'. Often in the early stages of planning, or in evaluating EIAs, it is possible to be forearmed with specific components that should be critical to the EIA. Thus if the method of assessment applied these known components, it would be possible to direct data collection and analysis more effectively, and reduce the time taken in the investigative stages of an EIA.

The Rapid Impact Assessment Matrix This paper describes a system of scoring within a matrix that has been designed to allow subjective judgements to be quantitatively recorded, thus providing both an

impact evaluation and a record that can be re-assessed in the future. The system is ideally suited to EIA where a multi-disciplinary team approach is used (Morris & Biggs, 1995), as it allows for data from different components to be analysed against common important criteria within a common matrix, thus providing a rapid, clear assessment of the major impacts.

The Rapid Impact Assessment Matrix (RIAM) method is based on a standard definition of the important assessment criteria as well as the means by which semi-quantitative values for each of these criteria can be collated to provide an accurate and independent score for each condition. The impacts of project activities are evaluated against the environmental components, and for each component a score (using the defined criteria) is determined, which provides a measure of the impact expected from the component.

The important assessment criteria fall into two groups:

- (A) Criteria that are of importance to the condition, and which can individually change the score obtained.
- (B) Criteria that are of value to the situation, but individually should not be capable of changing the score obtained.

The value ascribed to each of these groups of criteria is determined by the use of a series of simple formulae. These formulae allow the scores for the individual components to be determined on a defined basis.

The scoring system requires simple multiplication of the scores given to each of the criteria in group (A). The use of multiplier for group (A) is important for it immediately ensures that the weight of each score is expressed, whereas simple summation of scores could provide identical results for different conditions.

Scores for the value criteria group (B) are added together to provide a single sum. This ensures that the individual value scores cannot influence the overall score, but that the collective importance of all values in group (B) are fully taken into account.

The sum of the group (B) scores is then multiplied by the result of the group (A) scores to provide a final assessment score (*ES*) for the condition. The process can be expressed:

$$(a1) \times (a2) = aT$$

$$(b1) + (b2) + (b3) = bT$$

$$(aT) \times (bT) = ES$$

where

- (a1) and (a2) are the individual criteria scores for group (A)
- (b1) to (b3) are the individual criteria scores for group (B)
- aT is the result of multiplication of all (A) scores
- bT is the result of summation of all (B) scores
- ES is the assessment score for the condition.

Positive and negative impacts can be demonstrated by using scales that pass from negative to positive values through zero for the group (A) criteria. Zero thus becomes the 'no-change' or 'no-importance' value. The

use of zero in this way in group (A) criteria allows a single criterion to isolate conditions which show no change or are unimportant to the analysis.

Zero is a value avoided in the group (B) criteria. If all group (B) criteria score zero, the final result of the ES will also be zero. This condition may occur even where the group (A) criteria show a condition of importance that should be recognised. To avoid this, scales for group (B) criteria use '1' as the 'no-change/no-importance' score.

Assessment criteria The criteria should be defined for both groups, and should be based on fundamental conditions that may be affected by change rather than be related to individual projects. It is theoretically possible to define a number of criteria, but two principles should always be satisfied:

1. The universality of the criterion, to allow it to be used in different EIAs.
2. The value of the criterion, which determines whether it should be treated as a Group (A) or Group (B) condition.

At this point only five criteria have been developed for use in the RIAM. Nevertheless, these five criteria represent the most important fundamental assessment conditions for all EIAs, and satisfy the principles set out above. These criteria, together with their appropriate judgement scores are defined as:

Group (A) criteria

Importance of condition (A1) A measure of the importance of the condition, which is assessed against the spatial boundaries or human interests it will affect. The scales are defined:

- 4 = important to national/international interests
- 3 = important to regional/national interests
- 2 = important to areas immediately outside the local condition
- 1 = important only to the local condition
- 0 = no importance.

Magnitude of change/effect (A2) Magnitude is defined as a measure of the scale of benefit/dis-benefit of an impact or a condition:

- +3 = major positive benefit
- +2 = significant improvement in status quo
- +1 = improvement in status quo
- 0 = no change/status quo
- 1 = negative change to status quo
- 2 = significant negative dis-benefit or change
- 3 = major dis-benefit or change.

