WATER RESERVOIR IMPACT ASSESSMENT IN INDONESIA: THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS AND THE USE OF REMOTELY SENSED DATA

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By

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Abstract

Water resources developments in Indonesia is under the full authority of the government. All proponents for this type of development are government agencies. These developments are designed primarily for irrigation and are implemented mainly to alleviate socio-economic problems in society. However, water resources developments create serious socio-economic problems related to the relocation of people, because of the high population density of the country.

Due to the urgent fulfilment of the population demands, the developments will have to continue, but with special emphasis on minimizing the environmental impacts. This needs an environmental impact assessment (EIA) to be applied properly and monitoring of the environment to be carried out effectively. This thesis examines some shortcomings in the Indonesian EIA process and the role of public participation in the objective assessment of concerns regarding these developments. The thesis also examines how remotely sensed data can be used for water reservoir impact assessment and monitoring.

The Indonesian EIA process has some shortcomings when compared to other EIA processes, in that the entire process is a self assessment within the initiating department.

When the proponent is a private company, the reviewer in the initiating (government) department can act as an independent party between the proponent and the public. When the proponent is a government agency, there is an opportunity for the reviewer towards a self-interested bias. Other problems have involved people's protests against water resources developments which resulted from inadequate opportunity for public input into the EIA process.

A ground receiving station for satellite remotely sensed data is in existence in Indonesia. This station is able to receive and process LANDSAT MULTISPECTRAL SCANNER (MSS) and LANDSAT THEMATIC MAPPER (TM) data. However, few specialists in the field of water resource development in Indonesia utilize these data in their work. This thesis explores the use of remotely sensed data for the environmental impact assessment and monitoring of water resources developments particularly in reservoir impoundment projects. The proposed Lower Churchill River hydro-electric development project in Labrador, Canada, is used here for illustration of the use of remotely sensed data for an environmental impact assessment. This thesis examines the possible application of these remote sensing techniques in a water resource project in the South Kedu area in Central Java, Indonesia.

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The author would mention his friend Wim Hartono, who has dedicated his time for a sustainable environment in Wadaslintang, and inspired the author to learn further about EIA. It is impossible to list the names of all friends, colleagues, and relatives who provided support and assistance for the success in this program. For all of them the author expresses his acknowledgement.

To his wife Sri Rachmawati, and children Merry and Kartika, the author expresses his appreciation for their patience, understanding and support.

Finally, the author records with sadness the passing away of his close colleague, associate, and replacement in the South Kedu Multipurpose Project, Suhardi Basuki.

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List of Abbreviations

AMDAL	Analisa Mengenai Dampak Lingkungan (Indonesian EIA process)
ANDAL	Analisa Dampak Lingkungan (Indonesian EIS)
BAPEDAL	Badan Pengendalian Dampak Lingkungan (Board for Environmental Impacts Control)
BAPPENAS	Badan Perancangan Pembangunan Nasional (National Planning Board)
C-CAE	Centre for Computer Aided Engineering
CCT	Computer Compatible Tape
CIDA	Canadian International Development Agency
EARP	Environmental Assessment Review Process
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPR	Environmental Preview Report
ERS-1	Earth Resource Satellite (of ESA)
ESA	European Space Agency
FEARO	Federal Environmental Assessment Review Office
GIS	Geographic Information System
IEE	Initial Environmental Evaluation
IPPF	International Planned Parenthood Federation
JERS-1	Japan Earth Resource Satellite-1
LBH	Lembaga Bantuan Hukum (Institute for Legal Assistance)

LCDC	Lower Churchill Development Corporation
MID	Minister of the initiating department
MOE	Minister of the Environment (Canada)
MPE	Minister of the Population and the Environment (Indonesia)
MSS	Multi-spectral Scanner
MUN	Memorial University of Newfoundland
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
PIPLI	Pusat Informasi dan Pengelolaan Lingkungan Hutan Indonesia (Centre for Information and Forestry Management)
PIL	Penyajian Informasi Lingkungan (Description of Existing Information)
PKBI	Perkumpulan Keluarga Berencana Indonesia (Indonesian Planned Parenthood Organization)
PSKS	Proyek Serbaguna Kedu Selatan (South Kedu Multipurpose Project)
RADAR	Radio Detection and Ranging
RKL	Rencana Pengelolaan Lingkungan (Environmental Management Plan)
RPL	Rencana Pemantauan Lingkungan (Environmental Monitoring Plan)
SAR	Synthetic Aperture RADAR
SEL	Studi Evaluasi Lingkungan (Environmental Evaluation Study)
TM	Thematic Mapper
WALHI	Wahana Lingkungan Hidup Indonesia (Indonesian Environmental Organization)

1. Introduction

Food self sufficiency for the nation is a primary objective for development in Indonesia. For this purpose, water resources development to improve agricultural production is intensively implemented. Considering the fertility of the island, the established culture towards technical agricultural practices, and the existence of extensive irrigation networks, the island of Java is often the most appropriate location for this type of development in Indonesia. The population density in Java has reached about 800 people/km^2 in 1991 (Anon., 1991a). This relatively high density creates land pressure in the forms of, amongst others, over cultivation and shifting of forest areas into agriculture. Problem related to water resources development also arise due to the necessity of relocating people away from inundated areas.

Water resources development in Indonesia is under the full authority of the government. All proponents of this type of development are government agencies. Land and water managers in Java have a challenge to optimally utilize land and water resources for the benefit of the people. This entails monitoring and implementation of environmental programs to keep these resources sustainable.

Indonesian Environmental Law was established in 1982. This was followed by Environmental Regulations that were issued in 1987 to provide guidelines for the conduct of Environmental Impact Assessment (EIA). This thesis examines the impacts of water resources developments and the problems in conducting an EIA in Java. Some examples on the impacts of these developments are described. In addition, this thesis also discusses the use of remotely sensed data for the EIA and the environmental monitoring of these projects.

In order to evaluate the Indonesian EIA process, other EIA processes were studied, such as the Canadian Federal Environmental Assessment Review Process (EARP) and the Newfoundland and Labrador provincial EIA process. These processes are used for comparison and reference. It is revealed that public participation is inadequate in the Indonesian EIA process.

Remotely sensed data are useful in the assessment of the availability of water resources, and can be used to monitor deterioration of the environment that results as a consequence of their development. The LANDSAT receiving station in Cibinong, Indonesia, is able to receive and process multispectral scanner (MSS) and thematic mapper (TM) satellite data. These remotely sensed data are available for most areas of Indonesia. However, only a limited number of specialists in the field of water resources development in Indonesia utilize these data in their work. This periodically-available data and the large coverage have been useful elsewhere for accurate and timely decision making. A delayed decision on water resources problem in a densely populated area could result in a serious damage to the environment. With the use of data frequently acquired from LANDSAT as well as other satellites, decision makers can make timely decisions affecting water resources project.

The proposed Lower Churchill River hydro-electric development project in Labrador is used as an example of a North American environmental impact assessment and a guide for a procedure for using remotely sensed data in a similar water resource project in South Kedu area in Central Java, Indonesia.

2. Objectives

The objectives of this thesis are as follows:

1. To evaluate the EIA process in Indonesia, by using the Canadian EIA process as a reference and for comparison. This evaluation is directed towards the following goals:
   a. an understanding of current environmental concerns in Indonesia,
   b. anticipation of future environmental concerns in Indonesia,
   c. consideration of possible enhancements to the Indonesian EIA process which may facilitate the environmental assessment of water resources developments.
2. To critically evaluate the current use of remote sensing in water resources development.
3. To design a procedure for using remotely sensed data in the conduct of environmental impact assessment (EIA) of water resources development projects in South Kedu, Indonesia.

This thesis is intended to enhance the Indonesian EIA process, aid persons involved in the development and assessment of water resources projects, and aid researchers and students conducting research in water resources development.

3. Background

All water resources developments in Indonesia are implemented by government agencies as a means of alleviating economic problems. These developments are urgent due to population and land-demand pressures in the country. Yet the experience to date indicates that this type of development has often resulted in adverse impacts upon the physical, biological, and socio-economic environments. Protests have occurred against these developments.

An EIA process usually involves baseline studies, impact predictions, and design of mitigation measures. These activities involve scientists, experts, and the public, especially adversely affected people. The involvement and participation of the public in the process is essential as they usually have information on what has to be considered important in assessing the impacts of the development. It often happens that what is considered unimportant by the scientists is extremely important for the people.

The inclusion of remotely sensed data in this thesis is intended to provide examples of determining important items to be considered in water resources developments. The purpose is to encourage the use of these types of data for water resources developments. These data are readily available in Indonesia, but they have only been used occasionally by developers of water resources.

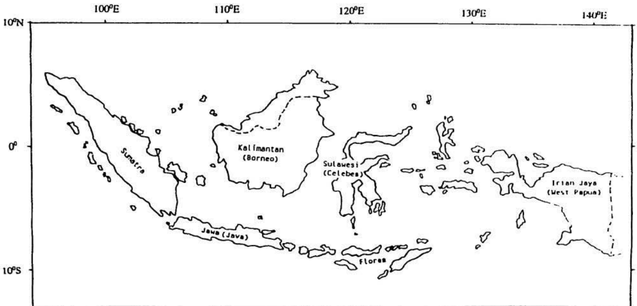

Figure 3-1 Indonesia

3.1 Water Resources Development Problems in Indonesia

Water resources development in Indonesia is usually designed to fulfil existing demands for irrigation, industry, and for domestic consumption. The latest census of Indonesia (December 1990), indicated a population of 179,321,641 (Anon., 1991a). The annual growth rate was 1.97% for the period 1980-1990. Sixty per cent of the whole population, more than 107 million, live on the island of Java (Fig. 3-1), resulting in a density in Java of 814 people/km^2. The figures for Sumatra and Sulawesi are 77 and 66 people per square kilometre respectively, while for Irian Jaya and Kalimantan the figure is less than one. With this uneven population distribution, water resources development projects are often planned and implemented in less populated areas to encourage transmigration[1] from more densely populated islands.

The water resources development policy in the agricultural sector is aimed at food self sufficiency for the country. Due to differences in population density and different environmental conditions, there are different methods and policies for implementing developments in Java and outside Java. All arable land in Java is presently being cultivated. Therefore increasing agricultural production often means increasing the productivity of the land. This includes the development and improvement of irrigation systems and provision of year round irrigation water. For example, some rice fields in

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1 Transmigration in Indonesia has a special meaning, which is to move to another island. A transmigration program is intensively implemented in Indonesia. This government program has as an objective to reduce the population of the densely populated island (Java) by relocating the people to less populated islands (Sumatra, Kalimantan, Sulawesi, Irian etc.).

Java (and throughout Indonesia) can only be harvested annually due to their dependence on the rainy season; with the provision of year round irrigation from a reservoir, the same area could produce two harvests of rice per year. Irrigation has been practised in Java for decades, so farmers readily accept irrigation technology for increasing rice production. In addition, Java is the most fertile of the islands in Indonesia for rice production. Under the same conditions of irrigation in the following islands, rice production in Java can reach 5.16 ton/ha., while in Sulawesi it is 4.15 ton/ha., in Sumatra it is 3.92 ton/ha., and in Kalimantan the figure is 2.69 ton/ha. (Soemarwoto, 1991).

On the islands outside Java, irrigation technology is not as advanced. It is a slow process to educate farmers to shift from traditional methods to technical irrigation. The cost of developing these resources projects require that the resources be utilized at full capacity, which is difficult in less densely populated areas. An example of this was the construction of a diversion weir in Mbay, Flores (Fig. 3-1), a small island in the region of Nusatenggara, Indonesia. The weir was capable of irrigating 12,000 ha, but after eight years, the amount of cultivated area was still only 2,500 ha (B. Hargono, personal data collection on Mbay, 1988).

The problems in Indonesia at present regarding the demand for food on all islands suggest that the development of water and land resources in Java to increase agricultural production, is still the best solution. However, with such a high population density (800 people/km²), any water resources development always includes land compensation. The issue of relocation is the most problematical for reservoir projects in Java (Table 3-1).

Development of the islands outside Java is being accelerated to show the intention of the government to evenly distribute development, to discourage migration of people to Java, and to encourage people to move away from Java, usually by a transmigration program. The government provides land and houses for those relocated people on less densely populated islands. Only a limited number of people usually join this program, the rest stay in the vicinity of the reservoir, which creates more land and population pressure. Some examples of relocation impacts are described in section 5.2.

Table 3-1 Examples of relocated people in dams constructed in the period 1981-1990

DAM	LOCATION	RELOCATED PEOPLE	NUMBER OF HOUSEHOLDS
Wadaslintang[2]	Central Java	28,000	8,100
Kedungombo[3]	Central Java	27,000	5,300
Saguling[4]	West Java	14,000	-
Cirata[5]	West Java	28,000	-

[2] Universitas Diponegoro (1989).

[3] Anon., 1991d.

[4] Institute of Ecology (1979), this dam is for hydro-electric power.

[5] Institute of Ecology (1982), this dam is for hydro-electric power.

3.2 Environmental Impact Assessment in Water Resources Development

In Java, since thousands of people usually have to move from reservoir sites, relocation impacts are serious. Physical and biological impacts that lead to loss of wildlife habitat, or aesthetic values usually are not of much concern to these people. However, it has to be kept in mind that physical, biological, and the socio-economic environment are interdependent. These aspects become more important as the population increases. This situation may result in more pressure on land resources and the life supporting ecosystem (Rees, 1986).

Environmental impact assessment (EIA)[6] is the process of identifying the likely consequences of implementing particular activities such as industrial development or the enactment of legislation (Wathern, 1988). It concerns the physical, biological, and socio-economic conditions (environment) of the area being developed. Its aim is to review this information at a stage prior to when a decision is taken on the approval or denial of a proposal.

3.2.1 Indonesian Environmental Impact Assessment Process

An environmental law in Indonesia was established in 1982. The basic objectives of the

6 Indonesian term for EIA is AMDAL (Analisa Mengenai Dampak Lingkungan). In this thesis the term is kept as EIA for both Canadian and Indonesian processes.

law include a congruence between the people and the environment, a proper management of the resources and the environment, and development that is sustainable and based on the concept of sound environmental protection. The government issued further environmental assessment regulations in 1986. The law as well as the regulations apply for both the national and provincial governments; provincial governments do not have their own environmental law and EIA regulations. For standardization of environmental assessment procedures the Minister of the Population and the Environment (MPE) issued guidelines for environmental assessment reviews in 1987 (Figure 3-2).

In accordance with the regulations, the entire EIA review process is conducted by the Minister of the initiating department (MID)[7]. During the environmental impact assessment of project proposals, the MID is assisted by an EIA Commission. At the national level, the members of the EIA Commission are appointed by the MID and include a representative from the MPE. The final decision regarding the acceptance of the project lies with the MID.

The EIA Commission has the task of evaluating all EIA documents, which includes preparing a technical manual for the EIA, establishing terms of reference for the

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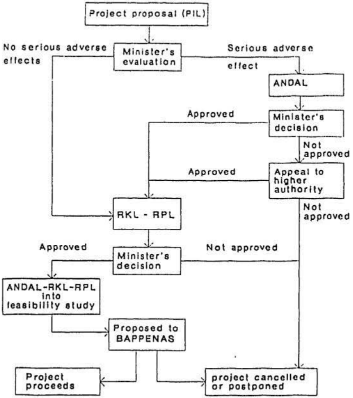
[7] The department that has the decision making authority for the project. The MID for water resources development for agriculture in Indonesia is the Minister of Public Works. If it is for hydropower generation, the MID is the Minister of Energy and Mining. The MID for private projects depends on the activities. For example, a proposal for a paint manufacturing company should be registered with the Ministry of Industry.



Legend

PIL:	description of existing environment
ANDAL:	environmental impact assessment
RKL:	environmental management plan
RPL:	environmental monitoring plan
BAPPENAS:	national planning board
Higher authority:	the President of the Republic of Indonesia, with MPE as the adviser

Figure 3-2 Indonesian National Environmental Assessment Process

environmental impact statement (ANDAL)[8], and making recommendations to the MID which assist decision making concerning the proposal. The EIA Commission is made up of permanent and non-permanent members.

The permanent members are:

- *chairperson*, first rank person (director general or other person with similar level status) under the Minister of the initiating department,
- *secretary*, second rank person under the Minister of the initiating department,
- representatives of the design unit of each directorate general,
- one member appointed by the Minister of Home Affairs,
- one member appointed by the Minister of Population and Environment,
- expert(s) in related areas from (a) non governmental agency(ies).

The non-permanent members are appointed by the MID when he/she considers it to be necessary, and can include the following:

- representative(s) of other related department(s),
- representatives of adversely affected people,
- knowledgable experts regarding the expected impacts,
- representative(s) of (a) non-governmental organization(s) (NGO),
- other members if the MID considers it is necessary.

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[8] Environmental impact statement (EIS) in Indonesia is termed as 'Analisa Dampak Lingkungan', abbreviated as 'ANDAL'. To avoid confusion with the term 'AMDAL', which is the whole EIA process, the author uses ANDAL for the Indonesian document which is similar to the Canadian EIS and retains use of EIA for the AMDAL.

For projects at the provincial level the EIA procedure is similar, except that the governor of the province replaces the functions of the State Minister of the National Planning Board (BAPPENAS)[9] as well as the MID. The flow diagram of this procedure is presented in Figure 3-3.

During the EIA of the project (provincial level), the governor assigns a provincial level EIA Commission. Similar to the national level, the commission is also made up of permanent and non permanent members.

The permanent members are:

- *chairperson*, Head of Provincial Planning Board,
- *secretary*, Head of Provincial Bureau of Environmental Works Guidance,
- a representative of the Provincial Planning Board,
- a representative of the Bureau of Environmental Works Guidance,
- a representative of a Centre of Environmental Studies from a local university.

If the Governor considers it necessary, non-permanent members of the EIA Commission can be assigned who can include:

- the Secretary of the Regency[10],
- the Head of the Regency Planning Board,

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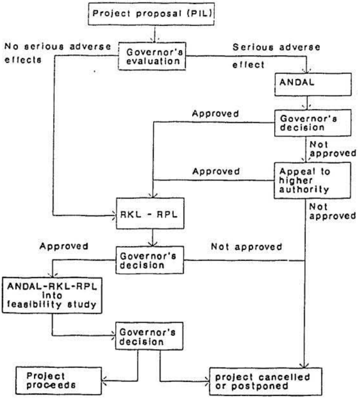
9 BAPPENAS is the abbreviation of 'Badan Perancangan Pembangunan Nasional', the National Planning Board.

10 Regency is a subdivision of a province. For further reference about Indonesian Government Organization please see Santosa (1990).



Legend

PIL:	description of existing environment
ANDAL:	environmental impact assessment
RKL:	environmental management plan
RPL:	environmental monitoring plan
Higher authority:	the Minister of initiating department or the Head of Board for Coordination of Capital Investment

Figure 3-3 Indonesian Provincial Environmental Assessment Process

- the Head of the Board for Coordination of Capital Investment,
- the Head of the Provincial Office of the initiating department,
- representatives of adversely affected people,
- knowledgable experts on related impacts,
- representative(s) of a NGO(s),
- other non permanent members if the Governor considers it necessary.

The tasks of the provincial level EIA Commission are similar to the national level EIA Commission's, except that the recommendation regarding acceptance of the project is submitted to the Governor.

The first step in the EIA requires that the proponent prepare a proposal including a brief description of the existing environment (PIL)[11]. The PIL presents the nature of the project, the potential interactions between the project and the environment, the prediction of impacts from these interactions, and the proposed mitigation measures. The proposal is submitted to the MID.

If the Minister's evaluation of the PIL leads to a conclusion that there would be no serious adverse effects to the environment, the proponent may directly proceed with the

[11] 'PIL', stands for 'Penyajian Informasi Lingkungan' and is a document that is similar to the 'Environmental Preview Report/EPR' in the Newfoundland and Labrador provincial EIA process, or the 'Initial Environmental Evaluation/IEE' in the Canadian federal EIA process.

environment management plan (RKL)[12] and the environment monitoring plan (RPL)[13]. If there is an indication of serious adverse impacts, the proponent is required to submit an environmental impact statement (ANDAL). If the ANDAL is accepted, the proponent may continue and prepare the RKL and the RPL. There is an option to submit an ANDAL without preparing a PIL, if the proponent believes that the proposal will result in serious impacts.

All documents, the PIL, the ANDAL, the RKL, and the RPL require approval by the MID. This proposal is then incorporated into the feasibility study for approval by the National Planning Board on whether to proceed or not.

The Indonesian EIA process seems to be effective for examining the proposals of private companies. The MID with the EIA Commission can act independently between the public and the proponent. One example was that regarding a proposal for forest harvesting in Irian for a pulp mill (Santosa, 1990). The MID in this case was the Minister of Industry. Public concerns were raised by NGOs questioning the effects of this project on the social life of the inhabitants. The result was that the government denied approval of the proposal.

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12 This document is termed as 'Rencana Pengelolaan Lingkungan/ RKL'.

