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ENVIRONMENTAL ASSESSMENT OF DEVELOPMENT PROJECTS

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Summary

The environmental effects of development projects are discussed with respect to developing countries and the objective quantitative approach to environmental assessment is recommended for each major project. Environmental base line studies are reviewed in terms of need, purpose and implementation. Preparation of environmental impact assessments is considered and the environmental impact matrix suggested as a useful approach to discourage subjective evaluation of results. The analytical techniques, materials balance, residuals dispersion, market simulation, and marginal and trade-off analyses are outlined and the concepts of decision criteria and measures of worth introduced.

An example of environmental impact assessment in Thailand related to the Quae Yai River hydroelectric scheme is reviewed. The scope of this included: water resource management; mining, forestry and river basin development; relocation of upstream inhabitants; health; fishery resources and aquatic weed infestations; inundation of archeological artifacts and sites; and aesthetic quality and tourism potential. Final recommendations are given for both the initial environmental reconnaissance study and the subsequent more detailed survey related only to medical, heavy metals, archeological and aesthetic aspects of the basin.

Introduction

Development projects will always have an impact on the environment and the ultimate decision on whether or not the ecological consequences are worth risking for the benefits gained is, ultimately, a subjective value judgement. However, there should always be an attempt made to measure the damages in relation to the benefits in such a way that a social choice can be made about the relative worth of a project. Unfortunately, environmental issues are inter-disciplinary, interactive, biological and probabilistic and, because information is always deficient, the outcome has a considerable degree of uncertainty or risk. Compounding this lack of certainty in developing countries is the conflict between

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development and conservation, which can never be absolutely reconciled, and which in most countries has led to political inaction on environmental matters.

Very few countries in Asia have taken a firm stance on environmental control and in others, where environmental studies have been carried out, they have usually been prompted by the requirements of external finance to fund projects. International funding agencies such as the World Bank now require environmental impact assessments of all major projects which are likely to involve their finance.

Environmental base-line and impact studies are designed to provide data bases and quantitative assessments of environmental factors related to development projects. Developing countries may well decide to interpret the results of these studies in a manner different from that in which they would be viewed in a highly industrialized country, reflecting the different political, social and economic priorities. But, development should not only be economic, it should also be effective. Two dimensional planning decisions based only on economic and social considerations may unnecessarily and irrevocably eliminate natural systems important to economic and social well-being.

Environmental base line studies

Developing countries are normally at a great disadvantage when it comes to evaluating the impact of projects because so little environmental data are extant, even for those parameters which are easily measured. For example, most developing countries in Asia will have only short-term meteorological and hydrological data and often the monitoring of important variables, such as streamflow in major rivers, is intermittent and haphazard. Environmental quality information is almost non-existent in many countries.

Before environmental impact of a development project can be assessed there is a need for background data on the natural conditions of the ecosystem. This will include information on physical, chemical and biological characteristics, on the distribution and abundance of species and on the normal variation in these attributes over the annual cycle. The environmental base line or background study is designed to provide these data for impact evaluation and use in project design (particularly for pollution control measures), but is also useful in the monitoring of environmental quality changes after a project is implemented. It is advisable for Governments to sponsor base-line studies in connection with private developments so that the extent of any subsequent deterioration of environmental quality can be quantified. Sometimes, private companies investing large sums in industrial projects that are known to be environmentally suspect may finance base-line studies of their own as protection against any unjustified claims that they have denigrated the environment. One other important use of a base-line study is in establishing the assimilative capacity of a natural system, consequently minimizing investment in control of polluting residual discharges.

Regular large-scale base-line studies of the commons (the atmosphere, oceans, etc.) will show the trends of environmental quality changes resulting from man's activities over a widespread area. This is being done on a global scale with the United Nations "Earthwatch" project and some Governments in this region are supporting their own national studies. An example of the latter is the Thai study of pollution in the Upper Gulf of Thailand, where regular sampling and analysis of marine water, benthic mud, flora and fauna are being carried out at many stations on a regular basis.