Group (B) criteria

Permanence (B1) This defines whether a condition is temporary or permanent, and should be seen only as a measure of the temporal status of the condition. (e.g.: an embankment is a permanent condition even if it may one day be breached or abandoned; whilst a coffer dam is a temporary condition, as it will be removed).

- 1 = no change/not applicable
- 2 = temporary
- 3 = permanent.

Reversibility (B2) This defines whether the condition can be changed and is a measure of the control over the effect of the condition. It should not be confused or equated with permanence. (e.g.: an accidental toxic spillage into a river is a temporary condition (B1) but its effect (death of fish) is irreversible (B2); a town's sewage treatment works is a permanent condition (B1), the effect of its effluent can be changed (reversible condition) (B2)).

- 1 = no change/not applicable
- 2 = reversible
- 3 = irreversible.

Cumulative (B3) This is a measure of whether the effect will have a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other conditions. The cumulative criterion is a means of judging the sustainability of a condition, and is not to be confused with a permanent/irreversible situation. For instance, the death of an old animal is both permanent and irreversible, but non-cumulative as the animal can be considered to have already passed its breeding capabilities. The loss of post-larval shrimp in the wild, is also permanent and irreversible, but in this case cumulative, as all subsequent generations that the larvae (as adults) may have initiated will also have been lost.

- 1 = no change/not applicable
- 2 = non-cumulative/single
- 3 = cumulative/synergistic

It is possible to change the cumulative component to one of synergism, if the condition warrens consideration of additive affects.

Environmental components The RIAM requires specific assessment components to be defined through a process of scoping; and these environmental components fall into one of four categories, which are defined as follows:

Physical/chemical Covering all physical and chemical aspects of the environment, including finite (non-biological) natural resources, and degradation of the physical environment by pollution.

Biological/ecological Covering all biological aspects of the environment, including renewable natural resources, conservation of biodiversity, species interactions, and pollution of the biosphere.

Sociological/cultural Covering all human aspects of the environment, including social issues affecting individuals and communities; together with cultural aspects, including conservation of heritage, and human development.

Economic/operational To qualitatively identify the economic consequences of environmental change, both temporary and permanent, as well as the complexities of project management within the context of the project activities.

The use of these four categories can be, in itself, a competent tool for EIA, though each category can be further sub-divided to identify specific environmental components that better demonstrate the possible impacts. The degree of sensitivity and detail of the system can thus be controlled by the selection and definition process for these environmental components.

Ranges To use the evaluation system described, a matrix is produced for each project option (Table 1). The matrix comprises of cells showing the criteria used, set against each defined component. Within each cell the individual criteria scores are set down. From the formulae given above each ES number is calculated and recorded.

No claim is made for the sensitivity of any ES value, and to provide a more certain system of assessment, the individual ES scores are banded together into ranges (Range values: RV) where they can be compared (Table 2).

Ranges are defined by conditions that act as markers for the change in bands. These conditions would normally reflect the changes in group (A) scores, combined with the upper or lower scores possible with the group (B) criteria.

Conditions have been defined to produce a range covering ± 5 , and the limits of the bands in this range can be defined as follows:

- Conditions that have neither importance nor magnitude will score a zero, and can be banded together. Any condition in this band is either of no importance, or represents the status quo, or a no change situation.
- A condition that is local in importance ($A2 = 1$), and a slight change from the status quo ($A2 = 1$), yet is permanent ($B1 = 3$), irreversible ($B2 = 3$) and cumulative ($B3 = 3$), represents the upper limit of the 'slight change' condition.
- A condition of 'change' will occur up to a condition of local importance ($A1 = 1$) with significant magnitude ($A2 = 2$), that is permanent ($B1 = 3$), irreversible ($B2 = 3$) and cumulative ($B3 = 3$).
- A condition of moderate change will lie between the limits of 'change' and 'significant change'.

Table 1. RIAM matrix.