13 This document is termed as 'Rencana Pemantauan Lingkungan/ RPL'.

3.2.2 Problems in the Indonesian Environmental Impact Assessment Process

The entire Indonesian EIA process is based on self assessment within the initiating department. This means that the EIA Commission has a great tendency to favour a proposal coming from a government agency of the same department. Another problem is that the participation of the adversely affected people and NGOs in the EIA Commission is under the full discretion of the MID or the Governor. These representatives are included only when the MID or the Governor considers it necessary. This makes the absolute exclusion of public participation in the EIA Commission possible. Even when the adversely affected people and the NGOs are represented on the EIA Commission, they are only a minority in comparison with other members who might be "suspected" of supporting the proponent.

With the current Indonesian EIA process, approval of a proposal for water resources development may be easily obtained. However, popular protests against water resources development in the past should remind decision makers about the need to involve the public intensively. (Note: The Canadian federal Environmental Assessment Review Process (EARP) and the Newfoundland and Labrador EIA process provide adequate opportunity for public participation. These processes are briefly described in sections 3.2.3 and 3.2.4.)

There are problems with regard to public participation due to the inherent cultural characteristics and social condition of Javanese people. Although some protests have occurred, the Javanese people are generally passive and acquiescent. Therefore, these protests indicate that the social or environmental problems are serious.

It is not easy for Javanese people to express their opposition to a respectful person's opinion (Santosa, 1990). In remote areas where traditional Javanese culture exists, the respectful persons may comprise parents, teachers, head of the village, and the government. This fact is not always true in a decision making process conducted at village level. Village people in South Kedu area, for example, meet every 35 days to discuss local problems and solutions. However, in a case of water resources development that is implemented by the national government, the villagers feel that they are obliged to follow the direction of the government. When the government requests the people to move from the reservoir area, they usually move without protest. While it is an advantage to the initiating agency, it is also difficult for the agency and the government to understand whether there are unexpressed concerns. These characteristics, in addition to the prevailing poor level of education in remote areas, make it difficult to encourage active public participation in the EIA process. In investigating the impacts of a development during an EIA process, accurate data on people's problems are important. When people do not express their concerns, it is difficult to design a proper mitigation measure to deal with these concerns.

3.2.3 Canadian Federal Environmental Assessment and Review Process

In 1973 the Canadian Federal Cabinet established the Environmental Assessment and Review Process (EARP). The process is administered by the Federal Environmental Assessment Review Office (FEARO), which is a responsibility of the Federal Minister of the Environment. In accordance with the Government Organization Act (1979), the Federal Minister of the Environment has the role *"to ensure that new federal projects, programs and activities are assessed early in the planning process for potential adverse effects on the quality of the natural environment..."* (FEARO, 1979).

The first level of assessment is an initial environmental evaluation (IEE), in which the initiating department examines the proposal. The IEE examines the potential environmental effects and public concerns. The decision arising from the review of the IEE is submitted to FEARO for publication. Public awareness and/or input may then occur at this stage. When the IEE states that a project may cause serious adverse environmental effects, or that there are serious concerns requiring a public review, the MID refers the proposal to the Minister of the Environment (MOE) for further assessment; otherwise the project may proceed. The initiating department may avoid the IEE and proceed directly to an EIS[14] level assessment if it decides there are serious effects expected from the project.

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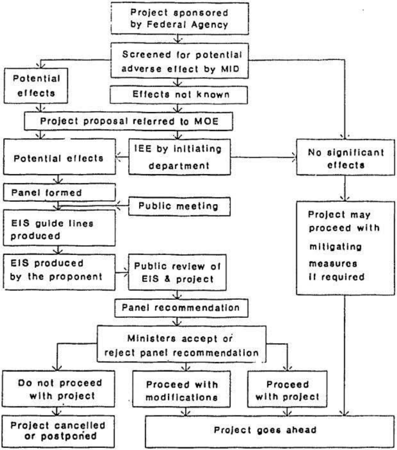
[14] An Environmental Impacts Statement (EIS) is a document that describes: project description, environment (physical, biological, socio-economic), impact assessment, and mitigation measures. The essential part of the documents is the final impacts of the project after mitigation measures have been implemented. This document is similar to ANDAL in the Indonesian EIA (AMDAL) process.

For a public review and an EIS, an Environmental Assessment Panel is appointed by FEARO. This panel is independent, in which "members must be free of potential conflict of interest or political commitments and should have special knowledge or relevant experience that is useful for reviewing the anticipated effects" (FEARO, 1987). This review panel is assigned for the duration of a project review.

The preparation of the EIS is the responsibility of the initiating department but may be delegated to the proponent. Information regarding the Panel's activities and review of the EIS, is disseminated through the Panel secretariat during the preparation of the EIS. Comments, review, and information are invited and can be submitted through the panel secretariat. Exchange of information and ideas occur during public meetings and public hearings. Commonly, a panel conducts two kinds of public meeting. The first kind is intended to collect public input for the preparation of the terms of reference for an EIS that is to be prepared by the proponent. The second kind is intended to provide opportunities for public comment and review of the EIS as it is completed and submitted to the Panel. Recommendations to the MOE are made by the Panel after these meetings. The final decision on the acceptance of an EIS lies with the MOE. The flow chart of the Canadian federal EIA process is shown in Figure 3-4.



Legend

MID: the Minister of Initiating Department
MOE: the Minister of the Environment
IEE: Initial Environment Evaluation
EIS: Environmental Impact Statement

Figure 3-4 Canadian Federal Environmental Assessment Review Process (Sources: FEARO, 1979)

3.2.4 Newfoundland and Labrador Provincial Environmental Impact Assessment Process

The Environmental Assessment Act for Newfoundland and Labrador was enacted in 1980. According to this law, all projects which may have impact upon the environment are to be registered with the Department of Environment and Lands for examination. Before passing this examination no approval from any provincial or municipal authority can be given.

The EIA process in Newfoundland and Labrador provides full authority to the MOE for the review. The reviews are completed by an Assessment Committee which is appointed by the MOE. The Assessment Committee is made up of government officials from various departments which may be interested in or affected by the proposed project (Leeder, pers. comm., 1991). In the event that the proponent is a division of a government department, this division cannot be represented in the Assessment Committee (Govt. of Nfld., 1984), thereby maintaining objectivity in the project review.

Following the receipt of the registration document, the MOE issues a press release and mails notices to interested parties. The MOE is also obliged to announce the proposal in a newspaper with distribution in the area where the project is to be located. In the case that there is no newspaper circulated in the area, the announcement has to be posted in public places such as post offices. These activities are intended to encourage public comments and provide information which the MOE considers when making the decision. The decision can be one of the following: the project may proceed, an environmental preview report (EPR)[15] is necessary, or an environmental impact statement (EIS)[16] is required.

When an EIS is required, the proponent has to include a proposal for a public information exchange program in its draft of the terms of reference. The information program can be in the form of a public meeting, or other methods approved by the MOE (Leeder, pers. comm., 1991). Thus, both the proponent and the MOE are involved in the dissemination of information and collection of public comments.

Public hearings are usually not required unless there is a strong public interest or concerns arise about the proposal. When this occurs, the MOE may request Cabinet to appoint an Environmental Board to hold public hearings. One-third of the board's members are residents of the project locality, but the chairperson must be neither a government official nor a resident of the project area. Since the promulgation of the environmental law, there has been no case in which an Environmental Assessment Board has been appointed. A flow chart of the Newfoundland and Labrador EIA process is

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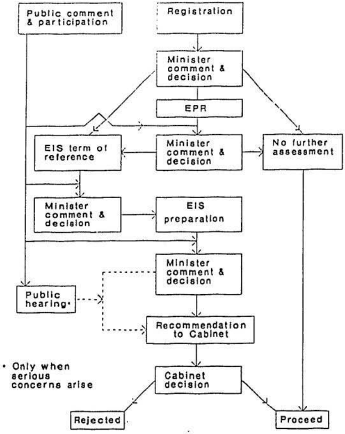
15 According to the Newfoundland *Environmental Assessment Act*, the environmental preview report is "a report that presents the result of a preliminary environmental assessment based only on readily available information, and in which certain essential subjects may be incompletely treated due to a lack of data".

16 According to the Newfoundland *Environmental Assessment Act*, the environmental impact statement is "a report that presents the result of a complete environmental assessment". However, it is similar to the EIS of the EARP process, and ANDAL of the Indonesian EIA process.The EPR is similar to the PIL of Indonesian EIA process and the IEE of the EARP.



Legend

Minister:	the Minister of the Environment and Lands
EPR:	Environmental Preview Report
EIS:	Environmental Impact Statement

Figure 3-5 Newfoundland and Labrador Environmental Assessment Review Process (Source: Govt. of Nfld., undated, and Leeder, 1991, pers. comm.)

presented in Figure 3-5.

3.2.5 Non-Governmental Organizations in Indonesia

Non-Governmental Organizations (NGOs) have been active in Indonesia. Their role includes reviewing the conduct of developments and the enhancement of public environmental awareness (Anon., 1991f). Some government institutions in Indonesia have been founded in order to emphasize environmental considerations in every aspect of the life of the nation, after the influence of among others, these NGOs. NGOs also encourage and help people to express their concerns regarding developments. It is considered important to include discussion about the role of NGOs in this thesis. The objective is to understand their role in controlling the conduct of water resources development in Indonesia, and in helping to enhance public participation in the EIA process.

3.3 Remote Sensing in the Environmental Impact Assessment of Water Resources Developments

Key components of environmental impact assessments for water resources projects as described by Canter, (1985) include the followings:

1. impact identification,
2. conduct of baseline studies,
3. prediction of impacts of various environmental factors,
4. assessment (interpretation) of the predicted impacts,
5. conduct of trade-off analysis,
6. identification and evaluation of mitigation measures.

In practice, these are often grouped into three major components:

1. baseline studies: includes the impact identification,
2. prediction and quantification of impacts: includes the assessment of predicted impacts,
3. design of mitigation measures: includes the conduct of trade-off analysis and the design of the procedure for monitoring the environment.

During baseline studies, remote sensing data can be used to determine important environmental parameters in the catchment areas as well as in the service area. For the purposes of a baseline study a ground survey or inventory is usually required, but this is often time consuming (Chiao et al., 1987) and expensive. When remote sensing data is available, ground surveys are often needed to obtain reference data. Inaccessible areas can be described with the aid of remote sensing imagery which could not be done by ground survey methods. Delineated features on the image can then be quantitatively assessed.

Satellite data are available regularly in Indonesia, therefore problems related to water resources development can be detected and evaluated without delays. Based on the interpretation of these data and on the knowledge of the surface characteristics, proper mitigation measures can be developed and implemented quickly.

3.4 Examples of Applications of Remotely Sensed Data

Remotely sensed data provide reliable information on the extent and the characteristics of a particular feature. However, to identify what is presented in the remote sensing imagery, ground reference data are required. Previous studies and information from persons knowledgable of the area involved are valuable in the design of the environmental evaluation process. These measures reduce the time and effort required for field observations for ground referencing.

To illustrate the use of remote sensing in water resources development, two case studies are presented. One of these is related to the hydropower development on the Lower Churchill River in Labrador, Canada. The other development is in the South Kedu area in Indonesia. Some environmental studies have already been carried out for the Canadian project. In this thesis various kinds of remote sensing imagery are interpreted to illustrate their usefulness in environmental studies for this area.

3.4.1 The Lower Churchill River Development

The Churchill River basin is located in central Labrador, in eastern Canada. The river is situated between 60^0 and 67^0 west longitude and 52^0 and 55^0 north latitude, and has a watershed of about 90,000 km^2 (Figure 3-6). The river flows to the east and eventually empties into Lake Melville and the Atlantic Ocean.

Water resource developments on the Churchill River have been, and will continue to be in the foreseeable future, exclusively for hydroelectric power generation. The first development was the hydroelectric power plant installation at Churchill Falls, which began operation in December 1971 (Smith, 1975). The Lower Churchill River (downstream of Churchill Falls) is about 225 km long and is suitable for further hydro development. The present proposal involves the installation of hydroelectric generating stations at Muskrat Falls, about 44 km west of Happy Valley/Goose Bay, and at Gull Island, about 60 km further upstream (Figure 3-6). The dams at these two sites will be designed to obtain potential head rather than to store water. The generating stations will use mainly the water released by the Churchill Falls power plant. With such an operation, the draw-down of the Gull Island and Muskrat Fall reservoirs are limited to six metres and one metre respectively (LCDC, 1980).

The presence of the dam at the lowermost generating station, and the created reservoir will have a direct effect on the Churchill River down to the estuary. Other impacts of

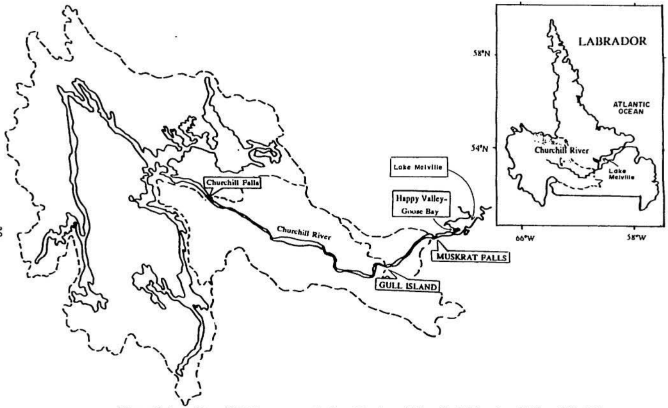


Figure 3-6 Churchill River watershed at Muskrat Falls, Gull Island and Churchill Falls (LCDC, 1980)

reservoir and dam construction at Gull Island will be similar. Therefore, the Muskrat Falls was chosen to illustrate the use of remotely sensed data in environmental assessment.

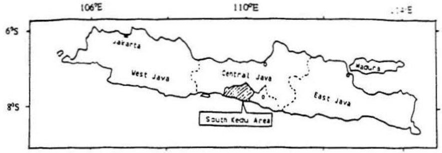
Labrador is sparsely populated. Total population of Labrador according to the 1986 Census publication 92-109 was 28,741 in an area of 265,437.43 km^2. There are two population centres near the Churchill River, one is the town of Churchill Falls and the other is Happy Valley/Goose Bay at the up stream and down stream ends of the Lower Churchill River, respectively. In 1975, a Federal Environmental Assessment Panel was established to review the proposed hydroelectric development project at Gull Island. Due to difficulties in obtaining financial support, the development was put on hold in 1976 (LeDrew, Fudge and Associates, 1991). In late 1978, the Lower Churchill Development Corporation (LCDC), a crown corporation jointly owned by the Federal Government and the Province of Newfoundland and Labrador, was founded as the project was re-activated and the Federal Environmental Assessment Panel established in 1975 was reconstituted. Following a review of the EIS the Federal Environmental Assessment Panel for this project issued a report (in December 1980) to the federal Minister of the Environment stating that the project could be acceptable provided certain environmental and socio-economic conditions were met (FEARO, 1980). Based on the report, the Minister of the Environment approved the project on December 11, 1980, and released it from further review under the Federal EARP (Govt. of Canada, 1980). However, construction has not proceeded due to problems of energy marketing and financing difficulties

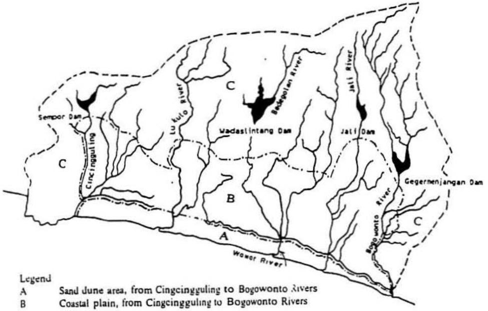
(Newfoundland and Labrador Hydro, 1990). Under the proponent of The Hydro Group of Companies this project was re-registered with the Department of Environment and Lands of the Province of Newfoundland and Labrador on 8 November 1990. A joint Provincial and Federal EIA process will likely be conducted. (Hill, pers. comm, 1992; Leeder, pers. comm. 1991; Jeffrey, pers. comm., 1991).

In the ten years following the 1980 approval of the project by the Minister of Environment, engineering and environmental studies have continued. In the few environmental studies which have used remote sensing, only aerial photographs acquired in 1973 have been examined (Beak Consultants, 1978). Other, more recent remote sensing data, including LANDSAT MSS and TM data of the area have been available, but have not been used.

3.4.2 The South Kedu Development

The Indonesian project is located in the South Kedu area on the south coast of Central Java. The government agency that manages this project is Proyek Serbaguna Kedu Selatan (PSKS). The important objective of PSKS is to develop water resources in the area for agricultural irrigation. PSKS manages five main river basins in the South Kedu area (approximately 3,000 km2): Cincingguling, Lukulo, Bedegolan/Wawar, Jali/Cakrayasan and Bogowonto (Figure 3-7). The South Kedu project also includes the





Legend
A Sand dune area, from Cingcingguling to Bogowonto Rivers
B Coastal plain, from Cingcingguling to Bogowonto Rivers
C Upland

Figure 3-7 South Kedu Area, Central Java utilization of water for power generation, when excess water is available. However, power generation is secondary to irrigation in this area.

There are three physiographic units within the project area: upland, coastal plain, and sand dune areas. The upland is covered by forest with cultivated land and small villages. Dry crops are prevalent in this area. Small irrigation systems for rice production are already in existence, but most of the area relies on rainfall. The bulk of the human population in the South Kedu area live in the coastal plain, where most of the irrigation networks are located. About 10,000 ha of the coastal plain is classified as a depression area. This area is subjected to yearly flooding due to excessive rainfall in the rainy season and it is also under cultivation for agricultural production during the dry season, but the risk of losing crops due to sudden floods is high. About 16,000 ha of sand dunes are located on the south coast. Although this area is not productive, it is also under cultivation.

Some irrigation systems in the South Kedu area have been in existence for decades. These comprise small weirs that divert river water to the cultivated land. In these systems the water is abundant during the rainy season. The average annual rainfall on the coastal plain ranges from 2,100 to 2,800 mm. In the upper catchment areas the annual rainfall generally varies from 3,000 mm at lower elevations to about 4,500 mm at higher ones. However, some stations recorded several years with 5,000 mm to 6,000 mm of rainfall (ECI, 1978a and ECI, 1978b). Excessive water is available during the rainy season which lasts about 6 months each year. Flooding is not uncommon on the coastal plain, but during dry seasons there is usually insufficient water in the river for diversion to the land.

With an increasing population in the South Kedu area, there is an urgent need for improvement of irrigation systems to increase agricultural production. The expansion of cultivated land in Java would require reducing the forested areas. However, the conservation of water resources also dictates the maintenance of forest areas as all arable land has been under cultivation. Therefore it will be preferable to increase agricultural production with appropriate land and water management. Year round water is provided through irrigation and the duration of floods and the size of flood areas is also controlled. This ensures the optimum utilization of land, water, and human resources of the area.

The master plan of the South Kedu project calls for the construction of four major multipurpose dams within the watersheds (Figure 3-7). Since 1978, two dams have already been completed, the Sempor dam on the Cincingguling river and the Wadaslintang dam on the Bedegolan river. The third dam is in the planning stage for the Jali river, and a fourth is planned for the Bogowonto river. These dams are located in the upland regions. The existing Sempor and Wadaslintang reservoirs irrigate about 40,000 ha. The proposed Jali and Gegermenjangan system would irrigate another 45,000 ha.

4. Methods

The research activities for this thesis included a literature review, data collection, issue determination, and discussions with various experts. The data were collected through literature searches, personal communication and consultations, and by attending seminars on the EIA process. The personal experiences of the author in water resources development projects were a significant asset in conducting the research. Personal communications and consultations were conducted with knowledgable persons from Memorial University of Newfoundland, Department of Environments and Lands of the Province of Newfoundland and Labrador, Environment Canada, Newfoundland Hydro[17], and a private consulting company, LeDrew, Fudge and Associates Limited.

4.1 Review of Environmental Impact Assessment Process in Water Resources Developments in Indonesia

Since one of the objectives of this thesis is the enhancement of the EIA process and practices in Indonesia, a main source of information was Indonesian EIA legislation. Information on current environmental practices and issues was obtained from Indonesian newspapers and magazines as well as an Indonesian news group through a computer network. The review of the Indonesian experience with the EIA process was aimed at

[17] A crown enterprise responsible for hydropower developments in Newfoundland.

finding the cause of the environmental problems resulting from water resources developments. The Canadian federal Environment Assessment Review Process (EARP) and the Newfoundland and Labrador EIA process and practices were used for comparison and reference in enhancing the Indonesian EIA process.

Cultural characteristics of Javanese people that hamper active participation in the EIA process were discussed. Appropriate methods of public participation and the role of NGOs were presented as one of the solutions.

4.2 Use of Remotely Sensed Data in Environmental Impact Assessment of Water Resources Developments

Environmental impact assessment and impact evaluation should cover physical, biological, and socio-economic aspects of the environment. There are various types of imagery available to obtain data useful for the impact assessment.

The remotely sensed data of the Lower Churchill River were studied to obtain information on the condition of the environment and to assess the expected impacts of Muskrat Falls hydroelectric power development on river morphology. The interpretation of images was carried out by the author with the aid of information already available from various sources. The experience and knowledge gained in studying the environmental impact statement of the Lower Churchill River Development and in interpreting remotely sensed data of the Muskrat Falls area provided a background to establish a proposed procedure for the South Kedu area in Indonesia.