In most countries, the coastal zone will be the most environmentally sensitive area under greatest developmental pressures. This zone will serve for recreation and tourism, as a habitat for marine living resources, as a livelihood for fishermen, as a medium for transport and commerce and as a receiving body for domestic and industrial wastes. It is unlikely that these latter two uses will be entirely compatible with the others and coastal zone management is essential to allow full benefit from the resources. Base line surveys will help to define those land and marine areas of the coastal zone which should be reserved for preservation, conservation or development.

In environmental management it is necessary to have coordinated efforts and this is particularly so in carrying out base line studies in developing countries. These studies are extensive and costly and must be carefully planned and executed. They do provide the opportunity for training of local personnel in a developing country if handled by local organizations. In many countries, the universities have been used for this purpose with advantage and studies are usually cheaper when carried out by educational institutions rather than by private companies. It is essential that independent organizations with experience in environmental matters be employed to produce reliable impartial results.

Environmental impact assessment

Before any large industrial or governmental development project is given final planning permission, a detailed environmental impact assessment should be prepared and considered. The purpose of an environmental impact analysis is to apply systematic techniques to measure the benefits and damages to the environment and see which species are affected adversely or beneficially. It may be considered to be in two parts: the evaluation and screening of projects which affect the environment to determine any adverse ecological reactions; and special studies of ecological impacts to ascertain the degree of biological damage and how it may be mitigated.

Applications for permits to construct development projects should include an environmental impact statement or report which discusses:

(i) the environmental impact of the proposed action,

(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) alternatives to the proposed action,

(iv) the relationship between local short term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

The U.S. Council on Environmental Quality in 1971 specified the required content of environmental impact statements in the following guidelines:

(i) A description of the proposed action including information and technical data adequate to permit a careful assessment of environmental impact by commenting agencies. Where relevant, maps should be provided.

(ii) The probable impact of the proposed action on the environment, including impact on ecological systems such as wildlife, fish, and marine life. Both primary and secondary significant consequences for the environment should be included in the analysis. For example, the implications, if any, of the action for population distribution or concentration should be estimated and an assessment made of the effect of any possible change in population patterns upon the resource base, including land use, water, and public services, of the area in question.

(iii) Any probable adverse environmental effects which cannot be avoided (such as water or air pollution, undesirable land use patterns, damage to life systems, urban congestion, threats to health or other consequences adverse to the environmental goals set out in section 101 (b) of the Act*).

(iv) Alternatives to the proposed action (section 102 (2) (D) of the Act requires the responsible agency to "study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources"). A rigorous exploration and objective evaluation of alternative actions that might avoid some or all of the adverse environmental effects is essential. Sufficient analysis of such alternatives and their costs and impact on the environment should accompany the proposed action through the agency review process in order not to foreclose prematurely options which might have less detrimental effects.

(v) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. This in essence requires the agency to assess the action for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations.

*The U.S. National Environmental Policy Act of 1969 (Public Law (91–190, January 1, 1970).

(vi) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. This requires the agency to identify the extent to which the action curtails the range of beneficial uses of the environment.

(vii) Where appropriate, a discussion of problems and objections raised by other Federal, State, and local agencies and by private organizations and individuals in the review process and the disposition of the issues involved. (This section may be added at the end of the review process in the final text of the environmental statement.)

The U.S. Atomic Energy Commission[1] produced a guide to the preparation of environmental reports for nuclear power plants in which the standard format recommended includes the following major sections: Purpose of the proposed facility; the site; the plant; environmental effects of site preparation, plant and transmission facilities construction; environmental effects of plant operation; effluent and environmental measurements and monitoring programs; environmental effects of accidents; economic and social effects of plant construction and operation; alternative energy sources and sites; plant design alternatives; summary benefit-cost analysis; environmental approvals and consultations. Agencies in developing countries responsible for environmental matters should develop similar guidelines which would apply to the type of project and circumstances likely to be experienced locally. To assist them, the World Bank[2] has published a handbook designed to provide guidance in the detection, identification and measurement of environmental and related human ecological effects of development projects which concentrates on sixteen kinds of projects typically financed by the World Bank Group.