Project option				
Physical/chemical components				
P/C	P/C	P/C	P/C →
A1	A1	A1	A1 →
A2	A2	A2	A2 →
B1	B1	B1	B1 →
B2	B2	B2	B2 →
B3	B3	B3	B3 →
ES 0	ES 0	ES 0	ES 0 →
RV	RV	RV	RV →
Biological/ecological components				
B/E	B/E	B/E	B/E →
A1	A1	A1	A1 →
A2	A2	A2	A2 →
B1	B1	B1	B1 →
B2	B2	B2	B2 →
B3	B3	B3	B3 →
ES 0	ES 0	ES 0	ES 0 →
RV	RV	RV	RV →
Sociological/cultural components				
S/C	S/C	S/C	S/C →
A1	A1	A1	A1 →
A2	A2	A2	A2 →
B1	B1	B1	B1 →
B2	B2	B2	B2 →
B3	B3	B3	B3 →
ES 0	ES 0	ES 0	ES 0 →
RV	RV	RV	RV →
Economic/operational components				
E/O	E/O	E/O	E/O →
A1	A1	A1	A1 →
A2	A2	A2	A2 →
B1	B1	B1	B1 →
B2	B2	B2	B2 →
B3	B3	B3	B3 →
ES 0	ES 0	ES 0	ES 0 →
RV	RV	RV	RV →

- The lower limits of ‘significant change’ can be taken as the point when a condition is outside local boundaries (A1= 2) but is of major importance (A2 = 3), yet is temporary (B1= 2), reversible (B2 = 2) and non-cumulative (B3 = 2).
- A ‘major change’ will occur at a point when the condition extends to a regional/national boundary (A1= 3) and is of major importance (A2 = 3). Such a change would also be permanent (B1= 3), irreversible (B2 = 3), though it could be non-cumulative (B3 = 2).

Once the ES score is set into a range band, these can be shown individually or grouped according to component type and presented in whatever graphical or numeric form that the presentation requires. The full EIA report will detail the criteria used, the components derived after scoping, the RIAM matrix, and the presentation of the RIAM results – together with the normal baseline information, conclusions and suggested mitigation.

Table 2. Range bands used for RIAM

RIAM Environmental Score (ES)	Range value (RV) (Alphabetic)	Range value (RV) (Numeric)	Description of range band
108 to 72	E	5	Major positive change/impact
71 to 36	D	4	Significant positive change/impact
35 to 19	C	3	Moderate positive change/impact
10 to 18	B	2	Positive change/impact
1 to 9	A	1	Slight positive change/impact
0	N	0	No change/status quo/not applicable
-1 to -9	-A	-1	Slight negative change/impact
-10 to -18	-B	-2	Negative change/impact
-19 to -35	-C	-3	Moderate negative change/impact
-36 to -71	-D	-4	Significant negative change/impact
-72 to -108	-E	-5	Major negative change/impact

The sensitivity of the ranges is still based on subjective definition of range bands. This does not permit more sensitive bands to be easily formed, and the present system may not be sensitive enough for use in marginal or fragile environments. (Table 2). Experiment has shown that a ±5 range band is as sensitive as can be developed for a 5-criteria matrix, and such a range band is shown in Table 2 (with both numeric and alphabetic RV values).

Conclusions The RIAM is described here on a theoretical basis, though research is continuing to assess the use of the RIAM in different project and environmental situations; as well as to computerise the system for ease and speed of use. The system has been tested in studies on river and coastal developments; in engineering and tourism projects; and has been found to provide a rapid and reproducible basis for assessment of the conditions by highlighting changes, and in comparing impacts from different planning options.

The RIAM is suited to EIA where a multi-disciplinary team approach is used, as it allows for data from different sectors to be analysed against common important criteria within a common matrix, thus providing a clear assessment of the major impacts. The discipline imposed by using the matrix allows the assessors to rapidly record their judgements. Objectivity is ensured by means of the defined criteria set on scales, which provide a figure on the judgement made.

By setting up a matrix with defined components, it is possible to compare the with- and without- project situation; make comparisons between development alternatives; and provide a basis for 'what if ...' scenarios in planning. Multiple matrices can be set up to compare alternative strategies and development options, isolate the major positive/negative impacts, define the temporary and permanent impacts, and show where mitigation can be effective in reducing negative impacts.

As the definition of components is the initial step in the system, and such definition is related to the project specific conditions, the RIAM can be used both as a screening tool for project options, as well as method of detailed impact assessment in specific stages in the development process. This system of checking with defined components also permits a rapid and reliable system of evaluation of EISs. Because of its simple nature, and the ability to use the matrix even where data is poor (by defining assumptions beforehand), the RIAM is an ideal tool for Initial Environmental Evaluations (IEE) as well as recording the results of a full EIA.

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