4.2.1 Remotely Sensed Data Available for the Study

The remotely sensed data available for this study comprised hard copies (pictures) of satellite data, airborne imagery, and digital data in CCT (Computer Compatible Tape) format. All of the presented imagery were chosen such that every image was centred around the proposed Muskrat Falls dam site. Table 4-1 contains brief descriptions of these various imagery.

4.2.2 Interpretation Procedure

The remotely sensed data were interpreted to find terrain characteristics that could be used to provide data for baseline studies and/or to evaluate the environmental impacts of the proposed dam. Most of the monitoring programs are designed to detect environmental changes of terrain features described in the baseline studies. The procedures and identification methods

Table 4-1 Imagery available to this study for the Lower Churchill Area[18]

TYPE	DATE	BAND	SCALE
NOAA	20-2-1973	Visible spectrum	1:9,000,000
LANDSAT			
Hard-copy:			
MSS	20-9-1987	Band 2 (red)	1:1,000,000
MSS	20-9-1987	Band 4 (near IR)	1:1,000,000
TM	20-9-1987	Colour composite band 1,2,3	1:500,000
Digital Data			
MSS	20-9-1987	Bands 1, 2, 3, 4	
TM	20-9-1987	Bands 1, 2, 3	
TM	11-10-1989	Bands 3, 4, 5, 7	
SEASAT SAR	19-9-1970	L (23.5 cm)	1:150,000
Aerial imagery			
Thermal scan	5-8-1973	thermal infrared	1:74,000
Colour infrared photographs	5-8-1973	visible to near infrared	1:40,000
Natural colour photographs	5-8-1973	visible	1:40,000
Natural colour photographs	23-8-1988	visible	1:12,500

[18] The detailed explanation of the terms in this table (MSS, TM, SAR) is provided in the Appendix A.

applied in the monitoring programs in general are similar to those used for the baseline studies.

In general three types of remote sensing are applied in environmental studies:

1. multi-spectral (band) remote sensing,
2. multi-stage (altitude) remote sensing, and
3. multi-temporal remote sensing.

Multi-spectral remote sensing is useful when the reflectance characteristics of objects are known, therefore specific bands can be applied for the observation of a specific terrain feature and/or its characteristics. Multi-stage remote sensing is required for different purposes. For example many objects cannot be clearly observed on satellite imagery, therefore lower altitude data such as aerial photographs or ground reference data must be obtained for the interpretation. Multi-temporal remote sensing is applied to investigate the change in terrain features over the course of time.

4.2.3 Interpretation of the Remotely Sensed Data for Geology

Remote sensing for geological investigations encompasses the principles and techniques of obtaining visual information and spectral analysis of optical and digital images (Williams Jr, 1983). This includes identification of spectral characteristics of different rock types and interpretation of geologic structures. Also, surficial geology is important especially concerning the interrelationship between landform and vegetation cover.

Multi-stage remote sensing was applied starting from the interpretation of a small scale (1:9,000,000) NOAA image. This was followed by the interpretation 1:1,000,000 scale LANDSAT MSS, a 1:500,000 scale LANDSAT TM colour composite image of bands 1, 2, 3, a 1:74,000 scale SEASAT SAR image, and a 1:40,000 scale stereo pair of false colour infrared aerial photographs.

Multi-spectral interpretation was demonstrated by comparing LANDSAT MSS band 4 (near infrared) with LANDSAT MSS band 2 (red) and LANDSAT TM colour composite image of band 1, 2, 3. This imagery was interpreted in terms of bed rock, structural geology, surficial deposits, and general land cover.

4.2.3.1 Bedrock Geology

A suitable classification system of bedrock geology of the Lower Churchill River area was developed. Individual units of a particular classification system were identified and delineated on the remotely sensed imagery. There was no field visit made for this thesis. The interpretation relied on previous environmental studies carried out concerning the area.

The bedrock geology data were compiled from maps published by the Geological Survey of Canada. The system used to interpret the bedrock geology of the Lower Churchill area was provided in the Canadian Geological Survey maps for Labrador. The maps were prepared by Greene et al., (1970), which cover the whole of Labrador, and by Stevenson (1965) which covers the area from Gull Island to Goose Bay. Two other maps which are still in their preliminary state were used for reference as well. These maps, covering the Lower Churchill area from Muskrat Falls to Goose Bay were prepared by Wardle and Ash (1985) and Wardle and Crisby (undated). The relevant information on all of these maps was transferred to the LANDSAT MSS band 4 and to the SEASAT SAR images, to interpret the characteristics of the geological features on the images.

On the NOAA image, observable lineaments were delineated. A geological map of Canada prepared by Douglas (1969) was used to help with the interpretation.

4.2.3.2 Surficial Geology

The surficial deposits classification system was adopted from Fulton et al., (1975) which is based on the description and identification of various landforms. The landforms are products of glaciation, further modified through erosion and deposition by glacial melt waters, and by the actions of modern day rivers and streams. The delineation was made based on the interpretation of different land systems[19].

In the first level of the classification each land system was identified and delineated on a 1:500,000 LANDSAT TM data. Similarly, the identification and delineation were carried out on 1:40,000 scale infrared aerial photographs for the higher classification level.

A 1:250,000 scale surficial geology map of Labrador published by the Geological Survey of Canada based on the works of Fulton (1986) was used for the interpretation. This map was supported by preliminary maps at a scale of 1:50,000 (Fulton and Hodgson, 1969) and a paper published in 1975 (Fulton et al., 1975). For the higher level classification, a report concerning surficial geology along the Lower Churchill River provided by Beak Consultant (1978) was used for the interpretation.

4.2.4 Interpretation of the Remotely Sensed Data for Land Cover and Land Use

The Multi-stage remote sensing was applied similarly with the interpretation for geology. At the same time, multi-spectral remote sensing was carried out for mapping of various terrain features. For an interpretation guide, a land cover and land use classification was

[19] A land system is defined as an area having recurring pattern of landform with homogeneous soil characteristics and supporting a particular type of vegetation (Bajzak, 1973).

developed first. The area was divided into two main land regions[20]: tundra and boreal forest (Rowe, 1972). The tundra was further divided into arctic tundra and coastal tundra (Wilton, 1965), and the boreal forest was divided into several small regions based on Rowe's (1972) work. These regions were delineated on the NOAA and the LANDSAT MSS imagery. Different spectral characteristics of each region as observed on the imagery were used as the mapping guide. Higher classification level, the third and higher, were based on spectral characteristics of various terrain features observed on the LANDSAT TM and the aerial photographs. These features were mapped on overlays attached to the imagery, and description of each terrain feature were provided. The descriptions were based on the previous studies concerning the area, such as Lopoukhine et al. (1977) and by Bajzak (1973).

4.2.5 Computer Assisted Interpretation Procedure

Computer assisted procedures were conducted using the VAX 8530 at the Centre for Computer Aided Engineering (C-CAE) with the GPX Graphic terminal of the Faculty of Engineering and Applied Science, Memorial University of Newfoundland (MUN). The software available at C-CAE was limited to image enhancement and display of digital numbers of pixel values.

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20 Land region is an area of land with a certain type of vegetation which manifests a distinctive climate (Bajzak, 1973)

Each band of LANDSAT TM bands 1, 2, 3 in the CCT were displayed separately, and colour enhanced to provide visualization of terrain data at a larger scale than the hard-copy of 1:500,000 scale imagery. This computer analysis was aimed at finding spectral characteristics of terrain features in each band. Since a more sophisticated digital image analysis system is not available at MUN the image analysis is concentrated around visual interpretation of hard copy images.

A CCT containing LANDSAT MSS digital data of Central Java, Indonesia (where South Kedu is located) was available, however, the computer at C-CAE was unable to read this tape. Other available digital data containing the image of Churchill River were LANDSAT TM bands 2, 3, 4, 5, and 7, acquired in 1989 and LANDSAT MSS bands 1, 2, 3, 4 acquired in 20 September 1987. Due to the limited time of the study and the limitation of the software for displaying various formats of the data, these digital data were not analyzed.

4.2.6 Assessment of Morphological Changes in the Lower Churchill River

As an example of the use of remotely sensed data in EIA, the morphological changes in the Lower Churchill River were assessed. This assessment needed inspections of multi-temporal remotely sensed data. Besides 1:50,000 and 1:250,000 scales topographic maps, the imagery presented in Table 4-2 were inspected.

Table 4-2 Imagery inspected to assess the river morphological changes

TYPE	DATE	BAND	SCALE
Thermal infrared imagery	5 August 1973	7 - 14 μm	1:74,000
Colour infrared photographs (23x23 cm)	5 August 1973	visible to near infrared	1:40,000
Natural colour aerial photographs (7x7 cm)	5 August 1973	visible	1:40,000
ditto (23x23 cm)	23 August 1988	visible	1:12,500
LANDSAT TM digital tape	20 September 1987	red	

The morphological changes that took place within the last two decades were assessed, and the changes that may take place in the future concerning the hydropower development at Lower Churchill were considered. The imagery were inspected for the conditions of the river banks and the sand bars. A multi-temporal approach was applied to assess the changes in river morphology during a 14 year period. The imagery acquired after 1987 were compared with those dated 1973. The LANDSAT TM digital tape was displayed to produce a 1:80,000 scale image. The red band was chosen as this band produced the best contrast among the available bands.

Continuous overlapping frames of vertical natural colour aerial photographs were inspected for the interpretation. They were acquired simultaneously with the thermal imagery. However, data gaps were encountered because the river in certain stretches was so wide that one side of the river could not be imaged on the aerial photos due to their scale and format. In such cases, the colour infrared transparencies, also in continuous overlapping frames, were used.

The use of the natural colour and the colour infrared aerial photography represents a multi-spectral approach. The false colour infrared imagery provided a kind of enhancement for the identification of some features such as tributaries or water bodies covered by vegetation. These could be better observed on these images than on the natural colour pictures. However, the location of sand bars under water and turbidity of water can be seen only on the natural colour photographs, as the infrared radiation is absorbed entirely by water.

The multi-stage approach was applied in this sequence: thermal infrared imagery, natural and false colour infrared photographs, and ground survey as reported in the EIS for the Lower Churchill development (LCDC, 1980). These imagery represent the condition in 1973. The river bed condition after 1987 was observed on the LANDSAT TM and MSS imagery (highest altitude) and on the large scale natural colour aerial photographs (lower altitude).

Based on these observations, the morphological changes were discussed. The main change that is expected to occur is the reduction in sediment discharge released by the reservoir in the future. This change will disturb the equilibrium of sediment transport in the river, that will result in a river bed degradation and slumping of the river banks. The regions where slumping and erosion will likely occur are identified on the various remotely sensed data.

4.3 Use of Remotely Sensed Data for the Environmental Impact Assessment of Water Resources Development in the South Kedu Area - A Procedure

Since the author was far removed from Indonesia, only limited data were available for this part of the research. Nevertheless, a procedure is provided for an appropriate environmental assessment and a plan is presented indicating the possible use of remotely sensed data for this particular project area.

Three basic sources of information were available for the South Kedu area: the knowledge and the experience of the author, previous environmental studies, and some maps available for the area. A description of the climate and the terrain condition in general is provided by ECI (1978a and 1978b). Another study conducted by Universitas Diponegoro (1988) provides terrain data for the Wadaslintang catchment area. The latter is considered representative for the whole upland of the South Kedu area. Several topographic maps (1:25,000) of the wet land and the sand dune areas and a map covering the whole South Kedu area having a scale of 1:130,000 were available for this study. The South Kedu map shows rivers in the area and the irrigated areas with the irrigation network.

Physiographic and land cover/land use classifications are proposed using these data. A flow diagram of reservoir impoundment impacts is also prepared based on the experience of the author in the South Kedu area and a review of studies elsewhere. The required remote sensing data are determined by judging what available system can provide the necessary data for environmental impact assessment and monitoring purposes. The type of imagery to be used is also influenced by the local conditions concerning vegetation cover and land use practices.

The impacts flow diagram classifies the physical, biological, and socio-economic impacts. In general, the methods to interpret terrain data using remotely sensed data concerning these impacts are provided. However, a more detailed impact assessment and other studies should be made by experts in each area to obtain pertinent information on the impact of each dam construction.

5. Environmental Impact Assessment of Water Resources Developments in Indonesia

There are always time and financial constraints in conducting an EIA, therefore baseline studies in the EIA process should prioritize "valued ecosystems" that may be adversely affected by the project (Beanlands and Duinker, 1983 and Beanlands, 1988). Scientists, experts, and the public may have different views regarding the value or the importance of an ecosystem. It is difficult to identify public concerns in the Javanese society. The inherent silence, passivity, and acquiesence of Javanese people make it difficult to find out their preferences and their social problems related to a development. In the following sections the shortcomings of the regulations for the conduct of an EIA in Indonesia and the inherent cultural characteristics that hamper active public participation are explored and possible alleviation of these problems is discussed.

5.1 Public Participation in Decision Making Process

Public participation is important in any development process. However, the perception of participation varies. Many administrators and bureaucrats in Indonesia perceive public participation as public support for the government's programs (Santosa, 1990). In other cases the collection of information for consideration by decision makers has been classified as public participation. Htun (1988) states that in those cases, what happens is 'public involvement' rather than 'public participation'. Public participation occurs when people are active in directing the decisions. Nevertheless, Htun (1988) emphasizes the importance of public involvement in improving the effectiveness of an EIA study by gathering information from people adversely affected by the development and by exchanging views about their perceptions and concerns.

5.1.1 Public Participation as Provided for by the Regulations

Public participation in the Canadian federal EARP and Newfoundland and Labrador EIA processes involves three steps: public information, public review and comments, and public hearings. In the Canadian EARP process, once the environmental assessment of a project is taken beyond the internal Initial Environmental Evaluation (IEE), the public may be involved at various stages. In the event of an EIS, the appointed panel conducts meetings in the appropriate communities. The expressed concerns are then used in the guidelines for the preparation of the EIS and to establish the scope of the work. After the proponent submits the EIS, the panel holds another series of public hearings to obtain comments on the findings of the EIS. Public comments are invited by the panel and by the proponent throughout the review process (FEARO, 1987). This potentially high level of public participation forces the proponent to carefully consider public opinion and attitudes concerning the proposed project.

In Newfoundland and Labrador, the Minister invites written comments from the public when a proponent registers their proposal. Under the *Environmental Assessment Act of 1980, "the proponent shall provide an opportunity for interested members of the public to meet with him, especially within or immediately adjacent to the geographical area of the proposed undertaking, ... "*. To comply with this act, the proponent is to design an information exchange program that has to be approved by the MOE. In practice, public participation is provided for in four ways (Trimper, pers. comm., 1991).

1. The MOE invites written comments from the public following registration of the project by the proponent. These comments can be made at any time during the EIA process.
2. The proponent conducts public meetings to provide information on the proposed project, and to obtain the concerns of the local community about the environmental impacts that may occur.
3. The proponent may meet with the public to provide an opportunity to review the EIS.
4. The MOE provides a public hearing if there is an indication of strong public concerns about the project (Govt. of Nfld., 1984)

In this EIA process, beside the intrinsic likelihood that the project creates public concerns, the intensity of public participation will depend on the effectiveness of the information exchange program of the proponent and the announcement by the MOE.

In the Indonesian EIA regulations *(Government Regulation no. 29, 1986, clause 31)*, public participation is stipulated as follows (Govt. of Indonesia, undated).

1. Any proposal which needs an EIA shall be published by the agency responsible for the proposal.
2. The PIL, the ANDAL, the RKL, the RPL, and the associated decisions are open to public scrutiny.
3. The openness, as stipulated in the above subclause, is practised as participation of the public in giving their opinion and ideas, orally or in writing, to the national EIA Commission or to the provincial EIA Commission before the permit is granted for the proposal.

These clauses give the public a chance to participate in the EIA process. According to this clause, participation is in the form of the right of the public to be informed, and in the form of a right to express ideas and concerns through the EIA Commission. In another part of the regulation, an opportunity for public participation is provided for adversely affected people and NGOs to be represented in the EIA Commission *(EIA regulation no. KEP-53/MENKLH/6/1987)*.

Three stages of public participation also exist in the Indonesian EIA process. Regarding information to the public, the Indonesian EIA regulations mentions that to satisfy clause 31 (subclause 1) stated previously, the announcements can be made through mass media and/or they can be posted on the information board of the initiating department (Govt.

of Indonesia, 1987). Public review and comments are provided for by allowing written ideas, opinions, and concerns to be submitted to the EIA Commission. An open public hearing or public meeting is not explicitly provided for in the regulation. However, people can be involved in the project review through their representative in the EIA Commission.

Concerning the EIA Commission, Santosa (1990) has the following criticisms:

1. the inclusion of non permanent members depends on the discretion of the decision makers,
2. there is no clear definition of who will be adversely affected by the project,
3. the decision maker can decide who will represent the adversely affected people and the NGOs,
4. lack of a budget for collecting and analyzing data means that NGOs and adversely affected people have no substantial input to the commission,
5. pressure for a consensus on the commission will direct the adversely affected people and the NGO to a decision maker's (and thus the proponents) point of view.

These criticisms lead to a conclusion that the EIA Commission has a pro development bias (Santosa, 1990).

5.1.2 Methods of Public Participation and Their Applicabilities in the South Kedu Area

Meaningful public participation can be obtained only if the method used is appropriate for the participants. Public information through newspapers for example, will not be effective in a poorly educated society where a significant proportion of the people cannot read. There are also cultural constraints that have to be considered, such as the passivity and acquiescence of Javanese people as previously described.

Santosa (1990) conducted a study on various public participation methods. The methods described in his study comprise: public hearings, brainstorming, nominal group discussions, public opinion surveys, advisory committees, and action or participation research. The following paragraphs present the description of each method and its applicability in the South Kedu area.

A public hearing has a formal character, that provides an opportunity only to people who commonly speak before an audience. Good representatives are required in such a forum. Opposition concerns are not easy to express when there is an authoritative relation in the forum. Authoritative relation in this case means the presence of "respectful" persons such as representatives of the government. This situation may impede real communication, and thus the real concerns of people may be difficult to ascertain.

The difficulties in expressing opposing concerns still occur in the brainstorming[21] method. In the nominal group discussion[22], this problem is partly solved by expressing the concerns in writing. Written expression also helps people who are not able to speak before others. A small group of not more than ten who know each other is effective in these methods. A community that consists of hundreds of households, however, has to conduct this method through representatives or in several stages. In these cases the real concerns of people may not be represented in the forum.

A public opinion survey may consist of personal interviews, mailed questionnaires, or phone surveys. Phone interviews are not applicable in remote places in the South Kedu area. Mail surveys are rather difficult to conduct as people in the project area are usually poorly educated. For example in the Wadaslintang project area, 75% of the population have only attended elementary school (Universitas Diponegoro, 1989). Although they can read and write, expressing ideas in writing is difficult, and may lead to a mis-interpretation of their ideas. Personal interviews can generally be carried out, but there is often suspicion regarding the objectivity of the interviewer (Santosa, 1990).

The advisory committee method involves a committee consisting of several persons who work together to prepare recommendations for decision makers. The EIA Commission

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[21] In brainstorming, people get together to express their opinions, ideas, and concerns on a particular problem. It has to be conducted in an unstructured manner. Early criticism of the opinions of a member have to be avoided to encourage spontaneity and participation of all members.

[22] This method is similar to brainstorming, but the ideas, opinions, and concerns are expressed in writing. Discussion of the ideas is carried out to prioritize the concerns towards a final conclusion.

in the Indonesian EIA process is an example of this type. In some cases, a limited number of people may make the work simpler. The weakness lies in the limitation of each member's capacity to represent people's concerns.

Action/participation research is a method to collect social data and to solve problems in a community with the researcher being merged with people in the community. The following are the rules outlined by Santosa (1990) for conducting this type of research.

"1. *The researcher endeavours to identify himself with the people.*

2. *The researcher should combine his critical insight and knowledge with the understanding and resources of the local people to generate an awareness of the problems inhibiting the social progress of the community.*

3. *The technique cannot be that of mere data gathering, but must accommodate an active endeavour to understand the conditions underlying community problems with a view to finding solutions to such problems.*

4. *The technique amounts to an educational process for both the researcher and the community through close interaction such as thorough dialogue and discussion.*

5. *The technique should respect the peoples capability to produce knowledge, and their potential to analyze it. Hence it challenges the notion that only professional researchers can generate knowledge for meaningful social reform".*

The important point is the involvement and participation of people who will benefit by the research. This type of research can be applied to encourage public participation in problem solving. For the South Kedu area, this method is suitable, in which close interaction created by the researcher and the people through dialogue, discussion, and mutual work may overcome the problem of the silent culture, and avoid an authoritative relationship. In this way, real concerns of people and problems in the community can be determined. When the problems are understood, improvement of factors inhibiting social progress, such as education, health, economic conditions and welfare in general can be carried out properly.

5.1.3 Non-Governmental Organizations in Indonesia

According to the records of the Directorate General of Social Issues and Politics, in the Ministry of Home Affairs, there are close to 4000 NGOs in Indonesia (Anon., 1991f). The real number may be much more than this figure. They exist everywhere in the country, in big cities as well as in the rural areas. In general, their operations are based on the same ideals: they are concerned about the future of the nation, the state, and the planet, as well as poverty, the population explosion, human rights, and the environment. They believe that this planet should be managed in a way to provide a better quality of life and to save the environment for future generations (Anon., 1991f).