It is imperative that environmental impact statements include and comment on the views of those opposing the proposals for environmental reasons, if any. The opinions and reports of all Government agencies and departments having environmental responsibilities, and with which the proposals should have been coordinated, should also be included. Care must also be taken to make the statement as objective as possible and overstating favourable effects must be avoided.

The environmental impact matrix

Systematic evaluation of environmental impact may be facilitated using a matrix or reference checklist. The U.S. Geological Survey[3] has proposed an environmental evaluation matrix which consists of 100 types of actions of a project listed horizontally across the top of the matrix and 88 ecological situations listed vertically. Thus the matrix contemplates the possibility of 8800 interactions but in practice it can usually be quickly reduced to a smaller number of related items. Thereafter, these can be increased to give a more detailed breakdown of actions of the project and their environmental effects.

The most efficient way to use the matrix is to check each action (top horizontal list) which is likely to be involved significantly in the proposed project. Generally, only

about a dozen actions will be important. Each of the actions thus checked is evaluated in terms of "magnitude" of effect on environmental characteristics on the vertical axis, and a slash is placed diagonally from upper right to lower left across each block which represents significant interaction. After all boxes which represent possible impact have been marked with a diagonal line, the most important ones are evaluated individually. Within each box representing a significant interaction between an action and an environmental factor, a number from 1 to 10 is placed in the upper left-hand corner to indicate the relative "magnitude" of impact; 10 represents the greatest magnitude and 1 the least. In the lower right-hand corner of the box, a number from 1 to 10 is added to indicate the relative "importance" of the impact, again 10 is the greatest.

Assignment of numerical weights to the "magnitude" and "importance" of impacts should be, to the extent possible, based on factual data rather than preference. Thus, the use of a rating scheme such as the one suggested here discourages purely subjective opinion and requires the author of an environmental impact statement to attempt to quantify his judgement of probable impacts. The overall rating allows the reviewer to follow the originator's line of reasoning and will aid in identifying points of agreement and disagreement. The matrix, is in fact, an abstract for the text of the environmental assessment.

The text that accompanies the completed matrix should be primarily a discussion of the reasoning behind the assignment of numerical values for the "magnitude" of impact effects and their relative "importance". The text should include a discussion of those actions which have significant impact and should not be diluted by discussions of obviously trivial side issues.

Usually, matrix analysis will make the critical environmental effects apparent and allow alternative actions to be identified and environmentally assessed and compared. Otherwise, or in addition, those actions which can be taken to reduce adverse impacts can also be studied. Answers to the questions raised by a matrix evaluation will require additional analytical studies of the special impacts on the environment, concentrating on those that appear most adverse. These effects may be measured by applying analytical techniques such as materials balance, dispersion modelling, market simulation, marginal cost analysis and trade-off analysis.

Application of environmental analytical techniques

The first and most basic analysis is to prepare a *materials balance* model of a project's operations showing all materials inputs and outputs. Inputs will depend on the type of project, and residuals relased to the environment will be related to the processes involved and the controls incorporated in the project.

Next, it is necessary to study the *dispersion of residuals* released to the ecosystem. In this way the concentrations and movements of pollutants may be determined and this will allow assessment of potential biological damage and other damage costs associated with subsequent uses of the environmental media.