The oldest NGO with the above kind of concerns in Indonesia is the organization for family planning (Perkumpulan Keluarga Berencana Indonesia, PKBI). It was founded in 1957 when the political belief was that the state would be stronger if the population was larger (Anon., 1991f). After the realization that the population explosion was a problem, this organization received strong support from the government in the 1970s. A board for national family planning coordination was founded. The head of this government board is directly responsible to the President of the Republic of Indonesia. At the same time, the President also appointed a State Minister of Population and the Environment (MPE).

In the 1970s NGOs with a concern for the environment were founded every where in Indonesia. The largest one is WALHI (Wahana Lingkungan Hidup Indonesia) that acts as a national coordinator of the environmental NGOs (Anon., 1991f). WALHI was founded in 1980. The concern of the government about the environment is shown by the existence of the MPE. The MPE has the task of designing and planning policy concerning development and environmental protection. However, as a state Minister, the MPE has no power with regard to the conduct of developments which are executed by other ministries. This has resulted in difficulties in avoiding or reducing the deterioration of the environment. There has been a lot of criticism in this regard by NGOs (Arimbi, 1991). Eventually the government founded the Board of Environmental Impact Control (Badan Pengendalian Dampak Lingkungan, BAPEDAL) in 1990. The head of the board at the moment is the same person as the MPE, and is directly responsible to the President of the Republic of Indonesia. At the moment, the three main tasks of the BAPEDAL include the controls of hazardous material, pollution in general, and the conduct of EIA (Anon., 1990).

An NGO that operates in the area of legal assistance and human rights has a very important role in water resources development. It provides information on human and legal rights and it assists the people in raising their concerns with parliament. In general this NGO, which is known as the Institute for Legal Assistance (Lembaga Bantuan Hukum, LBH) gives assistance to people who are politically or economically powerless (Anon., 1991f).

NGOs in Indonesia, which have the same concerns as NGOs all over the world, are part of the international NGO network. PKBI, the organization for family planning is associated with the International Planned Parenthood Federation (IPPF) in London (Anon., 1991f). This international organization gives financial support to PKBI. Other NGOs also get financial support from foreign NGOs, from foreign and Indonesian private companies, and from foreign government institutions and multilateral agencies. For example, CIDA (Canadian International Development Agency), a Canadian government agency, provided Can. $ 5.4 million for 13 Indonesian NGOs in 1991. USAID, an American government agency, provided US$ 3.15 million in 1991-1993 (Anon., 1991f). There are also NGOs that do not like to accept foreign funds. For example, the Centre for Information and Forest Environment Management (Pusat Informasi dan Pengelolaan

Lingkungan Hutan Indonesia, PIPLI) is founded and funded by Indonesian forestry resource companies (Anon., 1991f).

The limitation and weaknesses of the EIA Commission as an advisory committee as described in section 5.1.1, has meant that the NGOs are rather reluctant to participate in the work of EIA Commissions. In its program WALHI has put great emphasis on the campaign for environmental awareness in people rather than working with EIA Commissions in the EIA process (Arimbi, 1991). WALHI tries to enhance environmental awareness first, to create public concern. Often, during the planning of development, conflicts of interest can occur. In such cases, public concerns may be ignored or are considered to have lower priority, depending on the influence that the people may have. In some cases in Indonesia people have protested against projects that created adverse effects. This might never happen if people's concerns were considered prior to the approval of the project. It is important for people to clearly and effectively express their concerns. When people express their concerns in a more effective way, the decision maker (the government) will be more likely to pay attention. Participation of people through NGOs is more effective than concerns that are directly raised by individual persons. With the existence of NGOs the grass roots of society have greater influence.

5.2 Examples of Environmental Issues in Water Resources Projects in Indonesia

Environmental impact studies of developments have been practised in Indonesia since 1970. Normally EIA documents for water resources developments that were similar to current PIL and ANDAL were included in the feasibility study to comply with the requirement of an (international) funding agency. As the standardized procedure was not introduced 1987, those documents were usually of low quality compared with the current PIL or ANDAL.

Several environmental studies conducted in the late 1970s revealed serious concerns about the impacts of water resources developments. The emphasis of the studies was on the social impacts of the relocation of people. An example is the impact of the Saguling dam in West Java. This dam was constructed for hydro power generation in early 1980. The following examples also include Tapak River and Kedungombo, which are environmental cases that have been extensively covered in the Indonesian mass media. The Wadaslintang case is from the author's personal experience; here the practice of action/participation research in solving an environmental problem is described.

5.2.1 Relocation Impact of the Saguling Dam

The Saguling dam was constructed for hydroelectric power generation. This project relocated 14,000 people. The dam was under construction when the environmental law was promulgated. During the feasibility study in the 1970s, a survey was carried out on the reservoir and dam sites, but there was no formal information given to people with regard to the plan. This caused rumours amongst the people that resulted in many people selling their land at a low price. They were afraid that the price might be even lower if they took compensation from the government. A study that was conducted later revealed that the amount of land owned by the affected people at the time of payment of compensation had decreased by 25% from that in the period before the feasibility study. Further, the study found that the earnings of relocated people decreased by 15% from that in the period before the dam was constructed. Panic selling had deprived people of the level of compensation they could have obtained (Santosa, 1990).

There was no public protest regarding this impact. If a complaint was raised, government officials would answer that people would live better if they transmigrated. So, people accepted their conditions as if it was their fate. Another finding includes a perception by local government officials that giving information to affected people would create tensions and protests. The local government was also of the opinion that maintaining secrecy would guarantee a smooth implementation of the project (Santosa, 1990).

The project was completed without any obvious social problem. Javanese people contributed to this by being passive and acquiescent and they did not identify their less of income.

5.2.2 Relocation Impact of the Kedungombo Dam

Another example occurred in the development of the Kedungombo dam. The construction was started in 1985 and the inauguration was held in 1991. There was a problem regarding the amount of compensation to be paid. More than 1000 out of 5300 households resisted movement from their land. The construction went on, while the government kept on persuading these people to move. These people rejected transmigration as a solution. As an alternative, houses, land, a school, and other community facilities were provided close to the reservoir. Some of them accepted the offer, but still about 600 households refused to move. The reservoir impoundment was started, these people gradually moved to the side of the reservoir as the water level rose. Eventually they settled in an area that was provided for the green belt[23] associated with the reservoir. No building is allowed in this region, but they are there. This dam has become a big environmental and human rights issue in Indonesia (Anon., 1991b, anon., 1991c, anon., 1991d).

Public protests concerning the Kedungombo dam do not reflect the acquiescence of Javanese people. NGOs have been very active in this case. The NGOs were successful

[23] Green belt is a region along the reservoir shoreline extending up to ten meter above the reservoir surface elevation. This region is reforested to protect the reservoir bank from erosion.

in lobbying the government to provide a resettlement area nearby the reservoir, although for this purpose some forest had to be sacrificed. The result was that most of the people who had resisted movement from the reservoir area accepted the offer to move to the resettlement area (Arimbi, 1991).

5.2.3 Action/Participation Research in the Wadaslintang Dam Development

The relocation and compensation process in the Wadaslintang dam project in South Kedu area resulted in about 42% of the relocated people transmigrating to Sumatra, Kalimantan, and Sulawesi (Universitas Diponegoro, 1988). In their new place, they have much more land than they previously had. The people were motivated to transmigrate by previous transmigrants from Wadaslintang who were successful in their new land. The remaining 48% stayed in the vicinity of the reservoir. After the reservoir was developed previous inhabitants in the vicinity of the reservoir and the relocated people had to share their land, with the result both group had less land.

In order for the development to be environmentally benign a program had to be provided for the people who stayed around the reservoir. One task that had to be fulfilled by the Proyek Serbaguna Kedu Selatan (PSKS), the government agency that manages the water resources developments in the South Kedu area, in the Wadaslintang dam project was "*to develop upstream land and water management practices, which are designed to reduce* *erosion and sediment run-off through the promotion of reforestation and other proper land use measures, terracing and other physical conservation measures*" (ECI, 1978b). This task was implemented as a greening program[24] in the catchment area. The objective of the greening program is (1) to maintain a minimal erosion rate in the catchment area to keep the reservoir sustainable, and (2) to utilize the land resources in the catchment area in an advantageous manner for the inhabitants. High market value fruits were planted in these areas to increase people's earnings.

The inventory of critical lands[25] in the Wadaslintang reservoir catchment area in 1983 revealed that about 3010 ha could be categorized in this class (Hartono, 1987). In order to prevent development on these critical lands the greening program had to be implemented in a way that people could receive benefits, and thus voluntarily maintain the land. In order to achieve this criterion the program had to provide what people needed, and what they wanted. In addition, it had to be determined why the land was critical. These factors are described in the following paragraphs.

The investigation was implemented by conducting the following steps:

1. identification of farmer's problems through observation, dialogue and discussion,

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[24] A greening program is an effort to plant vegetation to improve land productivity and to protect the land from erosion.

[25] A piece of land is considered critical if it is non-vegetated, infertile, on a steep slope and has a character for contribution to a high rate of erosion.

2. solution to farmer's problems by giving guidance on how to conduct proper land management, introduction of marketable crops, supply of seedlings, fertilizer and other supporting materials,
3. greening campaign and competition.

This program had to be conducted in an informal way in order to be adapted to the passivity of Javanese people. A formal program would have made it difficult for them to state their concerns and preferences.

Through discussion, interviews, and observation, the following problems were identified (Hartono, 1987).

1. The area was isolated, so ideas from outside were rare, markets for their products were limited.
2. Improper land management, such as poor terracing, very little spaces between trees, and inadequate maintenance efforts occur due to lack of knowledge.
3. The low level of education restricted transfer of ideas.

Besides improper land management, critical land was generally produced by the exhaustive exploitation of the relatively high population in the area.

The access road used by the dam project during construction was expected to break the isolation and create better access for marketing farm products. So, part of the first problem would be automatically solved. The second problem could be solved by guidance in better farming practices. However, a specific method was required to improve the transfer of ideas to solve the third problem, poor education.

With regard to the second problem, it was realized that the high population level had caused serious pressure on land resources. Thus, the land had to be made highly productive through selective planting of economic crops and proper land management. This included extensive planting of elephant grass to protect terraces and to provide cattle food in the area. The latter was important because cattle frequently destroyed the terraces.

The greening program concerned 16 villages in the catchment area and one village located just downstream of the dam site. The method used for each village was different. The approach used was to work with people to make demonstration plots; at least one of which was situated in each village. In these plots, proper land cultivation and maintenance methods were practised.

In one village this idea was rejected. In this village people accepted the seedlings supplied by PSKS, took them home, and planted them in their own yard. The seedlings were various kinds of fruit plants of high economic value in the market. It was difficult for PSKS staff to provide adequate time to ensure that those plants were planted and maintained properly.

In another village some people worked together in a particular plot owned by one of the residents. The owner of the land would receive 50% of the yield of the first five year's of harvests, the other 50% would belong to the workers as long as both parties maintained the plants. For several months there was good cooperation, but later on the land owner worked alone. It took at least two years before the harvest of the plants, and people were not willing to work on somebody else's land for this period.

Besides working on demonstration plots, guidance was given through home visits. These visits gave direct guidance on how to fertilize properly, and other cultivation and maintenance practices. Exchanges of ideas occurred during this activity. In most cases people followed the guidance because PSKS staff always visited them and worked with them, to ensure that they carried out the maintenance properly. The efforts included the maintenance of existing trees to increase their production. On the other hand PSKS staffs learned from people's experience in adapting to nature, especially in overcoming natural hazards such as slope failure. The combined knowledge was used to give further guidance. The PSKS staff visited the farmers in informal ways to prevent the feeling of being inspected: they visited the people's houses, talked with them and tried to solve their problems. People had to feel that they had done everything for and by themselves. The supply of seedlings, fertilizer, and other supporting materials was also restricted. The intention was to make people aware that they can provide all the necessary materials themselves.

It took two years before eventually many people followed the guidance; this only occurred after they saw the results of the first harvest. The demonstration plot then provided the seedlings for them. Finally, the greening program was accelerated with a competition between villages and between farmers. The competition was carried out by the local government with PSKS as the sponsor. In 1987, after four years, the critical land was reduced to only 1540 ha (Hartono, 1987), which was a reduction of about 50%.

It was not easy to determine people's concerns in Wadaslintang. They only accepted that something was good after a real example has been shown. They only related to directly applied examples. Direct involvement of people and participation in doing the work for themselves is required. This example shows how action/participation research works in investigating people's problems and to find solutions.

5.2.4 Industrial Pollution in the Tapak River

The following example is not of a water resources development issue, but it is an example of the role of NGOs in managing an environmental problem. Several NGOs had campaigned for a boycott of the production of eight industries in Semarang, Central Java, following heavy pollution in the Tapak River. The Tapak River is a small ditch, only about one meter wide. After this area was developed into an industrial estate, in 1977, the river became heavily polluted. Sixty-six domestic wells were polluted as well as rice-fields and tambaks[26]. The complaints of people were never addressed by the company until 15 NGOs campaigned to boycott the products of the industries (Anon., 1991i).

The Governor of Central Java and the Mayor of Semarang did not support the adversely affected group of people; the group consisted of 249 households with less than 1000 people. This number is less than the 5,000 workers of the industries that were threatened with unemployment if the boycott was successful. After failing to persuade the people not to prosecute, the industries and the government agreed to solve the problem through mediation. A committee was formed, which consisted of the representatives of the government, the industries, and the NGOs including the Institute for Legal Assistance (LBH), and BAPEDAL. Through the mediation process, the eight industries agreed to compensate the farmers and the shrimp breeders for the damage caused by the pollution. The industries also agreed to rehabilitate the rice fields and the tambaks. The provincial government subsidized one-third of the cost of rehabilitation. The industries had to install a proper sewage treatment plant (Anon., 1991g).

In Indonesia a campaign was launched in 1991 for legal action against environmental abuses. More than 400 companies were prosecuted (Anon., 1991h). The MPE, encouraged this action and hoped to obtain feedback on shortcomings in the legislation (Arimbi, 1991). The case of the Tapak River is one example in which the MPE supported the adversely affected people and the NGOs (Anon., 1991g).

[26] A 'tambak' is a brackish water pond. In Indonesia this type of pond is extensively used for shrimp or milk fish breeding.

6. Remote Sensing in Environmental Impact Assessment of Water Resources Developments

Remote sensing is an invaluable tool for economically gathering information for large areas, and thus it is an important tool in environmental impact assessment. These applications include the design and the conduct of baseline (pre-development) studies, the prediction and quantification of impacts from the proposed development, and the design and conduct of effects evaluation and of compliance with monitoring programs. Baseline studies refer to a description of conditions existing at a point in time against which subsequent changes can be detected through monitoring (Beanlands, 1988). This definition implies that in the process of EIA, the baseline studies provide the before-project record, while monitoring gives the after-project measurement.

In order to understand the interpretation of the presented imagery by those who are not familiar with remote sensing, a brief description of the various systems is provided.

6.1 Remotely Sensed Data Collection System

Remote sensing is an activity for the collection of terrain data using reflectance and/or emissive characteristics of objects concerning electromagnetic energy. There are three major components in this activity: the electromagnetic energy, the sensors, and the platform. Specific terrain data can be collected if its reflectance characteristics are understood; appropriate sensors have to be used in accordance with the reflectance characteristics; and an appropriate platform sensor combination should be used, depending on the requirements for the data.

6.1.1 Electromagnetic Spectrum

A remote sensing system records the extent of electromagnetic energy reflected or emitted from a terrain surface which provides information on its characteristics. The characteristic of a surface or an object exhibited by various wavelength bands is termed its spectral response pattern. The spectral patterns of various objects, either natural or man made, can be obtained using electromagnetic energy sensors. The sensors include photographic and video cameras, thermal and multi spectral scanners, and passive and active microwave sensors. The platforms on which the sensor is mounted and the optics of the sensors will determine the extent of area coverage and the frequency of data acquisition. The commonly used platforms are helicopters, airplanes, satellites, and space shuttle vehicles.

A series of electromagnetic energy having different waves with increasing length is termed the electromagnetic spectrum (Table 6-1). The wave length, due to its wide range, is commonly expressed in micrometer (μm, 1 μm = 10^{-6} m), millimetre (mm), centimetre (cm), and metre (m).

Table 6-1 Electromagnetic Spectrum

NOMINAL NAME OF BANDS	WAVE LENGTH
gamma rays	10^{-6} μm
x - rays	10^{-4} μm
ultra violet	10^{-1} μm
visible light:	
blue	0.4 - 0.5 μm
green	0.5 - 0.6 μm
red	0.6 - 0.7 μm
near infra red	0.7 - 1.3 μm
mid infra red	1.3 - 3 μm
thermal infra red	3 - 14 μm
microwave	1 mm - 100 cm
television and radio	1 m or larger

The major source of electromagnetic energy is the sun. As it reaches the surface of the earth the electromagnetic energy is reflected, absorbed, and transmitted by terrain features. The reflected energy in the visible part of the spectrum (blue, green, red) enables people to perceive the existence of various objects. The amount of reflected and/or emitted electromagnetic energy in the various bands can be detected with the use of appropriate sensors.

6.1.2 Operational Satellites

Satellites have become important remote sensing platforms. These platforms provide periodic terrain data automatically. With the availability of satellite data, change over time and space can be detected easily. If more detailed data are required, airborne remote sensing can be conducted or ground reference data obtained. The lower altitude remote sensing can be limited to areas of concern only, thus the cost is minimized. Several satellites with remote sensors on board are listed in Table 6-2.

6.2 Water Resources Development Related Examples

The result of a literature review on the application of remotely sensed data in water resources developments is summarized in Table 6-3. Particular attention was given to environmental impact studies of reservoir developments for agricultural purposes. These studies include the evaluation of terrain features that may indicate the impacts of such developments. These include detection of land use and land cover patterns, detection and quantification of water bodies, assessment of hydrological properties of watersheds, and assessment of agricultural condition. The papers referred to are useful guides in similar applications. Appendix B summarizes the use of each of LANDSAT TM bands. Similar use is made of the corresponding LANDSAT MSS bands and other sensors operating in similar bands.

Table 6-2 Summary of the Operational Satellites

Type of Satellite	Frequency of Pass (days)	Sensor	Resolution	Swath width	Remarks
NOAA (USA)	8 to 9 & 4 to 5*	MSS	1.1 km (at nadir)	2400 km	Mainly used for meteoro logical purposes, but can be used for environ-mental monitoring
LANDSAT (USA)	16	MSS TM Thermal TM	80 m 30 m 120 m	185 km	Land resources satellite comprises 4 bands of MSS and 7 bands (inclusive of thermal infrared band) of TM
SPOT (French)	26	MSS (colour) Panchromatic	20 m 10 m	117 km	With two pointable sen-sors, the viewing range extends to 950 km, and data of a particular site can be obtained every 4 and 1 day(s) alternately.
ERS-1 (ESA)**	3	SAR (RADAR) Band C VV polarization	30 m	100 km	Covers Europe, North America, and parts of Africa.
JERS-1 (Japan)	44	SAR (RADAR) L band MSS	18 m 18 m x 24 m	75 km	Launched on 11-2-1992 Data available late 1992
RADARSAT (Canadian)		RADAR	varies from 11 m x 9 m to 100 m x 100 m	varies from 100 km to 500 km.	Available after 1994.
IRS-1A IRS-1B (Indian)	11 (two satellite combined)	LISS I LISS II (each satellite is loaded with these two)	72 m 36 m	145 km	Four spectral bands ranging from blue to near infrared

Note:

* These satellites provide data of a particular place every 12 hours.

** European Space Agency

Table 6-3 Imagery, Methods, and Remotely Sensed Data Interpretation

Application in EIA	Author	Imagery	Method	Remarks
Land use and land cover	Prasad, et al., 1990	LANDSAT MSS	Visual interpretation	Soil ground surveys are conducted along with interpretation of LANDSAT imagery to establish thematic maps for land irrigability capability, and land use planning
	Cautam and Chennaiah, 1985	LANDSAT MSS	Visual and computer assisted procedure	- only broad land use categories can be identified. - multiple uses on a particular site made identification of each uses difficult. - land use categories are sometimes too small to be identified and/or to be mapped
	Hoffer and Lee, 1990	SEASAT and SIR-B (RADAR imagery)	Computer assisted procedure	Overlay display is the most effective method to assess major changes of forest cover, compared to ratioing, image differencing, and principal component analysis.
	Chiao, et al., 1987	LANDSAT MSS	Computer assisted procedure	Image differencing method is more accurate than classification differencing method to detect changes in land cover type.
	Voss, 1987	SLAR, LANDSAT, aerial photography	Computer assisted procedure	SLAR (RADAR) imagery is the most reliable data compared to LANDSAT and aerial photographs for Kalimantan, Indonesia, due to constant cloud cover in the area.
Hydrology	Saowapon, et al, 1989	LANDSAT MSS	Computer assisted procedure	Hydrological parameter can be determined based on land cover units. River flow estimates can be made where rain gauge is not available.
	Tao and Kouwen, 1989	LANDSAT MSS	Visual interpretation	Based on land cover units, runoff can be predicted for real time flood forecasting.
Water quality	Lillesand, et al., 1987b	NOAA, SPOT, LANDSAT TM	Computer assisted procedure	Reflectance in visible bands highly correlates water quality parameters, including secchi disk depth, turbidity, total suspended particle, and water tempurature.
	Choubey and Subramanian, 1990	IRS1A (Indian satellite)	Computer assisted procedure	Reflectance in visible bands can be used to quantify suspended sediment material. However, results for similar research to other reservoirs will depend on watershed characteristics, climates, and mineral constitutes the sediments.

Application in EIA	Author	Imagery	Method	Remarks
Water quality	Lathrop 1992	LANDSAT TM	Computer assisted procedure	A turbidity model is unique for each lake. This depends on geological and geomorphological regimes that result in different grainsizes of the sediment
Water body quantification	Gupta and Banerji, 1985	LANDSAT MSS	Visual interpretation	Infrared imagery is best for delineating water bodies. Manual procedure for area quantification can achieve app. 90% accuracy for water bodies larger than 2.5 ha
	White, 1978	LANDSAT MSS	Manual, electronic, and computer assisted procedure	Infrared imagery is best for delineating water bodies. Manual area quantification using dot grid and electronic planimeter can achieve app. 90% accuracy. Computer assissted procedure gives results that differ > 28%
Flood monitoring	Barton and Bathols, 1989	NOAA-AVHRR	Computer assisted procedure	Thermal imagery acquired at night provide more contrast between water and land than day time imagery. NOAA image can be used to assess flood propagation
	McMahon and Collins, 1985	LANDSAT MSS	Computer assisted procedure	Wetting of soils and stressing of vegetation after being flooded reduce their reflectance properties. It can be identified using infrared band imagery. Principal component analysis has an advantage over the image data, in that it reduces relevant material for analysis. However, it requires considerable computer time.
Agriculture	Nellis, 1984	Thermal and colour airborne imagery	Visual and computer assisted procedure	Crop types are interpreted visually using texture, pattern, and hue of the colour infrared imagery. Density slicer is used to enhanced the thermal image, to interpret irrigation methods.
	Thetford and May, 1987	LANDSAT TM	Computer assisted procedure	Red (R) band can be used to interpret chlorophyl density. Infrared (IR) can be used to assess vegetation volume. IR/R has a statistical relationship with grain yield
	Wheeler, 1987	LANDSAT MSS, aerial photographs	Computer assisted procedure	Five level rice crops indication can be distinguished based on plant density and watering conditions.
	Henrickson, 1986	NOAA-AVHRR	Computer assisted procedure	Drought monitoring in Ethiopia in 1983 and 1984.

Table 6-3 (cont'd) Imagery, methods, and remotely sensed data interpretation.

Application in EIA	Author	Imagery	Method	Remarks
Geology	Drury, 1987 Miller and Calvin, 1961	visible bands & near infra-red, aerial photos, satellite data & RADAR imagery	visual interpretation (photogeology)	1. Drainage & glacial erosion pattern observed on an imagery can be used to explain geomorphological history and stage of development of a terrain. 2. Remotely sensed data can be used to identify sedimentary rocks, intrusive & extrusive igneous rocks, and metamorphic rocks.
	Drury, 1987	Thermal infra red imagery	Computer assisted procedure	1. Manipulation of digital data is one method to recognize certain geologic features based on their spectral characteristics. 2. Multi-temporal imagery is useful, since different moistures of rock and soil, and different vegetation appear on the same type of rock in different seasons often provide clues of the rock characteristics.
	Drury, 1987	RADAR imagery	Visual interpretation	1. RADAR imagery may overcome problems of cloud cover. However, image of tropical terrain is not as sharp as those of arid region due to dense vegetation cover. 2. Depends on the wavelength used, substantial penetration of sub surface may reveal characteristics of rock thinly covered by sand.
	Lillesand and Kieffer, 1987a.	Satellite imagery	Visual and computer assisted procedure	1. Small scale geologic mapping on the satellite imagery is mainly mapping of lineaments that may explain regional morphological features, such as streams, escarpments, and mountain ranges. 2. Tonal features of surface expressions may represent geological features such as fractures or fault zones.

6.3 Examples of the Use of Remotely Sensed Data for the Lower Churchill River Development

Some remotely sensed data were used in a previous EIS conducted by the Lower Churchill Development Corporation (LCDC, 1980). This EIS was supported with several reports of environmental studies. The use of remotely sensed data in these studies examined the following imagery (Beak Consultants, 1978):

1. black and white aerial photographs acquired in 1970 and 1971 (scale of 1:20,000), and
2. infrared colour aerial photographs acquired in 1973 (scale of 1:20,000).

Other available remotely sensed data such as black and white aerial photographs at a scale of 1:50,000, acquired in 1968 -1970; historical black and white aerial photographs at a scale of 1:30,000 acquired between 1949 and 1957, and satellite imagery, were not inspected due to budget limitations (Beak Consultants, 1978). Recent discussions with Newfoundland Hydro personnel (Hill, pers. comm, 1992) indicated that remotely sensed data are being considered in connection with the development of a Geographic Information System (GIS)[27] for the future re-assessment of this project. The only activity related to remote sensing conducted by Newfoundland Hydro currently is ice movement monitoring along the river using video and oblique photographs from a

[27] A Geographic Information System is a system designed to store, manipulate, and display a spatially ordered collection of data (geobased file). The data are related to the land and are recorded according to location (Lillesand, et al, 1987a).

helicopter.

In this study some of the available remotely sensed imagery for the Lower Churchill area were interpreted to illustrate their usefulness in EIS. The results of this are discussed in the following sections with hard copy illustrations. The delineation of the various units was made on transparent overlays attached to each of the images. The three separate classifications (bedrock, surficial geology, land cover/land use) were shown on separate fold-out overlays. These can be observed separately or together to indicate the existing interrelationship between the various classifications.

6.3.1 Interpretation of Remotely Sensed Data for Geology

Interpretation of remotely sensed data for geology for the EIA of water resources development should give information on bedrock and on structural and surficial geology of the reservoir site and its surroundings, and along the river downstream of the dam sites. Knowledge of these features is important for the assessment of environmental impacts resulting from dam construction and from the force or load exerted by the dam and water in the future reservoir.

In order to have a successful identification interpretation of rock types, there are two pre-requisites, as stated by Drury (1987):

1. there should be sufficient correlation between geology and the landform,
2. it requires a combination of experience, patience, perception, and ingenuity by the interpreter.

While the first pre-requisite may be present on the imagery, the second one was difficult to be fulfilled by the author who is not a geologist. Therefore, the level of the interpretation was limited to the observation of lineaments that may explain the morphological and geological features and to an understanding of the geological features that appear on the imagery as described by previous geological studies.

In this section, the geologic interpretation of the remotely sensed data includes the bedrock geology and the surficial geology. The interpretation is presented using a multi-stage approach, starting with the smallest scale imagery. Multi-spectral approach is also applied to clarify features which are not sufficiently clearly visible on certain bands but show up well on others.

6.3.1.1 Bedrock Geology

The Canadian Geological Survey maps prepared by Greene et al., (1970) and Stevenson (1965) were used to develop the classification system for this study (Table 6-4). This classification system was not applied to the NOAA imagery, however, an attempt was made to interpret geological features that appear on this small scale image. The code number of each unit as shown in the Table 6-4 are used to annotate the imagery.

Table 6-4 Bedrock Geology Classification System

i	sand
ii	pink quartzo-feldspathic gneisses
iii	black and white gneisses
iv	granite to granodiorite
v	anorthosite series
vi	syenite-monzonite series
vii	gabro dykes
viii	conglomerate

NOAA imagery (Figure 6-1, overlay A)

Lake Melville (LM) appears white as it is covered with ice and snow. The Churchill River (CR) forms a long line enhanced by ice and snow cover and the very dark tone of vegetation at its banks. At about the middle of its course, the Churchill River bends several times at about right angles forming a rectangular drainage pattern.

From the Atlantic Ocean (AO), Lake Melville and the Churchill River form a lineament that is continued to form a long curved line ending in Ungava Bay, northwest of Labrador. This Bay is located at the upper left beyond the imagery. It was known from the Geological Map of Canada (Douglas, 1969) that these linear features indicate faults. Another fault is delineated at the right side (east) of the Churchill Falls reservoir.

Figure 6-1 NOAA imagery, Labrador, part of Quebec Province, and Newfoundland, cloud covers most of the Newfoundland Island. The legend is provided in the following page. This 1:9,000,000 scale image was acquired on 20 February 1973. (Source: Faculty of Engineering and Applied Science, Memorial University of Newfoundland)

Legend to Figure 6-1, NOAA image

Geology (overlay A)

AO	Atlantic Ocean
LM	Lake Melville
CR	Churchill River
WB	Water bodies
R	River
F	Faults
	Catchment area boundary

Land Cover and Land Use (overlay B)

A	Tundra	
	Aa	Arctic tundra
	Ab	Coastal tundra
B	Boreal Forest	
	Ba	Forest tundra
	Bb	Sub-arctic forest
	Bc	Sparsely forested heath-and moss barrens
	Bd	Productive mixed forest
	Be	Productive black spruce forest

[dashed box] Area covered by LANDSAT MSS image (Figure 6-2)

Since the imagery was acquired in winter, the water bodies (WB) are covered by ice and snow making them appear similar to of barren lands.

It is difficult to distinguish between the two, although most of the barren lands appear as white coarse textured spots, while the texture of water bodies is smooth. Moreover, the water bodies usually are associated with rivers flowing into and out of them.

Only large rivers (R) can be identified on this imagery because of the poor resolution. Due to the ice and snow cover, some rivers appear as a continuous light grey line. Banks of wide rivers are covered by forests, showing up as dark continuous lines.

LANDSAT MSS Band 4, near infrared (Figure 6-2)

The mapping on this image is based on the first classification level presented in Table 6-4. Sand and barren land are observed as having bright tones on the picture. The igneous rock on zone iii and zone vi of the classification system form hills indicating high resistance to erosion. There is no specific spectral characteristic indicating igneous rock that can be observed on this image.

The lineaments, may indicate streams, escarpment, mountain ridges, faults, and fractures. Some faults defined by Stevenson (1965) and Greene et al., (1970) appear on this image as escarpments and tonal differences.

Figure 6-2 LANDSAT MSS Band 4, near infra red band, the Lower Churchill River and vicinity. The legend is provided in the following page. This 1:1,000,000 scale image was acquired on 20 September 1987. (Source: EOSAT)

Legend to Figure 6-2, LANDSAT MSS Band 4, near infrared

Bedrock Geology map of Stevenson, 1965 (map 7-1967), and Greene et al., 1970

i	Sand
ii	Pink quartzo-feldspathic gneisses
iii	Black and white gneisses
iv	Granite to granodiorite
v	Anorthosite series
vi	Syenite-monzonite series
vii	Gabro dykes (too small to be mapped on this image)
viii	Conglomerate

fault

geological boundary

Area covered by SEASAT SAR image (Figure 6-4)

The absorption of infrared energy by water makes this image suitable to map drainage patterns. Layering such as shown by trellis drainage pattern is observed in the upper right of the image. An angular drainage pattern appears at the bottom of the image. Such drainage patterns may indicate rock type, and structure. However, interpretation of a rock type cannot be done based on drainage pattern only. More evidence is required in order to have an accurate interpretation (Drury, 1987).

LANDSAT MSS Band 2, red (Figure 6-3)

No detailed geological interpretation was carried out on this image. Nevertheless, it was observed that sand appears much brighter than barren land. These two features appear in similar tone on the near infrared imagery. The water bodies do not appear as dark on this image as they did on the near infrared picture, so that water turbidity can be observed.

SEASAT SAR (RADAR) Imagery (Figure 6-4)

The classification system applied for the interpretation of this image is the same as for the LANDSAT MSS Band 4 (Figure 6-2). This image has a larger scale than the imagery previously interpreted. Alluvial sand can be observed with erosion scars (ib) along the left bank of the Churchill River downstream of Muskrat Falls. Where the sand is sparsely vegetated, as on the sand dunes, it exhibits a dark tone (ia). This probably occurs because much of the energy is reflected away from the sensor due to the smooth surface. The igneous rock (iii and vi) is characterized by its hilly topography which

Figure 6-3 LANDSAT MSS Band 2, red, Lower Churchill River and vicinity. The legend is provided in the following page. This 1:1,000,000 image was acquired on 20 September 1987. (Source: EOSAT)

Legend to Figure 6-3, LANDSAT MSS Band 2, red

Aa Arctic tundra

Ba Forest tundra

Bb Subarctic forest

Bc Sparsely forested heath-and-moss barrens

Bd Productive black spruce forest

1 Forest land

- 11 mixed forest
- 12 black spruce forest
- 13 burnt areas
- 14 moving sand dunes and extensively eroded areas

2 barren land

- 21 rock barren
- 22 low shrub barren

3 wetland

- 31 open bog
- 32 treed bog

☐ Area covered by LANDSAT TM image (Figure 6-5)

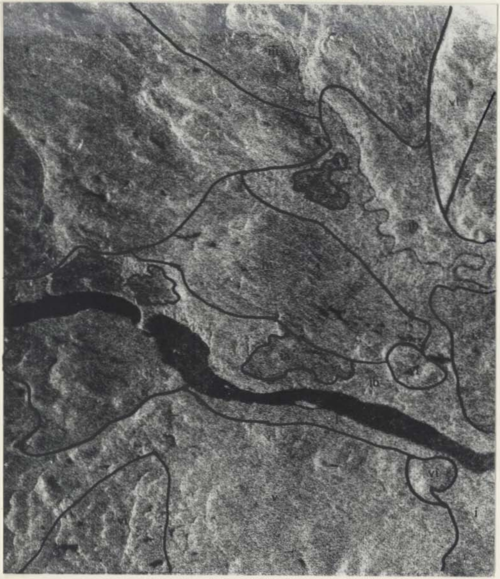


Figure 6-4 SEASAT SAR (RADAR) imagery, band L (23.5 cm), Churchill River at Muskrat Falls site and vicinity. The legend is provided in the following page. This 1:150,000 image was acquired on 19 September 1978. (Source: Faculty of Engineering and Applied Science, Memorial University of Newfoundland)

Legend to Figure 6-4, SEASAT SAR (RADAR) image

Bedrock geology map of Stevenson (1965), map 7-1967)

i	Sand	
	ia	sand dune or levelled sand
	ib	eroded alluvial sand
ii	pink quartzo-feldspathic gneisses	
iii	black and white gneisses	
v	Anorthosite series	
vi	Syenite-monzonite series	

geological boundary

appears as having a bright tone on the near side to the sensors and dark in the far side. Rivers and water bodies appear dark due to their smooth surface with minimal reflection. Subtle bright toned speckles observed on the Churchill River surface indicate the presence of sand bars, turbid water, and/or waves.

6.3.1.2 Surficial Geology

The applied classification system for the surficial geology is based on identifiable landforms on the LANDSAT TM image and the infrared aerial photographs (Table 6-5). The description of each landform is presented based on the works of Fulton et al. (1975) and Beak Consultants (1978). The symbols appearing in the Table are used to annotate the terrain features on the imagery.

LANDSAT TM Colour Composite of Bands 1, 2, 3 (Figure 6-5)

This image approximates the natural colour of the terrain. At this 1:500,000 scale image, the lineaments and surface texture can be observed clearer than on the LANDSAT MSS and on the NOAA imagery. The poor contrast between water and land makes drainage patterns difficult to distinguish. The occurrence of bright sand banks and sand bars gives clues for the location of rivers.

Delineation of surficial geological units on this image was carried out with the aid of a map prepared by Fulton (1986). Five surficial features could be identified: alluvial deposits (F), marine deposits (W), rock (R), morainal deposits (M), and glaciofluvial deposits (G). This classification is based on the origin and depositional form of the material. The aquatic system (Q) can be observed as rivers and lake. Exposed rock (R) and colluvial deposits (C) are too small to be mapped on this image.

Table 6-5 Surficial Geology Classification System

C	Colluvial deposits	
F	Alluvial deposits	
	Fe	Eroded fluvial landform
	Ft	Fluvial terrace
	Fn	Duned fluvial terrace
	Ftu	Fluvial terrace remnants dissected by flow from upper slope
W	Marine deposits	
	Ws	Steep slope adjacent to stream on the rims of flow slides adjacent to alluvial terrace and other marine slope complexes
	We	Steep active dry sand flows and vertical cliffs of clay without vegetation protection
	Wu	Uniformly dissected slope on fine textured marine sediments
	Wz	Earth-flow complex on marine clays
	Wsr	Steep slope on a shallow marine and glacial drift veneer on a bedrock
M	Morainal deposits	
O	Organic system	
	Ofs	string fen
G	Glaciofluvial deposit	
Q	Aquatic system	
R	Rock	
	Rv	Rock veneered

The vegetation obscures the surface of the terrain, therefore delineation of surficial deposit units based on spectral characteristics alone is difficult. However, some

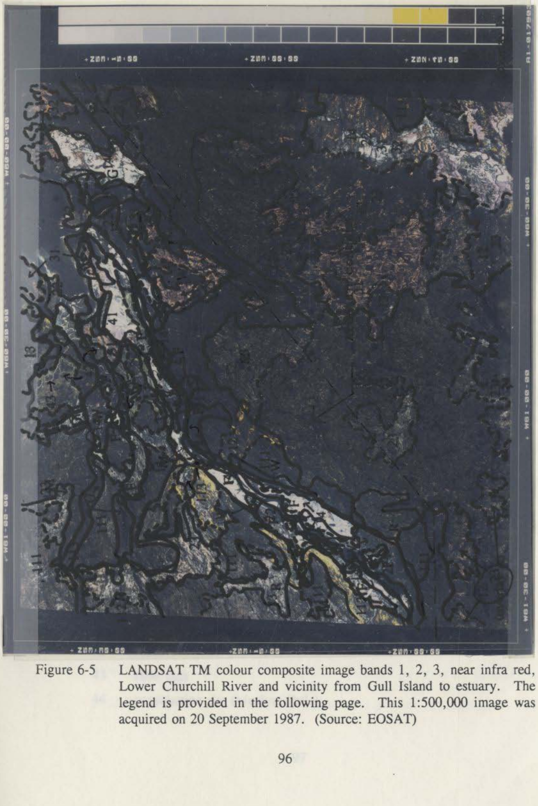


Figure 6-5 LANDSAT TM colour composite image bands 1, 2, 3, near infra red, Lower Churchill River and vicinity from Gull Island to estuary. The legend is provided in the following page. This 1:500,000 image was acquired on 20 September 1987. (Source: EOSAT)

Legend to Figure 6-5, LANDSAT TM natural colour

Surficial Geology (after Fulton (1986), map 1621A)
(overlay A)

F	Alluvial deposits
W	Marine deposits
R	Rock
M	Morainal deposits
G	Glacio-fluvial deposits

Land Cover and Land Use (overlay B)

11	mixed forest	
	111	softwood
	112	softwood hardwood
	113	hardwood softwood
	114	hardwood
12	black spruce forest	
13	burnt areas	
14	moving sand dunes and extensively eroded areas	
22	low shrub barrens	
23	treed barrens	
31	open bog	
32	treed bog	
41	settlements	
42	roads	
43	clear cuts	
44	construction site (Muskrat Falls)	

characteristics of the vegetation cover may be valuable for geological interpretation, for example yellow leaves of hardwood and brownish pink of wet land, which grow on particular landforms, vegetation appear clearly on this image.

Colour Infrared Aerial Photographs (Figure 6-6)

The delineation of units on this imagery is based on Fulton and Hodgson's map (1969) and on the Beak Consultants (1978) land classification system. The area covered by this picture is divided into the following land systems:

Colluvial deposits (C)

Colluvial deposit is loose material accumulated on and at the foot of slopes by various processes of mass movement (Fulton et al., 1975). The texture ranges from clay to rubble and boulders, generally poorly sorted, and massive to crudely stratified. The nature of colluvial deposits depends on the material from which they are derived. In the Lower Churchill Valley these materials are found on steep slopes above the limit of significant fluvial and glaciofluvial water washing and deposition (Beak Consultants, 1978)

Alluvial deposits (F)

Fulton et al., (1975) defined those deposits as having alluvial genetic category. These deposits as encountered in the Lower Churchill River valley have bevelled surfaces, frequent braided channel patterns and flat micro-relief (Beak

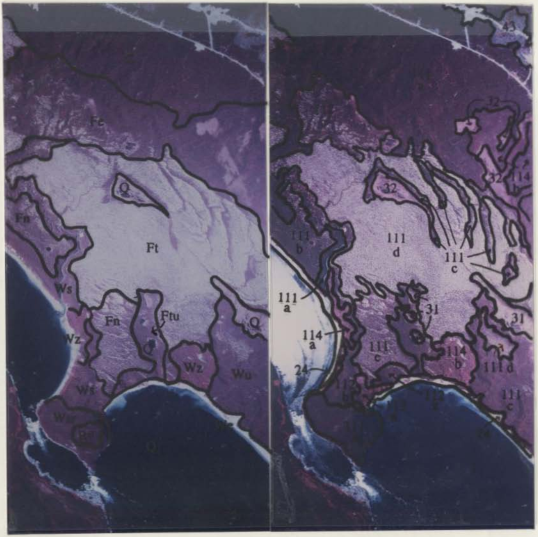


Figure 6-6 False colour infrared aerial imagery, Churchill River at Muskrat Falls site and vicinity. The legend is provided in the following page. This 1:40,000 image was acquired on 19 September 1978. (Source: Faculty of Engineering and Applied Science, Memorial University of Newfoundland)

Legend to Figure 6-6, colour aerial photographs

Geology (overlay A - left of figure)

C	Colluvium
Fe	Eroded fluvial landform
Ft	Fluvial terrace
Fn	Duned Fluvial terrace
Ftu	Fluvial terrace remnants dissected by stream flow from upper slope
Ws	Steep slope adjacent to stream on the rims of flow slides adjacent to alluvial terrace and other marine slope complexes
We	Steep active dry sand flows and vertical cliffs of clay without vegetation protection
Wu	Uniformly dissected slope on fine textured marine sediments
Wz	Earth-flow complex on marine clays
Wsr	Steep slope on a shallow marine and glacial drift veneer on a bedrock
Q	Aquatic system
Rv	Rock veneered

Land Cover and Land Use (overlay B - right of figure)

- 11 mixed forest
  - 111 softwood
  - 112 softwood hardwood
  - 113 hardwood softwood
  - 114 hardwood
- 22 low shrub barrens
- 23 treed barrens

Consultants, 1978). The material consists of well-stratified, well sorted to moderately stratified and sorted sand, gravel, silt and clay. This may include gravel and boulder pavements washed bedrock, bouldery channel deposits, and channel fillings of silt and clay.