The third step is to construct a *market simulation* of the ecosystem which involves attaching shadow prices to unpriced values. Easily obtained market prices will be for project development costs, construction costs, materials, power, labour and other operating costs and product (if any) prices. Unpriced components will be related to socio-economic, cultural and ecological factors and are the values attached to resettlement and change in life-style of people, employment opportunities, archeological and historical artifacts and sites, water quality, air quality, wilderness quality, scenic views, biological health, species balance and hazards to species. Careful study and planning of resettlement and heritage protection will minimize adverse effects in these sectors at costs which can be estimated. However, it is impossible to estimate the true damages of human relocation and change in lifestyles or the potential loss of artifacts and archeological sites resulting from pilferage at a newly accessible site or from losing access to a site due to a project (for example, through inundating an area for a hydroelectric scheme). Some of these unpriced components, including biological damage, can be valued at the cost of rectification or avolidance; damage costs of poor air and water quality can be determined by estimating the costs of removal of pollutants to a desirable or safe level. Valuation of aesthetic qualities is more difficult, but even here the avoidance costs can be used. For example, damage to wilderness quality and scenic views caused by power transmission lines from a hydroelectric scheme could be assigned costs associated with either burying the lines underground or re-aligning them to minimize their impact on these environmental factors. The objective of a market simulation is the determination and exposure of these external costs so that they can be included in decision-making. Projects should be evaluated on the basis of internalizing the external environmental costs but the level of environmental quality to be maintained should be carefully considered in a developing country because it will have a severe influence on these external costs. Also, so that a non-competitive situation does not arise in trade, all similar projects should be forced to bear similar environmental costs using the same quality criteria.

The optimum level of environmental quality may not be immediately apparent because the marginal cost for each degree of quality is not constant. Therefore, the next step in the analysis is estimation of *marginal costs and marginal returns* in terms of environmental quality. This will allow a *trade-off* between the demand for quality and the cost, as illustrated by Fig. 1,* for waste withholding. Clearly, the optimum point would be at C where the marginal return is just equal to the marginal investment. The public demand for quality is difficult to quantify but might be estimated by what people are willing to pay for a product to maintain a "satisfactory" environment. There is some subjective point at which human beings equate the degree of environmental quality against cost and this point can be estimated by a careful study of biological damage in relation to incremental avoidance costs. In simpler terms, the point would be determined by the amount people would pay to protect a certain proportion of the population of an endangered species, allowing some of the weaker species to succumb to that quality level which would incur high incremental costs to improve.

*Taken from Kneese, A.V. and Bower, B.T. (1968) *Managing Water Quality: Economics, Technology, Institutions*, Johns Hopkins Press, Baltimore, p. 99.

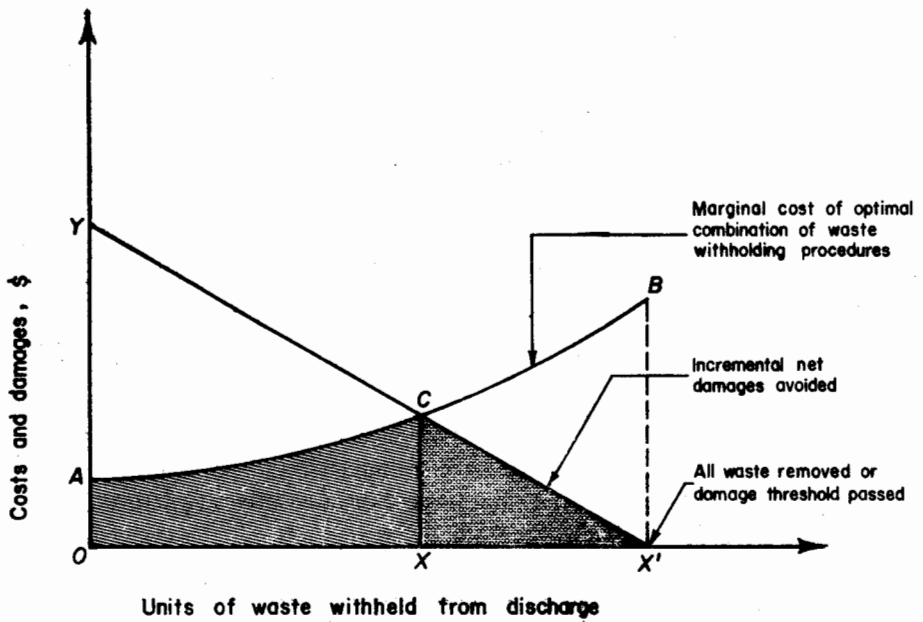

Fig. 1 Trade–off Analysis in Waste Handling.