On the image several landform types can be mapped (Beak Consultants, 1978):

Fe: Eroded fluvial landform.

Ft: Fluvial terrace. Flat topped alluvial materials, with its surface terminated by abrupt changes in slope on one or more sides.

Fn: Fluvial terraces with numerous parabolic sand dunes.

Ftu: Fluvial terrace remnants dissected by stream flow from upper slopes.

Marine deposits (W)

The marine deposits include parent material at depth laminated by clayey silt and silty clay with frequent sand partings of preglacial marine and estuarine origin (Beak Consultants, 1978). This material overlaps glacial drift and bedrock, and is mantled with a veneer of alluvial sand. Extensive areas of this system are observed with slope failure and earth flow type slides, since they are very sensitive to disturbance. Creep and surface slope movement are common in this land system. Marine deposits are differentiated by some morphologic modifiers, mainly in the form of slopes as described by Beak Consultants (1978) as follows:

Ws: Steep slopes adjacent to stream on the rims of flow slides adjacent to alluvial terraces and marine slope complexes. This slope is usually marked by dry sand flows, but clay talus blocks may occur. Slopes are stabilized with vegetation, but active creep occurs.

We: This unit comprises steep active dry sand flows and vertical cliffs of clay without vegetative protection. Occurs on the rim of flow slides and at points of river bank erosion, these units are potentially unstable. Continued bank erosion may initiate further slope failure, and retrogressive earth flow slide may occur.

Wu: This unit has uniformly dissected slopes on fine textured marine sediments: clayey silts and silty clays. Dense drainage patterns occur with 150 to 300 m order of spacing.

Wz: Earth flow complex type in marine clays is included in this unit. Hummocky micro-topography and slide block islands are arranged in radial patterns in a matrix of remoulded clay and sand. Earth flow slides form a chaotic mixture of remoulded silts and clays, desiccated crustal blocks, aeolian and fluvial sands, tree trunks, and organic soil.

Wsr: This unit is a mixture of Ws unit and Wr unit, which is a shallow estuarine and glacial drift veneer on bedrock.

Organic system (O)

The organic system occurs within old slide bowls, elevated meanders, channel scars, high sand terraces, and where internal drainage is restricted by impermeable soil layers. This organic system is mostly composed of bog-fen complexes. A fen is an organic system where there is a possible flow of water. On the image, Ofs indicates a string fen.

Aquatic system (Q)

The aquatic systems include the Churchill River and major tributaries, large lakes, small ponds, kettle ponds, and small streams.

Rock system (R)

This system includes resistant rock uplands of Precambrian granitic gneiss with irregular local micro-relief but rounded regionally. On the image, one rock system is found, Rv abutting the Muskrat Falls rapid, which is a hard rock with thin veneer drift, occasional deep pockets, and some outcrops.

6.3.2 Interpretation of Remotely Sensed Data for Land Cover and Land Use

The sample interpretation of land cover/land use in this thesis is centred around the area along the Lower Churchill River, as this area will be much influenced by the proposed development and will go through significant changes as the dam at Muskrat Falls is completed. The developed land cover/land use classification system is presented in Tables 6-6a and 6-6b. The symbols and/or the numbering as they are listed in the two tables are used to annotate the terrain features on the imagery.

Table 6-6a Land Cover & Land Use Classification (first and second levels)

A. Tundra
   a. Arctic tundra
   b. Coastal tundra

B. Boreal Forest
   a. Forest tundra
   b. Subarctic forest
   c. Sparsely forested heath-and-moss barrens
   d. Productive mixed forest
   e. productive black spruce forest

NOAA Imagery (Figure 6-1, overlay B)

The tundra region (A), covers the entire coastline and gradually widening hinterland extending north from latitude 54^0 30' (Wilton, 1965). Tundra is extensive upland areas of exposed bedrock. These units are interspersed with a sparse cover of lichens and dwarfed shrubs and trees growing in scattered hollows (Lopoukhine et al., 1977). Covered by snow during most of the year it appears as smooth textured light areas on the image. The arctic tundra (Aa) exists due to the climatic factors in the area at the north of the mentioned latitude. The coastal tundra (Ab) exists due to a combination of wind-caused factors such as fog, low temperature, wind force, drying effect of the wind, and wind born constituents. This coastal tundra occurs along the coast of Labrador (Wilton, 1965).

The forest of Labrador is part of Boreal forest (B) that creates a belt from this area westward to the Rocky Mountains and northwestward to Alaska (Rowe, 1972). Forest tundra (Ba) is a transition between subarctic forest and tundra. This forest comprises a pattern of tundra barrens and patches of stunted forest. The primary species in these forests are black spruce and white spruce and tamarack accompanied by alder and willow shrubs. The land classified as subarctic forest (Bb) comprises lakes and rivers, bogs, swamps and muskeg, with areas of upland barrens and forest. The vegetation cover consists of open park-like woodland of black spruce with ground covered by lichens. The sparsely forested heath-and-moss barrens (Bc) are located in south-eastern Labrador. The appearance of the vegetation generally is stunted, open and patchy or sometimes continuous cover of black spruce and balsam fir, alternating with moss-and-heath barrens, rock outcrop and lakes, on a generally featureless, windswept terrain. The productive mixed forest (Bd) is located along the Lower Churchill River and Lake Melville. The most prevalent species is black spruce. This species can be in a pure stands or mixed with balsam fir and white birch. Other species encountered in this region are balsam fir, white spruce, white birch, balsam poplar, and trembling aspen. The productive black spruce forest (Be) occurs because of the prominence of this species on peaty lowland sites and on well drained upland drift and rock. These land conditions are poor for other vegetation species. This makes the variety of vegetation cover type limited.

Table 6-6b Land Cover & Land Use Classification (third and higher levels)

1. Forest land
   11 mixed forests
      111 softwood (76%-100% softwood, 0-25% hardwood)
      112 softwood hardwood (51%-75% softwood, 26%-50% hardwood)
      113 hardwood softwood (26%-50% softwood, 51%-75% hardwood)
      114 hardwood (0%-25% softwood, 76%-100% hardwood)
   12 black spruce forests
   13 burnt areas
   14 moving sand dunes and extensively eroded areas

2. Barren land
   21 rock barren
   22 low shrub barrens
   23 treed barrens
   24 soil barrens

3. Wet land
   31 open bog
   32 treed bog
   33 hardwood thickets

4. Cultural features
   41 settlements
   42 roads
   43 clear cuts
   44 construction sites
   45 right of way

<u>LANDSAT MSS Band 2, red (Figure 6-3)</u>

The area imaged by the LANDSAT MSS data is indicated on the NOAA imagery by a rectangle (Figure 6-1). This image mainly represents the productive mixed forest region (Bd). Better resolution and several spectral bands are provided by LANDSAT MSS, therefore the mapping of the various units is more accurate on this image than on the NOAA. This causes discrepancies concerning the location of boundary lines as they appear on the two different imagery.

Water bodies on this image appear dark with a smooth texture, for example Lake Melville at the upper right part of the image. Another lake (Grand Lake) is located near the top, in the middle of the image. The Churchill River is observed as a thin, long, dark line in between the moving sand dune area (14). Mud Lake is observed at the right (east) side of the Churchill River near the estuary. The major units (Aa, Ba, Bb, Bc, and Bd) were delineated first. The productive mixed forest (Bd) was further divided into sub units. The forest land (1) occupies most of the area imaged which appears as dark toned features. The terrain having very dark and smooth texture within this forest land is classified as mixed forest (11). Some brighter spots in this area located at the north (upper part) of the Churchill River indicate forestry activity (clear cut logging). Black spruce forest (12) occupies the area to the south of the productive mixed forest.

Areas of burnt forest (13) are found at the south side of Grand Lake. This feature does not appear on images of other bands of LANDSAT MSS.

The area along the banks of the Churchill River are classified as moving sand dunes and extensively eroded areas (14). Similar areas also appear at the east of Mud Lake.

Although large areas of barren land (2) do occur throughout the area imaged on this picture, they cannot be identified with the exception of the huge Mealy Mountain (Aa) region. A large complex area containing rock barren (21), low shrubs barrens (22), and treed barrens (23) occurs in the east of the black spruce forests (12).

Wetland (3) in this area is encountered near the mouth of the Churchill River and along the coast of lake Melville. The complex area mentioned in the previous paragraph also contains the open bog (31) and treed bog (32). Hardwood thickets (33) are barely detected on this small scale imagery.

Cultural features (4) observed in this image are the towns (settlement (41)) of Happy Valley and Goose Bay. They are located at the left side of the Churchill River before the river reaches the estuary. The settlement of Mud Lake cannot be identified on this image.

LANDSAT TM Colour composite Bands 1, 2, 3 (Figure 6-5, overlay B)

The larger scale (1:500,000) and finer resolution of this image compared to the previous images make it possible to conduct a higher level interpretation. The colour of this image approximates natural colour of the terrain. The mixed forests (11) of the previous classification can further be divided into softwood forest (111) and hardwood forest(112). The yellow colour observed on the image indicates hardwood leaves in its natural colour in the fall.

Rock barren (21) cannot be observed as an individual feature in this small scale image.

Low shrubs barren (22) can be observed along the Churchill River downstream of Gull Island at the left edge of the image. Some treed barren (23) are encountered in between the black spruce forests (12).

All wetland (3) types (open bog (31), treed bog (32), and hardwood thickets (33)) can be observed on this image, however, their individual delineation is difficult on this small scale imagery.

Cultural features (4) can be identified easily on this image. These are the towns of Happy Valley and Goose Bay (41) and roads (42). The roads are observed as continuous white lines. The clear cuts (43) are very distinctive because of their light tones. Other items such as oil tanks near the sea port at the north of Goose Bay, and a landing strip in the town of Goose Bay are discernible. The construction site (44) of Muskrat Falls dam can be located on the image easily.

Aerial photographs (Figures 6-6 and 6-7)

The highest level of classification is made based on the observation on the false colour infrared and natural colour aerial photographs. Figure 6-6, the 1:40,000 scale false colour infrared photographs provide data on crown density of vegetation cover, and clear distinction of deciduous trees (hardwood) against coniferous trees (softwood). The hardwood appear brighter pink. Figure 6-7, the 1:12,500 natural colour aerial photographs, provide more detailed data on vegetation cover. The identification of

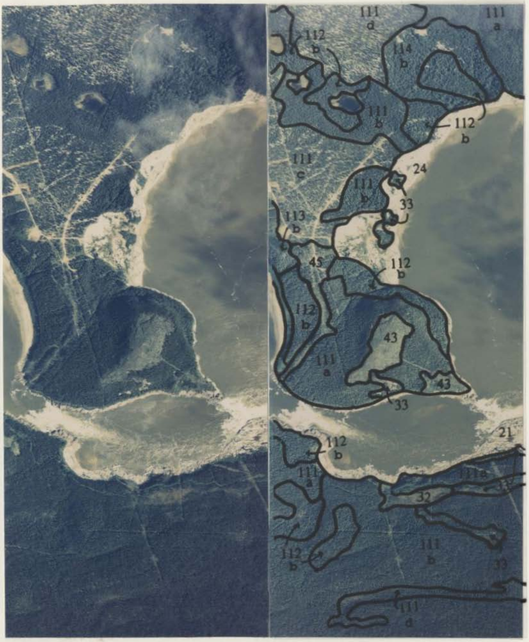


Figure 6-7 Colour Aerial Photographs, Muskrat Falls Dam site and vicinity. This 1:12,500 scale imagery was acquired on 23 August 1988. The legend is provided in the following page. (Source: Department of Environment and Lands, Newfoundland, Canada)

Legend to Figure 6-7, colour aerial photographs

1 Forest

- 111 Softwood
- 112 Softwood - hardwood
- 113 Hardwood - softwood
- 114 Hardwood

Crown density:

- a: Very dense
- b: Dense
- c: Open
- d: Very open

2 barren land

- 21 rock barren
- 22 low shrub barren
- 23 treed barren
- 24 soil barren

3 wetland

- 31 open bog
- 32 treed bog
- 33 hardwood thickets

4 cultural features

- 42 road
- 43 cleared land
- 45 right of way

different types of vegetation, namely: softwood, hardwood, and hardwood thickets can be determined based on different textures. A map of the Newfoundland and Labrador Forest Inventory (1990) was available to aid the interpretation. The classification presented on the natural colour aerial photographs is a modified version of the Newfoundland forest inventory system developed for Labrador. In applying this system the 'forest' classes were further subdivided into sub-classes by crown density:

a.	very dense:	75% - 100% ground coverage
b.	dense:	51% - 75% ground coverage
c.	open:	26% - 50% ground coverage
d.	very open:	0% - 25% ground coverage

The code system of these sub-classes is used to annotate the imagery.

6.3.3 Assessment of Morphological Changes in the Lower Churchill River

The wide valley along the Churchill River downstream of Gull Island rapids has been defined as the Churchill River Low Land region (Beak Consultants, 1978). The river morphology within this low land region downstream of Muskrat Falls was studied in this thesis. This study emphasizes observations of terrain features concerning the morphological changes on the available multi-temporal remotely sensed imagery. Upstream from the dam at Muskrat Falls, the river surface will be elevated to 39 m above sea level. Downstream of the dam, river bed degradation will likely occur followed by slumping of the banks and considerable shift in position of sediments.

6.3.3.1 Topography

As can be observed on the topographic map (Figure 6-8), this region comprises the area from sea level (Lake Melville) to an elevation of about 160 m (app. 500 ft.). This area contains moderate to steep slopes that lead to higher lands and peaks that reach about 500 m (app. 1500 ft) on both sides of the river. Downstream of Muskrat Falls for about 20 km, the valley is narrow, then two peaks of app. 300 m high can be found at both sides of the river. Farther downstream to the estuary (about 25 km), the terrain is very flat on both sides. This extends to about 10 km on at the north side and to about 20 km on the south side. The towns of Happy Valley and Goose Bay are located on this flat terrain at the north side of the river. A small community, Mud Lake, is located at the south side of the river near the estuary.

This topographic map (Figure 6-8) was made by photogrammetric methods using aerial photography dated 1951. The location of sandbars are indicated in this map starting just downstream of Muskrat Falls to the estuary.

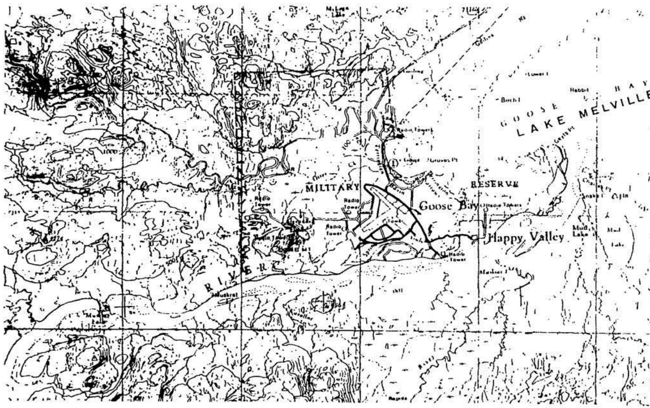


Figure 6-8 Topographic Map of Lower Churchill River and vicinity. Scale 1:250,000. (Source: Department of Mines and Technical Surveys, printed in 1965).

6.3.3.2 Geology

Stevenson (1965) indicated that the Churchill River low land region, especially along the river, comprises sand, except at the south abutment at the dam site and farther downstream just before the wet land areas. The south abutment of the dam is metamorphic rock consisting of black and white gneisses; and at the other side igneous rock of syenite-monzonite series can be found. Conglomerate and sandstone underlay a part of the reservoir site between Gull Island and Muskrat Falls.

According to Fulton (1986), most of the areas on both sides of the river are covered by alluvial deposits. These deposits are detrital materials which were transported by the river along the flood plain. In this area, the alluvial deposits consist of sand and gravel up to 15 m thick, and commonly overlay a considerable thickness of finer grained lacustrine or marine sediments, and in some places covered by extensive bogs (Fulton, 1986).

Some morainal deposits are found at the right side of the Lower Churchill River downstream of Muskrat Falls (Fulton, 1986). This material, transported and deposited by the glaciation process, is dominated by sandy and gravelly till.

Marine deposits, which were deposited by sea water, are encountered in the reservoir site between Gull Island and Muskrat Falls (Fulton, 1986). These materials can exceed 100 m in thickness at this site; the thickness may even reach 1000 m according to the report provided by Beak Consultants (1978). The marine deposits in this area are sub-littoral deposits of silt and clay, commonly laminated with minor fine grained sand. Marine deposits in this site are sensitive to disturbance (Beak Consultants, 1978). Landslides involving this material are common and in many areas the landslides appear to be accompanied by liquefaction (Fulton, 1986).

Observation of false colour infrared imagery of 1:40,000 scale along the Churchill River from Gull Island to the estuary revealed the presence of alluvial sand covers at many places along the river sides. Underneath this alluvial sand, layers of estuarine or marine clay exist. Silt and clay with only minor fine grained sand is a source of poorly drained soil. Wet lands along the river sides may indicate these characteristics. Containing relatively high moisture content, this marine clay supports dense vegetation. Slumping, sliding, and earth flow may be used as indicators for the presence of this marine clay material.

6.3.3.3 Observation of Multi-temporal Remotely Sensed Data

Observation of terrain conditions along the river in 1973 was mainly carried out on continuous overlapping frames of 1:40,000 scale natural colour and false colour infrared imagery. The overall area can be observed on a strip of the thermal infrared scan imagery (Figure 6-9), except a portion at the Muskrat Falls site. The thermal imagery was numbered such that one unit represents app. 650 m.

Large scale (1:12,500) natural colour aerial photographs (Figure 6-7) were also studied. The overall area can be observed on the LANDSAT TM imagery (Figures 6-4, 6-10a, and 6-10b). These imagery represent data acquired after 1987.

<u>Observation made on imagery acquired in 1973</u>

Generally the river banks are densely vegetated. At the right side, rough banks comprising rocks can be observed on the natural colour aerial photographs. Part of these are discernible on Figures 6-6 (false colour infrared) and 6-7 (natural colour), and from line 155 to line 166 on the thermal infrared scan imagery (Figure 6-9). A tributary can be found at line 153 at the very left of Figure 6-9 with alluvial deposits at its mouth. A meandering tributary is observed at line 170. Here the alluvial deposits are distributed from line 166 to 173, where fluvial terraces and wet land are located. Still at the right side, rough river banks occur again between line 174 and 175.

At the left side smooth river bank is observed all the way down from Muskrat Falls to the estuary. Heavy flow slides occur from Muskrat Falls to line 155, from 161 to 165, and from 169 to 171. Beyond line 176 at both sides of the river terraces can be found. The tributaries are meandering indicating that the area is very flat. Wet lands are prevalent throughout the area. Cultural features and the town of Happy Valley are

Figure 6-9 Thermal Infrared Airborne Imagery. The legend is provided in the following page. (Source: Faculty of Engineering and Applied Science, Memorial University of Newfoundland)

Figure 6-9 Thermal Infrared airborne imagery, downstream of Muskrat Falls site to the city of Happy Valley. The Muskrat Falls dam site is beyond the image at the left side of the upper image. This 1:74,000 scale image was acquired on 5 August 1973.

Legend:

HV Happy Valley

GB Goose Bay

O Bed rock outcrops

approximate new shore line as observed on LANDSAT TM imagery

probable future shoreline.

observed at the left side of the river from line 161 to 196.

A large sand bar developed in line 155. The frequency of sand bars gets higher starting at line 163. Twenty five sand bars and islands can be observed on Figure 6-9, from Muskrat Falls to Happy Valley.

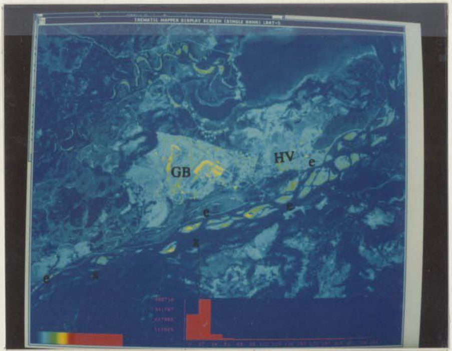
Ground reference data

A survey reported in the EIS (LCDC, 1980) provided a map that indicates the location and condition of erosion along the river bank. This is the result of an observation along the river in January 1978. At the south bank, bed rock outcrops were observed at lines 156, 158, 174, and 175 (Figure 6-9). Slope failures and other signs of erosion were observed along 12 km of the right bank. At the left side, 18 km of the river bank were observed to have erosion scars and land slides. Erosion has occurred along the river in Happy Valley. People raised their concerns on the possibility of an increase in intensity of the erosion after the Muskrat Falls dam is constructed (FEARO, 1980).

Observations on imagery acquired in 1987

The display of digital LANDSAT TM data on the computer screen, provided an image at a scale of about 1:80,000. Band 2 (green) and band 3 (red) are shown in Figure 6-10. The reproduction of the images from the display screen does not provide a clear distinction between river and land. Some changes along the river banks can be observed, however, lower altitude data are required to obtain more accurate interpretation. An

(a)



(b)

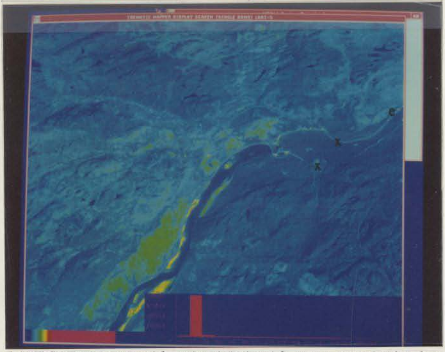


Figure 6-10 LANDSAT TM (a) band 3, red and (b) band 2, green, reproduction from computer screen. The legend is provided in the following page. Scale: 1:250,000. (Source: EOSAT)

Legend to Figure 6-10. LANDSAT TM (a) band 3, red and (b) band 2, green

HV	Happy Valley
GB	Goose Bay
e	eroded bank or site vulnerable to erosion
x	changes observed compared to previous imagery, however need lower altitude data for more accurate interpretation.

example of the lower altitude data is provided in Figure 6-7, the large scale natural colour aerial photographs of the Muskrat Falls site.

The alluvial deposits at the right bank at line 153 of Figure 6-9 is larger in the 1987 image compared with the 1973 figure. The huge sand bar as shown at line 153 of the thermal image (Figure 6-9) in the middle of the river has vanished in 1987 (see Figure 6-10b). The river bank just downstream of this huge sand bar has retreated, and the river has become wider in this section (marked x in the left bank, as seen on Figure 6-10b). The alluvial deposit at the right bank between line 166 and 173 (Figure 6-9) does not show a clear contact line with the river (the most left x of Figure 6-10a). Comparison was made with LANDSAT MSS data band 4, near infrared (Figure 6-2). On this image the shoreline is clearly distinguishable. However, the scale of the LANDSAT MSS data is too small to detect the change.

A significant difference is observed concerning the number of sand bars. Around 40 sand bars and islands have developed between Muskrat Falls and Happy Valley. This is about 1.6 times the number of sand bars and islands observed on Figure 6-9 acquired in 1973.

Larger scale imagery provided as Figures 6-6 and 6-7 were studied and compared. These imagery represent data of the Muskrat Falls site acquired in 5 August 1973 and in 23 August 1988 respectively. The imagery are of different types (false colour infrared and natural colour) and different scale (1:40,000 and 1:12,500). However, terrain features for comparison of both imagery can be observed clearly except that they are in different colours.

Comparison of water turbidity cannot be made between these two imagery because water appears in an absolutely dark tone on the infrared image. The water and soil contact line may indicate the water elevation roughly. Although there might be a slight discrepancy, it is reasonable to assume that the elevation of water is about the same in both imageries.

Some vegetation has grown on previously bare soil. An example is observed in the mouth of a tributary at the left bank of the river, downstream of Muskrat Falls. The vegetation is observed on the 1988 image while in the same place it is observed as bare soil on the 1973 image. Vegetation growing on previously bare soil are also observed in some other places beyond this imagery. However, the reverse phenomenon also occurs. For example, the bare soil at the top of the rock knoll, at the left abutment of the Muskrat Falls is wider in the 1988 imagery. Vegetation has been cleared for road and railway (Newfoundland and Labrador Forest Inventory, 1990). The track and the right of way can be observed on the natural colour imagery acquired in 1988 (Figure 6-7). In the infrared imagery acuired in 1973 (Figure 6-6) the only road observed is the Trans Labrador highway at the top of the image.

An important change related to the river morphology occurred as a large land slide at the downstream part of the neck connecting the rock knoll (the left abutment of the Muskrat

Falls) and the main land. In the 1973 imagery this area was densely vegetated, while most of the vegetation as observed on the 1988 imagery has gone. On the LANDSAT TM imagery (Figure 6-10a and b), these land slides appear as bright yellow dots. These dots are observed on the left river bank farther downstream (Figure 6-10a). Based on these data, one may assess that landslides that occurred in the past, in the locations of the yellow dots, may have also developed similarly to the one that occurred in the Muskrat Falls site.

If a thorough assessment of the river morphology is required, observation of similar imagery along the river to the estuary can be made. The development of the landslides as observed as bright yellow dots on the LANDSAT TM imagery can be observed on large scale aerial photographs such as Figure 6-7.

7. Possible Enhancements of the Environmental Impact Assessment Process for Water Resources Developments in Indonesia

This chapter deals with possible enhancements of the EIA process in Indonesia, based on experience in Indonesia and features of the Canadian EIA process, outlined in previous chapters. There are several factors that may prevent the proper conduct of an EIA process in Indonesia:

1. the shortcomings of the existing regulations,
2. limited concern with environmental impacts in evaluating the success of a development, and
3. the lack of awareness and the cultural characteristics of Indonesian people that are not conducive to meaningful participation.

The following discussion is centred around these three problems. At the end of this chapter, examples and procedures of using remotely sensed data are presented. Wide application of remote sensing in water resources development should enhance the EIA process including monitoring.

7.1 Possible Enhancements of the Indonesian Environmental Impact Assessment Regulations

The environmental case in Kedungombo (see sections 5.2.2) represents one that occurred after the promulgation of the Indonesian environmental law. Although the industries that polluted the Tapak River were founded in 1977, under the 1982 environmental law they had to make an Environmental Evaluation Study (SEL)[28], Environmental Management Plan (RKL), and Environmental Monitoring Plan (RPL). The government (the Minister of Population and Environment/MPE and the Board of Environmental Impact Control/BAPEDAL) prosecuted more than 400 companies responsible for environmental abuses and expected that shortcomings in the environmental regulations could be found out through these court actions (Arimbi, 1991). This shows that the Indonesian government realizes the possible shortcomings in the environmental regulations and is willing to enhance them.

In order to encourage and to provide opportunities for public to participate in the EIA process, the Canadian federal EARP provides for:

1. public information dissemination,
2. review by an independent party, and
3. public review/public hearings.

[28] 'SEL' is an abbreviation of 'studi evaluasi lingkungan'. This document is similar to ANDAL, but it is made after the completion of a project. Every industry that was founded before 1982 has to provide this document in addition to an RKL and an RPL.

With a slightly different emphasis, the Newfoundland and Labrador provincial Environmental Assessment process also has the same emphasis. The discussion on the Indonesian EIA regulations in this thesis is structured around these three points.

7.1.1 Public Information Dissemination

Seeking the opinions, ideas, and concerns of people is a common practice in an EIA process. In order to have substantial public input, a good program of information dissemination has to be conducted. In the EARP it is the obligation of a minister of the initiating department (MID) to publish the proponent's proposals through the Federal Environmental Assessment Review Office (FEARO). FEARO also provides information on the activities of all working environmental assessment panels. In the Newfoundland and Labrador provincial process, the regulations stipulate the obligation of a proponent to conduct an information dissemination program. It is also stipulated in the regulations that the MOE has to announce a proposal to make sure that the public are well informed. For example, an announcement of a project proposal has to be posted in the local community where the project is to take place in public places such as post offices. The Indonesian EIA regulation states that *"a proposal can be announced through mass media and/or posted on announcement boards of the responsible agency so that people can contribute their opinions and ideas" (Enclosure of Government Regulation no. 29, 1986, clause 31(1)* (Govt. of Indonesia, undated). Compared with the EARP and the

Newfoundland requirements this regulation has deficiencies. It does not state in sufficient detail how a proponent and the government have to announce a proposal. With this wording there is no assurance that the public is well informed. When a proposal is not announced effectively, the objective of collecting people's ideas and opinions will not be met.

In order to obtain public input and participation, people have to have adequate information about the project. This information has to be comprehensive, communicated in a timely manner, and understandable (Arimbi, 1991 and Hardjasoemantri, 1990). The case of the Saguling dam demonstrates the type of unexpected impact that may happen due to lack of public information (section 5.3.1).

A poor level of education is characteristics of remote areas in Indonesia. When a lot of information regarding one project has to be announced, an order of priority has to be made. The proponent has to schedule the announcements in accordance with their importance. People should have sufficient time to think about the issues and then raise their concerns. It is important to provide a liaison officer in the project area during the EIA process who can provide information as well as receive people's concerns, and opinions. It is also important that the liaison officer has an office in a place where people are not reluctant to enter. A community centre, or other place where people usually gather is appropriate, rather than a luxurious office. In this way information can be disseminated while opinion and suggestions can be collected.

7.1.2 Review by an Independent Party

The Saguling dam and Kedungombo dam (section 5.2) were constructed before the guidelines for the EIA process was issued in 1987. Nevertheless, under the regulations, the proponents of these developments have to provide an environmental evaluation study (SEL), an environmental management plan (RKL), and an environmental monitoring plan (RPL). The EIA Commission should have reviewed and judged the adequacy of these documents. Since the protests in Kedungombo continued until 1991, it is uncertain whether the SEL, the RKL, and the RPL have been prepared; whether the EIA Commission has evaluated and reviewed these documents; and whether these documents are adequate to overcome the problems.

As an independent institution outside the initiating department, the Board of Environment Control (BAPEDAL) can urge the agency that is responsible for the development to provide the SEL, the RKL, and the RPL if these document are not available. The EIA Commission should review these documents, then mitigation measures can be applied. The approval of these EIA documents lies with the MID after the recommendation of the EIA Commission. As long as the agency and the EIA Commission are in the same initiating department, control over the conduct of the review process may be inadequate.

The BAPEDAL can urge the proponent to undertake mitigation measures. However, the obligation of the proponent is only to conduct the mitigation measures in accordance with the RKL. In order to have ANDAL, RKL, and RPL which are acceptable to all parties, there should be an independent party for the review of these documents. In this way the objectivity of the reviewer may lead to an EIA review process which is acceptable to all parties.

For the Indonesian national EIA Commission, the regulations provide for the presence of permanent members, experts on the impacts of the proposal from non-governmental agencies. In provincial commission, such expertise is provided by representatives of institute of the environment from the local university. In both cases, representatives of other departments in the government are permanent members. NGOs and adversely affected people may be represented when intensive public concerns arise. However, the EIA Commission is under the same initiating department as that containing the proponent agency. The MID can determine who shall be represented and who are the representatives. The final approval lies in the MID which may have a strong tendency towards a bias in favour of the proponent.

The objectivity of the national EIA Commission can be improved by releasing the MID from the executive authority for the approval of the EIA documents. This authority can be shifted to the Minister of Population and Environment (MPE). The composition of the EIA Commission can be kept as previously, with the chairman and the secretary personnel of the Ministry of Population and the Environment. The objectivity of the review process can be established if neither the proponent or the adversely affected people are represented in the EIA Commission, or both are represented. Due to financial and time constraints, and lack of expertise to analyze the possible impacts, the impact study carried out by the adversely affected people, if any, is usually inferior compared with that of the proponent. In such cases the proponent's position will dominate. Therefore, it is better to have both parties excluded from the EIA Commission.

In the provincial EIA process, all proposals have to be registered with the Governor. The EIA Commission members are from various divisions in the government. In order to maintain objectivity, with the same reasons described for the national EIA process, the proponent and the adversely affected people have to be excluded from the EIA Commission.

Even if the EIA Commission is made independent, adequate ANDAL, RKL, and RPL can only be made when sufficient public input is available for the review. In order to be independent, an EIA Commission member probably knows very little about the adversely affected people and the area of the development. Therefore, public environmental awareness has to be enhanced, and active participation of the public has to be encouraged to include all possible relevant information for the EIA review process.

7.1.3 Application of Public Hearings in the Environmental Impact Assessment Review Process in Indonesia

In the Canadian federal EARP process, public review and hearings are provided for in the process. In Newfoundland and Labrador the *Environmental Assessment Act of 1980 (section 17.1)* states that *"During the course of the environmental assessment, the proponent shall provide an opportunity for interested members of the public to meet with him, ...".* According to this Act, the MOE may provide guidelines on the procedure for public contact and involvement with the proponent. Under the *Environmental Assessment Regulation 225/84*, a proponent has to propose an information dissemination program that has to be approved by the MOE. This government regulation also states that public hearings are required only when serious concerns about a proposal are raised.

In the Indonesian process, the public input, as regulated by the EIA legislation, is provided for by the inclusion of representatives of adversely affected people in the EIA Commission. There is no obligation of a proponent to conduct a public meeting or hearing regarding a proposal. However, in order to successfully implement a water resource development a meeting with the public is a common procedure, especially in densely populated areas. If the people are ignored, the project implementation may be in jeopardy; sabotage or vandalism may occur. Therefore, although it is not stipulated in the regulation, public meetings are usually organized.

The agenda of a public meeting usually covers, public information, negotiations on land compensation, schedule for irrigation and any water resource development and utilization problems. To accomodate EIA requirements the meeting agenda can be extended to collect information, concerns, ideas and solutions for environmental problems. At a village level, where people usually schedule regular meetings, to include public meetings for discussing environmental concerns should not be a problem.

Such a public meeting is effective for conveying information and collecting ideas and opinions. However, the outcome of such a public meeting usually does not include possible adverse impacts that might happen due to a development. It does not provide for intensive discussion on solutions to social problems that may relate to the development. The discussions are only centred around technical solutions of water resource and agricultural problems. In addition, cultural characteristics and a low level of education may hamper the expression of concerns. These limitations are the source of difficulties in recognizing and analyzing environmental problems.

A prohibition in Javanese culture against opposing respected people (Santosa, 1990) also creates an obstacle. When there is a person of authority in the gathering, people usually do not feel free to criticize. In such cases public meetings and hearings may be used to fulfil a legal procedure which may not reflect the real concern of people. To a poorly educated society, this kind of public meeting can be considered a coercive effort to force people to accept a decision. The Kedungombo case (section 5.3.2) is an example.

People had already signed the agreement on land compensation, but they protested subsequently (Anon., 1991d).

7.2 Limited Concern with Environmental Impacts in Evaluating the Success of a Development

In Indonesia, where development is intensively carried out to fulfil the primary needs of people, the success of a development is often viewed as the completion of a project on schedule, and how it alleviates existing socio-economic problems in general, such as how it provides employment opportunities. The extent to which the development creates environmental (including socio-economic) problems is usually ignored. New problems may be considered something that further development should solve; or may be ignored because they affect only a relatively limited number of people. The EIA guidelines state that the number of people adversely affected has to be less than 10% of the beneficiaries of the project in order for an impact to be considered as unimportant (Govt. of Indonesia, 1987).

The case in Kedungombo (section 5.2.2) has shown that limited numbers of people can raise a problem into an international issue. The case in Tapak River (section 5.2.4) shows that a limited number of adversely affected people can gain the attention of a higher authority (MPE and BAPEDAL) when a local authority (in this case the Mayor of the city and the Governor of the province) ignored the case. Such cases may jeopardize the political position of the authorities, such as losing the next election. It is expected that the perception that a limited number of adversely affected people is not important will gradually change. Everyone should accept that the importance of an impact is based on the intensity and the nature of the impact. The Indonesian environmental regulation has provided a specific clause for this (Govt. of Indonesia, 1987), but the practice is such that the quantity of adversely affected people (or other environmental units, such as how many hectares of forest, number of houses, and the like) still governs. Nevertheless, a new perception should emerge that a development cannot be considered successful if a serious environmental impact results from it.

7.3 Enhancement of Public Environmental Awareness

In remote areas, Javanese cultural values usually have not changed much, new values have not had much effect on the society, and level of education is poor in general. The passivity, acquiescence, and uneasy feeling when opposing respected people are prevalent in these areas. These factors create substantial difficulties in investigating people's concerns and opinions about a project. People usually accept their fate when the government, as a "respected" party, requests them to make a sacrifice for a development.

Being aware of environmental problems that may result, it is the task of a proponent to enhance people's awareness of consequences of a development. People have to be made aware about all possible impacts that will result from the development. People can be involved and participate in the design of mitigation measures. In this way the design can reflect people's preferences.

The tendency towards protest only started in the late 1980s (Anon., 1991e, Anon., 1991i., Anon., 1991g). The protests show that there has been an enhancement of public environmental awareness. They also indicate that environmental problems have already reached a level that cannot be ignored. In Java, it has been very difficult to look for other spaces to live if one has to move due to the inundation of a reservoir or any other cause.

Action/participation research is an excellent approach for understanding and solving people's problems concerning development in Indonesia. Environmental awareness can be enhanced as well through this research. This type of research needs intensive involvement of researchers in public activity and participation of people in the research activity. Cooperation with NGOs would bring a substantial benefit in terms of results as well as time and cost. Generally, this research takes a relatively long time to come to a conclusion. This makes this research relatively expensive compared with other public participation methods such as public hearings and brainstorming.

NGOs have been very active as grass roots organizations that intensively involve people. NGOs, as exhibited in some environmental cases in Indonesia, have shown their contribution in developing public environmental awareness. In many cases NGOs have successfully represented grass roots concerns that were previously ignored by high level government. NGOs also have a role in ensuring that developments are more environmentally sensitive. As their existence is recognized in the environmental legislation, it shows that their efforts have reoriented the decision making process towards more intensive public participation.

However, there is still a serious problem concerning the operational costs. Some NGOs receive their financial sources from domestic companies. In the 1970s LBH (see section 5.1.3) obtained financial assistance from the Governor of Jakarta, but now this fund is no longer available (Anon., 1991f). Most of the NGOs are still dependent on foreign financial assistance. It is a disadvantage that programs of NGOs have to be approved by foreign funding agencies; it reduces their freedom to determine their own programs.

The financial problems can be solved if the proponent shoulders the financial expense. Activities in an EIA process can be carried out by NGOs and people in cooperation with the proponent. The disadvantage of this solution is that the proponent, as the one providing the funds, may be able to influence the result to their own concerns. However, with an environmental awareness by all parties, each party can contribute results that maintain objectivity.

7.4 The Use of Remotely Sensed Data for Environmental Impact Assessment of Water Resources Developments

This section provides a concrete example on how remotely sensed data can be utilized for environmental assessment and monitoring. The terrain data as observed on the remotely sensed imagery studied in this thesis can be used to supplement the EIS issued by LCDC (1980). These data are particularly valuable in providing information on terrain features that will be inundated. Some physical impacts of the inundation are presented. These impacts are assessed based on the understanding of characteristics of the terrain as observed on the LANDSAT data and aerial photographs.

The biological environment can be observed from the NOAA and the LANDSAT data. Aerial photographs of appropriate scale (for example 1:12,500) show the details of physiography and of vegetation cover that may indicate specific habitats of important plant and animal species.

The LANDSAT TM and the aerial photographs show cultural features adequately. Location of archaeological sites and of other important features may be detected and studied in order that mitigation measures can be designed if these features are to be preserved. For further description of the environment and mitigation measures, expertise in the appropriate field should be required.

As an example, the terrain data as observed on the remotely sensed data studied in this thesis are used to assess the physical impacts based on the expertise of a civil engineer. Morphological changes in the Lower Churchill River are assessed and presented in sections 7.4.1 and 7.4.2.

Intensive applications of remotely sensed data are suggested as a part of enhancements of the EIA process of water resources developments in Indonesia. A process of extensive use of remotely sensed imagery in Indonesia for EIA is suggested. Water resources development in the South Kedu area was chosen as an illustration.

7.4.1 Impact of Reservoir Inundation on the River Banks

Both banks of the Churchill River in the reservoir site are generally very steep, therefore the future reservoir shoreline on the small scale imagery will appear very similar to the current river banks. Based on the surficial geology interpretation (Figure 6-6) the reservoir shore line represents alluvial and marine deposits. The interpretation of 1:40,000 scale false colour infrared imagery covering the river from Gull Island to Muskrat Falls indicates that most of the shore lines are on marine deposits.