Decision criteria and measures of worth

The decision process outlined seeks to arrive at a suitable balance between gain in human utility and loss in the ecosystem. This balance will vary with the degree of development of a country and so needs constant re-evaluation with time. However, with our limited knowledge of ecological consequences we should always be as conservative as possible by trying to maintain the existing balance of biological species as undisturbed as possible.

The media for expressing human values and social choices related to the quality of life are political, through elections, referenda, legislation, law enforcement and, sometimes, lawlessness. Environmental impact issues have given rise to public fervour both parochially and globally, and political stability is dependent on environmental decisions being made at the level which will satisfy society's perception of a satisfactory quality of life. There is no question that the quality of life has generally been sacrificed in developing countries for the short-term gains of economic development. Government planning organizations must accept the responsibility for stewardship of our environment and environmental impact assessment is of increasing importance in providing a basis for decision-making.

Environmental reconnaissance

An environmental or ecological reconnaissance may be carried out to give a preliminary assessment of environmental impact of a project and to indicate those aspects which deserve further in-depth study. It provides only a cursory review of principal impacts and is therefore of more limited scope and depth than an environmental impact study. The time scale for environmental reconnaissance would be much shorter than for environmental impact, perhaps of the order of 1 to 4 or 1 to 5.

Even though a reconnaissance is expected to be less thorough than an impact study it should be as detailed and quantitative as time and resources permit. It will normally involve a multi-disciplinary team coordinated by a project leader, who might well be an environmental engineer. The outcome of the study should be identification of those environmental impacts of a project which need further study, recommendations on alternatives for those components of a project which are likely to be environmentally unacceptable, recommendations on actions which should be taken so as to preserve or exploit natural or cultural resources and reduce adverse impacts, and preliminary recommendations on the likely acceptability of the total project or alternatives (wherever appropriate) from an environmental point of view.

Normally, as a result of an ecological reconnaissance survey there will not be surfficient data on which to base a trade-off analysis and recommendations will normally be based on subjective evaluation of information available. Where a project is estimated to have little adverse impact on the environment, the ecological reconnaissance study may obviate the necessity for a full environmental impact study and thus reduce costs while still allowing further study and remedial actions to be carried out on specific aspects with adverse effects.

Environmental impact assessment in Thailand

McGarry and others[4] of the Environmental Engineering Division, Asian Institute of Technology (AIT) conducted the first ecological reconnaissance to be carried out in Thailand. This was for the Electricity Generating Authority of Thailand (EGAT) and was concerned with development of the Quae Yai River in Western Thailand for power generation through the construction of a 140 m high conventional rock fill dam at Ban Chao Nen. The scope of the reconnaisance was based on terms of reference suggested by the World Bank of EGAT and included the following aspects:

Water resource management – In view of the multi-purpose function of the proposed Quae Yai dams, consideration was given to the likelihood of the projects' operating regimes being incompatible with simultaneous power, irrigation and other water resource needs and requirements. More specifically, studies were carried out on: the possibility of flooding of downstream urban centres and agricultural lands; the possibility of interference with downstream navigation; erosion or changes in the down-stream channel resulting from the proposed dams' operations; the likelihood of unfavourable changes in ground water

levels and associated soil's physicochemical alterations; and the impact on upstream and downstream irrigation schemes.

Mining, forestry and river basin development – Consideration was given to existing mineral deposits in the basin, particularly those which were to be inundated and those which might be exploited following dam construction with consequent sediment and pollutant inputs to the reservoir. The most important component of the basin's plant community was the forest stands; it was desirable to survey the existing forest stands of the Quae Yai basin, particularly those in the area proposed to be inundated to establish the value of stands which might be lost. Post-impoundment basin development can have strong influences on erosion and consequent sediment transport to the reservoir; in so far as possible, soil properties, ground cover and vegetation were studied with a view to predicting possible effects of human activities in upstream areas, including proposed resettlement sites.

Relocation of upstream inhabitants – The people most likely to feel immediate adverse effects of reservoir filling are those living up-stream in areas to be inundated. As the human inhabitants of the basin were observed to be culture specific and of several sects it was necessary to emphasise this aspect as being of major importance in the reconnaissance. In relation to socio-economic aspects of the communities, upstream surveys were made of physical geographic features of village areas, settlement patterns, population, social organisation, economic enterprise, land holdings, village economy and attitudes towards the proposed relocation scheme. Government plans for relocation were reviewed and their impact on the relocated population assessed. Of specific interest were the adequacy and sufficiency of settlement site design, housing and services to be supplied, the adequacy of relocation plans with reference to their social and economic welfare, health, safety and education including pre-removal orientation and information programs for the inhabitants. Investigations were also to be conducted on the agricultural potential of the proposed resettlement site.

Health – In parallel with socio-economic aspects of the relocated people, an investigation was undertaken to assess the impact of the dams on the health and nutritional characteristics of the basin's inhabitants, with particular reference to water-borne and insect-transmitted diseases. This investigation comprised surveys of villages above, at an below the proposed site; blood samples were taken from more than one thousand persons. The survey also included existing levels of environmental sanitation, food habits, mosquito species distribution, the existence of intestinal protozoan and helminthic infections, malaria, filariasis, encepthalitis, haemorrhagic fever and other common illnesses. Downstream irrigation schemes were inspected for the presence of eosinophilic meningitis and schistosomiasis. Consideration was given to the impact on the health of local inhabitants of the migration of labourers from other parts of Thailand to the dam site during construction.

Fisheries resources and aquatic weed infestations – Use of the reservoir as a fish production unit could be assessed as a benefit, however, interruption of existing downstream fisheries operations through interference in spawning habits, the release of deoxygenated

water from the dam or the retention of nutrients in the dam could be detrimental. A survey of existing fish was conducted, above, at and below the proposed dam site to better assess the relative importance of the above possibilities. Post-impoundment fisheries resources and their probable impact on the basin residents were evaluated.

Inundation of archaeological artifacts and sites – Prehistoric and historic findings have been made in the Quae Yai basin. Important archaeological remains from this area may be grouped into three prehistoric stages, the Pleistocene, the Hoabinhian and early village farming through the beginnings of metallurgy. An initial archaeological reconnaissance of the accessible portion of the river basin included a literature and secondary-source information survey and a three weeks search along the basin for archaeological remains.

Aesthetic quality and tourism potential of the Quae Yai Basin– Any disruption of natural conditions for purposes of commercial gain tends to deteriorate the high aesthetic quality of the environment. Therefore, the possibility of dam construction deteriorating aesthetic characteristics of the basin was assessed. The potential use of the dam as a tourist attraction was also considered as the lower Quae Yai and Noi basins are already tourist attractions of considerable value to the region.

This whole study involved an interdisciplinary group made up of: AIT staff and students in environmental engineering, water resources engineering and agricultural science and engineering; Department of Fisheries personnel; Kasetsart University staff in forestry; National Museum archaeologists; Chulalongkorn University social scientists; and a Mahidol University medical team. The details of the techniques used and findings of the study are too voluminous to present herein, but the following short list of recommendations, not in order of priority, were made in the report:

1. A final decision as to the location of the resettlement site had not been made at the time of the reconnaissance, therefore only guidelines for resettlement plans were available. It was recommended that investigations should be conducted into the proposed and alternative resettlement sites in terms of their water, soil, topography, access and potential for future development. Concurrent with these investigations, it was suggested that detailed surveys of existing upstream inhabitants' holdings and properties should be conducted and a judicious means of compensation devised. Upon deciding on locations for the settlement sites, it would be necessary to draw up detailed plans for resettlement site areas, water supplies, access and internal roads, land allocation, monetary compensation, administration, health and welfare services and educational and rehabilitation programs. Care would be necessary to ensure adequate hygiene levels at the resettlement sites and that provision was made for safe and plentiful water supplies. A forecast of the socio-economic status of the inhabitants of the proposed sites would also be advisable. As it is likely that several government departments would be involved (EGAT, the Departments of Public Welfare, Public Health, Credit and Marketing Cooperatives, Fisheries and Forestry and the Royal Irrigation, Land Cooperative, and Land Development Departments), it was strongly recommended that a coordinating body be established and a project manager

given the responsibility for plan implementation with the assistance of the cooperating departments. It was also recommended that a separate settlement site or sites should be located upstream for the Karen people. Accurate information related to the resettlement sites and scheme implementation should be distributed to the inhabitants of the valley as soon as possible.

2. It was recommended that a health centre should be established at the dam site to be staffed by a qualified doctor, at least during dam construction, and made available to the resettled population and construction labourers. Second class health centres should be located in all other sizeable resettlement sites. Eradication programs against malaria, haemorrhagic fever and filariasis should be initiated and/or expanded. Further investigation was required to establish whether the intermediate hosts of water-borne parasitic diseases were present in the river basin. If found, detailed surveillance of inhabitants should be conducted and the epidemiology of these diseases investigated. The introduction of diseases such as opistorchiasis by way of in-migrating labourers from other parts of Thailand should be monitored and preventive measures taken.

3. It was strongly recommended that, as soon as possible, a dry season archaeological survey of at least six months duration should be conducted in the watershed area by qualified archaeologists in accordance with recommendations made in the report. Protection of artifacts and sites against theft and damage should be provided during and after dam construction. All valuable artifacts either to be inundated or accessible to the public should be placed under the protection of the National Museum.

4. It was suggested that the benefits associated with fisheries on the reservoir should be realized through sound management practices. A Department of Fisheries station should be located on the reservoir to record catches, control methods of harvest and cooperate with the Department of Credit and Marketing Cooperatives in establishing fish marketing cooperatives.

5. Aquatic plants were recognized as a potential problem on the reservoir and in the downstream irrigation system and it was recommended that provision should be made for their control, adopting techniques suggested in the report.

6. Erosion was not considered a threat in terms of premature filling of the reservoir by sediment. However, erosion of topsoil should be prevented whenever possible; this would be due to poor construction methods and the subsequent practice of shifting agriculture. It was recommended that a realistic forecast be made of basin development and plans drawn up and implemented to ensure adherence to sound basin management practice. Also, commercial exploitation of forest stands which were to be inundated was recommended and that, within this area, timber companies be encouraged to remove all forest stands.

7. Further investigations were recommended to be conducted into the possibility of heavy metal contamination of the reservoir from lead and zinc mining operations.

Huge quantities of fluorite were to be removed from the vicinity of the dam site prior to dam construction and it was recommended that sound marketing policy be adhered to in order to prevent an excess supply to the world market and consequent price depression.

8. Finally, if the multi-purpose nature of the dam was to include benefits through tourism, lowering the high aesthetic quality of the valley should be avoided wherever possible. This recommendation was related particularly to the open mining of fluorite, rock quarries and the presence of transmission lines in the vicinity of the dam. The current tourist activity in the Quae Yai could be enhanced by the presence of a well-maintained dam, reservoir and associated facilties.

The overall conclusion was that, apart from those aspects requiring further investigation and provided that the above recommendations were implemented, there was no single ecological consequence or combination of consequences which was of sufficient importance to deter or preclude construction of the Ban Chao Nen Dam.

Subsequent to this study report being presented, McGarry and his co-workers[5] carried out further selected ecological surveys of the Quae Yai Hydroelectric Scheme. The additional investigations related to medical and archaeological aspects of the Quae Yai basin, to the impact of heavy metal mining operations within the basin and to deterioration in the aesthetic quality of the Quae Yai Valley.

Although schistosomiasis, opistorchiasis and paragonimiasis were not found during the health study of the basin, several of their intermediate hosts were. Concern was expressed over the likelihood of introduction of these diseases to the area by the in-migrating labourers from the north-east and central Thailand.

A thorough study of heavy metal pollution of alluvial soils, water and aquatic biota (reported by McGarry and others[6]) was observed to be a result of lead mining, ore concentration and spent slag washing operations in the basin. The level of contamination was not considered high enough to give rise to concern for human health with the exception of the case of slag washing labourers who live in what appears to be an environment heavily polluted by lead. Amongst others, recommendations were given for wastewater treatment and water quality monitoring programs to control heavy metal pollution.

Alternatives to the proposed transmission line routing, rock quarries and soil borrow area sites were investigated. An acceptable alternative transmission line route was suggested, as were recommendations for alternative quarry site investigations and the return of the soil borrow areas and quarry sites as far as possible to their original condition.

The existence of several archaeological sites which might be submerged or located adjacent to the reservoir were demonstrated. These sites, ranging from Hoabinhian rock shelters to historic structures evidenced a long and continuous human occupation

of the Quae Yai Valley and under-scroed the area's archaeological importance. Recommendations were given for further investigations including excavations.

It was again finally concluded that, apart from those aspects still requiring further investigation and provided that the several recommendations of the latter study and those given in the former ecological reconnaissance were implemented, there was no single ecological consequence or combination of consequences which was of sufficient importance to deter or preclude construction of the Ban Chao Nen Dam. On the basis of these environmental studies and other relevant factors the decision was taken to proceed with the project, and construction is now underway.

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บทคัดย่อ

ผลลัพธ์ของสิ่งแวดล้อมต่อโครงการพัฒนาได้มุ่งพิจารณาไปในส่วนที่เกี่ยวข้องกับประเทศที่กำลังพัฒนาเป็นประการสำคัญ และมุ่งพิจารณากำหนดช่องทางที่ได้ผลในการประเมินคุณค่าของสิ่งแวดล้อม สำหรับใช้ในโครงการสำคัญ ๆ แต่ละโครงการด้วย การศึกษาขั้นต้นจะพิจารณาเกี่ยวกับความต้องการ จุดประสงค์ เครื่องมือที่จะนำมาใช้เป็นต้น ส่วนการเตรียมการประเมินคุณค่าสิ่งแวดล้อมก็ต้องคำนึงถึงด้วย และองค์ประกอบเด่น ๆ ของสิ่งแวดล้อมเองจะเป็นเครื่องชี้แนวทางในการประเมินผลงานให้ถูกต้องยิ่งขึ้นอีก วิธีการวิเคราะห์ผลความสมดุลย์ทางอัตรา การกระจายตัวที่ยังเหลืออยู่ ความไม่แน่นอนของตลาด การวิเคราะห์ขอบข่ายของงาน และผลชดเชยที่จะได้รับกลับมาจะนำมาเป็นเค้า

โครงของงานและเป็นแง่คิดของบันทัดฐานการตัดสินใจ และนอกจากนั้นมาตรการที่มีคุณค่าอื่น ๆ ก็จะนำมาใช้ด้วย

ตัวอย่างการประเมินคุณค่าสิ่งแวดล้อมในประเทศไทยที่ได้นำมาทบทวนคือโครงการไฟฟ้าพลังน้ำที่แควใหญ่ ขอบเขตของการศึกษานี้รวมถึง แหล่งน้ำ เหมืองแร่ ป่าไม้ การพัฒนาลุ่มน้ำ การอพยพของผู้อยู่ต้นน้ำ การอนามัย การประมง วัชพืชน้ำ ปัญหาน้ำท่วม วัตถุโบราณสถานดึงดูดใจนักท่องเที่ยว ในที่สุดจะแนะนำถึงการสำรวจศึกษาสภาพเดิมของสิ่งแวดล้อม และให้รายละเอียดเพิ่มเติม เกี่ยวกับวัตถุ โลหะ ยา ความสำคัญทางโบราณคดี และความงามของลุ่มน้ำ