The inundation of the reservoir on the marine clay will saturate the clay, it will increase its pore pressure and remould the material that eventually will reduce its shear strength

(Richards, 1982). Loads exerted on this material, such as reservoir water above it or material deposited from tributaries, will act as disturbance that may result in sliding of the marine clay. Retrogressive earth flow slide may occur and the reservoir will get wider.

The alluvial/sand material is stable. Inundation of this well drained material will not result in serious changes in shear strength. However, erosion may occur due to wave action or moving water which will initiate the movement of sand particles. Serious problems may occur since these materials lay on the clay marine deposits. When the shear strength of clay is reduced the alluvial material may collapse.

More extensive and comprehensive assessment of the impacts of reservoir inundation is provided by Beak Consultants (1978) and the EIS (LCDC, 1980). The remotely sensed data will provide the location and the extent of the impacts as described by these references.

7.4.2 River Bed Degradation Downstream of Muskrat Falls

There are two factors that determine the equilibrium of a river: the forces exerted by flowing water and the resistance of its river beds and banks to erosion (Richards, 1982). Alluvial channels like the Churchill River carry a sediment load and erode their bed and banks locally in space and time. The cross section in a particular site may change in time depending on the fluctuation of the water and sediment discharges, but it can return to its previous condition and create a cycle that can be considered stable.

Water forces will not change significantly after hydropower development in Muskrat Falls in the future, as the hydropower generation is designed as a run-of-the river type. During high flow a number of sediments will be picked up and deposited farther downstream. Normally, resupply of sediment will be provided during low flows with low velocities. When most of the sediments are trapped upstream of Muskrat Falls after the dam is completed, resupply of sediment will only depend on the amount carried by tributaries downstream of the reservoir. This resupply will not be sufficient to replace the eroded sediment, thus degradation of the river bed will occur (Galay, 1983).

The river banks consist of sensitive marine sediment (Beak Consultants, 1978). Slumping of the river banks occur as observed on Figure 6-7. In the future after the degradation of the river bed, further slumping will occur. The river will get wider and the velocity of water reduced. This reduces the capacity of the river to transport the sediments. The river may return to an equilibrium state with wider cross section and flatter longitudinal slope. An adverse slope may occur as the final result of such river bed degradation (Galay et al., 1985).

The degradation of the river bed may cease when fine sediments have been taken out and the force existing in the flowing water is not sufficient to carry the remaining coarse sediment or when the river bed meets a massive bedrock (Richards, 1982). This case may happen to the Lower Churchill River considering that the right bank consists of hard rock rather than alluvium.

Erosion of sand bars may occur, therefore the number of the bars and their size will change over time. Sand bars deposited by flowing water will be more resistant than river banks that contain finer material and that are not covered by alluvium. If the bank is covered by alluvium and the erosion by the clear water from the reservoir uncovers this alluvial materials that exposes the marine clay, erosion may become more serious. This will happen especially to the left bank up to line 175 (Figure 6-9, thermal infrared imagery) where erosion and earth flow slides have already occurred. The right bank, from Muskrat Falls to line 175 (Figure 6-9), will be stable as the material is more resistant than the left bank.

Downstream from line 175 both banks have similar chances of being eroded. The EIS (LCDC, 1980) stated that one location of the eroded right bank has a spring in its toe. This indicates that a clay layer of fine grain material is exposed. Erosion to this type of material will occur first. These most vulnerable river banks can be identified using large scale aerial photographs and/or by a ground survey.

On the LANDSAT TM (Figure 6-5), it can be observed that most of the sand bars are developed in the middle of the river. Only a few of them can be found at the river bank. The sand bars developed at the river banks may protect the banks from erosion. The direction of flow between the sand bars will determine which part of the river bank will be subjected to the relatively high force of flowing water. This includes the relatively highly populated river bank at Happy Valley and most of the natural river banks. Based on this analysis, the river banks that are vulnerable to erosion and the enlargement of the river were indicated on Figure 6-9.

7.4.3 Procedures for Using Remotely Sensed Data for Environmental Impact Assessment of Water Resources Developments in the South Kedu Area

This section provides a procedure for using remotely sensed data available in Indonesia for the EIA of a reservoir impoundment project. The recommended procedure is based on visual interpretation. The use of computer assisted interpretation is considered, but at the present it is limited to displaying and enhancing the image for easier visual interpretation.

The area concerned for an EIA study of water resources development for irrigation is the catchment area, the area along the river downstream of the dam to the estuary, and the irrigated (service) area of the South Kedu. In the following discussion the environment of this area is described. Some specific examples relating to the Wadaslintang dam project are provided. This dam is the only one in this area in which environmental impact studies were prepared shortly before the construction. Some other environmental studies were carried out during the construction.

7.4.3.1 History

A brief environmental assessment for Wadaslintang Dam in South Kedu area was included in the Feasibility Study of the development (ECI, 1978a). Since there were no regulations and guidelines available for preparing an EIS in Indonesia during the period of the feasibility study, the format followed the guidelines established by government agencies of the United States of America based on the National Environmental Policy Act of 1969. The overall result was presented in a Summary of Project Impacts on Physical and Cultural Environment in a checklist format.

The Environmental Evaluation Study (SEL) of the Wadaslintang Dam was made in 1987 to comply with the EIA regulation (Universitas Diponegoro, 1988). The scope of this study is larger than the previous one included in the feasibility study. The duration of this study was 8 months. This SEL was followed by another study to establish the RKL and the RPL (the environmental management and monitoring plans) that took another one year to finish. The SEL, the RKL, and the RPL were presented in matrices and a network diagram which are similar to the ones shown by Canter (1985). The socio-economic analysis took up most of the study, although the duration of the study only allowed a sample of 10 out of 66 villages that were potentially to be affected by the development.

The RKL and RPL indicated who was responsible for monitoring, how to mitigate the impacts, and who was responsible for the mitigation measures. However, specific description indicating level of impacts, and locations in the order of vulnerability to the impacts was minimal. For example, there was no indication of which part of the river banks were susceptible to erosion.

7.4.3.2 Recommended Use of Remotely Sensed Data for the South Kedu area

Although large scale (1:5,000 and 1:10,000) aerial photographs acquired in 1975 are available for the South Kedu area, they were not utilized for the environmental studies. This imagery was used for overall development planning and for the detailed designs of some hydraulic structures including dams and canals. Topographic maps at scales of 1:5,000 and 1:1,000 were made using these aerial photographs to update the available 1:25,000 scale topographic maps of the area dated in the late 1800's (ECI, 1978a).

Other remotely sensed data, such as satellite data should have been available for the South Kedu area. The satellite ground receiving station in Cibinong, Indonesia is capable of receiving and processing the LANDSAT MSS and TM data. These data can be obtained from the PUSDATA office of Ministry of Public Works. However, due to a lack of expertise these data were not used in making the SEL, the RPL, and the RKL. In the Environmental Assessment which was made in 1978, there was no reference made to the use of remotely sensed data. The satellite data should be collected and studied to improve the existing SEL, to establish baseline data, and to conduct further monitoring works.

The construction period of Wadaslintang dam was between 1983 and 1987. The impoundment was started in 1987. It is possible to assess the environment of the area in three periods: before 1983, between 1983 and 1987, and after 1987. LANDSAT TM and MSS data concerning the Wadaslintang area can be grouped according to these periods. Since cloud cover may be a problem, three sets of information about the terrain can be collected based on a mosaic of the satellite images. Based on the multi-temporal approach, the effect of the development can be investigated and monitored.

For an environmental study concerning water resources development in the South Kedu area, LANDSAT TM imagery is appropriate since it can be used to identify and evaluate relatively small features. The Bedegolan river is only about 50 m to 80 m wide. The largest irrigation canal in this area is 20 m wide. With adequate contrast against the background, these features can be observed on this imagery. The LANDSAT MSS imagery can provide data on large features such as land use and land cover units.

Multi-stage remote sensing can be applied using satellite data acquired before 1983 with the available aerial photographs. Unknown features on the data acquired after 1987 can be identified and described through ground surveys. If necessary aerial photographs can be acquired as well.

Other remotely sensed data can be purchased when necessary. In order to have the maximum result the characteristics of each set of data have to be understood by the users. For example, the 1.1 km resolution of NOAA imagery will be too coarse to provide terrain data for the South Kedu area. SPOT data, with 20 m and 10 m resolution will be useful, although cloud cover is still a problem. IRS imagery provide excellent data that compares with LANDSAT TM and MSS data. However, it does not cover the South Kedu area. For terrain data in Indonesia, this satellite only covers about a half of Sumatra. JERS-1, the Japanese satellite, was launched on February 12, 1992. This satellite carries a SAR (Synthetic Aperture RADAR). The data will be available in late 1992 (Anon., 1992). Although the interpretation of RADAR is rather more complicated than other remotely sensed imagery, SAR will provide terrain data of the South Kedu area through clouds.

For the EIA of water resources development in the South Kedu area the use of LANDSAT MSS and TM data, and aerial photography is recommended due to their availability at present. Appendix B describes the spectral characteristics and the recommended use of each band of the LANDSAT TM data as a reference.

7.4.3.3 Existing Environment

The description of the existing environment in this section is based mainly on the author's knowledge about the area supported by the data provided in the previous environmental studies conducted by ECI (1978a and 1978b) and by Universitas Diponegoro (1988). Only 1:25,000 scale topographic maps of the depression area and sand dune area downstream of the Bedegolan River and another 1:130,000 scale map of the South Kedu area were available for this thesis work. These maps give information on land formation and on water resources of the area.

Climate

Located on an archipelago along the equator, the South Kedu area has a tropical climate which is characterized by a rainy season from about October to May and a dry season from June to September. Mean monthly temperature and relative humidity are nearly constant. Wind velocity and direction change according to the season. The climate of the area is influenced by both regional and local geographic features (ECI, 1978b). The regional features include primarily the latitude, the migration of low gradient pressure systems that cause the monsoons, and the change of wind direction. Local geographic features are basically topography and proximity to the sea.

The percentage of open sea in Indonesia is greater than the land mass, therefore, a hot, humid tropical climate is prevalent. The regional climate changes due to the annual migration of a low pressure trough between app. 15^0 south and 15^0 north latitudes. Dry months from June to September in Central Java results from low-to-moderate velocity winds which blow steadily from southeast to northwest (ECI, 1978b). These winds bring warm and dry air from the land mass of Australia. The reverse pressure gradient brings warm and moist air from South China Sea across Central Java. This causes heavy rain in the months of November through March.

The local geographic features, the topography and proximity to the sea, affect the climate in the South Kedu region by doubling mean annual rainfall between the low coastal plain and the upland region (ECI, 1978b). The differential heating and cooling between the land and the sea affect the strength and direction of the prevailing wind by causing a diurnal shifting between a sea and a land breeze.

Monthly temperature in the South Kedu area ranges from 25^{0}C to 27^{0}C (ECI, 1978b). Diurnal variation is about 7^{0}C. Mean monthly average humidity ranges from 85% to 90%. As it stated in Section 3, relatively high rainfall intensity is recorded in the area: 2000 mm to 3000 mm in the coastal plain, and 3000 to 4500 mm in the upland (ECI, 1978b). Some stations show that 5000 - 6000 mm of rainfall is not surprising in the upland.

Duration of sunshine hours is normally reported as the percent of time with sunshine between 8.00 am to 4.00 pm. At Sempor, the mean annual sunshine duration is 53%

(ECI, 1978b). However, there is no significant correlation between sunshine duration and rainfall (ECI, 1978b). In the wet season, high cloud cover in the morning will be followed by an afternoon downpour. In the dry season, heavy cloud cover in the morning is usually blown by strong southeast wind and replaced by higher altitude clouds.

Physiography

It has been mentioned in Section 3.4.2 that there are three physiographic units in the South Kedu basin: the upland, the coastal plain, and the sand dunes. The upland is located at the north part and relatively small portions in the east and west parts of the basin. The coastal plain can be considered as a depression area surrounded by these uplands and the sand dune area in the south. A classification system for the physiography of the area was developed based on the limited available information (Table 7-1). The numbering system in the classification can be used to annotate maps and imagery.

The available topographic maps with scales of 1:1,000; 1:5,000 and 1:25,000 are useful for delineating the first level of classification, which is the three physiographic units in South Kedu area. A better presentation can be made on a standard size (A1) 1:125,000 scale topographic map with 10 m spaced contour lines. The contour lines can be used to delineate the boundary between the upland and the coastal plain. However, closer spaced contour lines, every 2 m, are needed to determine the boundary between the coastal plain and the sand dune areas. Using the same topographic map the watershed boundary of the whole South Kedu area and of the reservoirs planned in the area can be mapped. These boundary lines can then be transferred to a LANDSAT MSS image of 1:1,000,000 scale.

Table 7-1 Physiographic Classification system for the South Kedu area

1	Upland		
	11	alluvial plain	
		111	parallel drainage pattern
	12	mild slope	
		121	parallel drainage pattern
		122	dendritic drainage pattern
	13	steep slope	
		131	dendritic drainage pattern
2	Coastal plain		
	21	high area	
		211	parallel drainage pattern
	22	depression areas	
		221	year round flooded areas
		222	yearly flooded areas
3	Sand dune area		
	31	sand flats	
	32	undulating areas	

Any single band of LANDSAT MSS data shows different reflectance characteristics between sand, agricultural (low) vegetation, and high trees. These characteristics also clearly distinguish the sand dunes, the coastal plain, and the upland. However band 3 and band 4 (near infrared) are more useful than band 1 (green) or band 2 (red) for showing the physiography of an area. Clearly observable drainage patterns in the near infrared bands enhance the topographic characteristics of the area imaged so that peaks, valleys, and troughs can be easily interpreted.

The upland (see Figure 3-7) at the north part of the basin has its highest elevation ranging from 700 m to 900 m above mean sea level. In the east and west the highest level in the catchment area is around 350 m. A hilly topography is prevalent in the upland with lots of peaks. Around the Wadaslintang reservoir some peaks up to 300 m high can be found. With the reservoir at full level (185 m), these peaks form relatively steep slopes.

The South Kedu coastal plain is bounded by the Cingcingguling River in the west and the Bogowonto River in the east. Only a very small portion of this plain is located in the east part of Bogowonto River. These two rivers, the upland in the north and the sand dune area in the south, create an approximately rectangular shape of the coastal plain, which is about 100 km long and 15 km wide. This coastal plain is gently sloping southward starting from about 40 m to app. 3 m above mean sea level. The soils here are fine grained and clayey in texture (ECI, 1978a).

The sand dune area occurs along the coastal plain from the west to the east ends of the South Kedu area. It makes a long strip of about 4 km wide and 100 km long.

The slope as a further component of the upland in the classification system at second level can be clearly observed when the imagery is viewed in stereo. Thus, for this purpose aerial photographs or stereo SPOT images should be used. However, a topographic map produced from the aerial photographs could be used instead. The delineation of the boundary between the alluvial plain (2% to 15%), mild slope (15% to 40%) and steep slope (> 40%) can be made based on the density of the contour lines.

The alluvial plains lie along the main rivers and in the downstream parts of tributaries. In the Wadaslintang watershed, the mild slope areas have a lithology of a mixture between marl and volcanic breccia (Universitas Diponegoro, 1988). The steep slope areas mainly consists of volcanic breccia. Land mass movement is a common phenomenon, especially after a downpour in the wet season in the areas with slopes steeper than 40%. The width of the land slides is usually less than 10 m.

In the coastal plain the relatively high area can be differentiated from the depression area using LANDSAT MSS band 3 or 4 (near infrared). The depression area in South Kedu region is the low area in the coastal plain where floods of more than three days duration frequently occur in the wet season. The maximum flood areas may be observed on the LANDSAT image when it is obtained during the flood period. When the area is imaged right after the peak flood, the vegetation stressed by the excess water can be distinguished from the undisturbed plants using infrared LANDSAT MSS data (McMahon and Collins, 1985). Based on this characteristic the boundary of the depression areas can be delineated. Two main depression areas exist, one in the downstream part of the Cingcingguling River and the other in the downstream part of the Bedegolan River.

In the sand dune areas, two topographic units can be differentiated using a topographic map having 2 m contour lines: the sand flat areas with elevation about 3 - 5 m located in the north part, and the undulating areas with average elevation about 10 m is at the south part adjacent to the ocean. Some peaks in the undulating part exceed 20 m. Most of the peaks are 10 m to 20 m high.

The third level of the physiographic classification system is concerned with the drainage pattern in the area. Due to the small sizes of the rivers, imagery with finer resolution has to be used. LANDSAT TM band 4 (near infrared) would be the best for water body delineation. Rivers may be observed as long continuous dark lines, or they can be identified from the presence of riparian vegetation.

A dendritic drainage pattern is prevalent in the upland area. Only in the very upstream of the Bogowonto River parallel drainage patterns are found. Cingcingguling and Bogowonto Rivers exhibit a sub-dendritic pattern. One side of their banks are in the coastal plain while the other is in the upland area. Infrared aerial photographs could provide better details of the natural drainage, especially when they cannot be observed on the LANDSAT TM imagery.

In the coastal plain the drainage patterns are mostly parallel. The main rivers flow between irrigated lands, approximately parallel from north to south. Almost all water in the South Kedu basin drains to these main rivers. The sand dunes create barriers so that only the five major rivers bring the water to the ocean (see Figure 3-7). Some natural drainage channels run along the edge of the sand dune area parallel with the coast line.

Depression areas can be observed on a LANDSAT MSS band 3 or 4 (near infrared), but on a LANDSAT TM band 4 image these features will be better observed. Imagery acquired in the wet season delineate the whole depression areas, and the ones acquired in the dry season will show the year round flooded areas. The yearly flooded areas can be determined by subtracting these two areas. During the early part of the wet season, estuaries in the South Kedu area are impeded by sand dunes which form across the river mouths during the dry season. This makes the floods in the depression area more severe. Usually a pilot channel is constructed through these sand plugs to assist the river to break through to the sea.

The mapping of the physiographic classification system (Table 7-1) on the remotely sensed (LANDSAT MSS and TM) data can further be interpreted in terms of bedrock geology and surficial geology. These two items are important in the EIA of water resources development.

LANDSAT TM data will provide adequate information on location of surficial mass movements in the upland and on small rock outcrops. Red band would be best for this purpose (Energy, Mines and Resources Canada, 1987). However, if more detailed information is required, aerial photographs have to be used.

Mapping of the surficial deposits can be carried out on the LANDSAT TM image. Bedrock and structural geology can be mapped separately on the same type of imagery. Existing geology maps of the area can be used for the first level mapping. The help of an experienced geologist should be requested to assist with further level interpretation.

Land cover and land use

It is useful to apply the land cover and land use classification and mapping separately to the three distinct physiographic units because of different characteristics of major features. The upland is mostly occupied by forest, the coastal plain is occupied by low seasonal vegetation (agriculture), and the sand dunes are mostly bare sand with specific sand vegetation. However, distinct land cover and land use can be classified in several levels as shown in Table 7-2. The numbering system in the classification is used to annotate maps and imagery.

Table 7-2 Land use and land cover classification of South Kedu area

1	Forest		
	11	natural (mixed) forest	
	12	artificial forest (planted)	
		121	deciduous (teak) forest
		122	coniferous (pine) forest
		123	private plantation (clove)
	13	garden/house yard vegetation	
2	Agriculture		
	21	dry crops	
		211	soya
		212	corn, cassava, and others
	22	rice	
		221	rainfed
		222	technically irrigated
3	Barren		
	31	rock barren	
	32	soil barren	
	33	sand barren	
4	Water bodies		
	41	reservoirs	
		411	large reservoirs/lakes
		412	fish ponds
	42	rivers	
		421	main rivers
		422	small tributaries
5	Wetland		
	51	permanently flooded	
	52	cultivated wetland	
6	Cultural features		
	61	population centres	
		611	towns
		612	villages
	62	transportation	
		621	highway
		622	small roads
		623	railway
	63	hydraulic structures	
		631	dams
		632	weirs, barrages
		633	irrigation canals

The first level of the classification system can be interpreted and mapped on LANDSAT MSS imagery of 1:1,000,000. Bands 3 and 4 (near infrared) will clearly show forests, agricultural areas, barren land, water bodies, and wetland. The cultural features can be identified more easily on band 2 (red). Features at the second level generally can be detected and distinguished using LANDSAT TM. In the third level, aerial photographs will be needed, except for the delineation of forest and agricultural features for which LANDSAT TM can be used.

The terrain feature classified as forest comprises clusters of high trees. For the delineation of the second level features within the forest, LANDSAT TM band 4 (near infrared) should be used. Composite image consisting of visible and near infrared bands are commonly used for this purpose, for example an image of combination of band 2 (displayed in blue), band 3 (in green), and band 4 (in red) appears similar to a false colour infrared photograph.

The natural (mixed) forests in the South Kedu area are located in the high parts of the upland and they are far from the highways. The vegetation cover comprises several layers, from high trees, and bushes to mossy areas. On the image, these can be distinguished from artificial forests, because the latter usually consists of single species. The single species forests will show a homogeneous texture and hue, and sometimes specific patterns. Cluster of high trees also occur in house yards. Most of the houses in remote areas are covered by tree crowns, however, there are always some spaces where the ground and the roof tops are exposed. This can be observed on the LANDSAT TM imagery as a different hues creating different patterns from mixed forests and from the artificial forests.

The artificial forest in the South Kedu area comprises mainly teak (deciduous) and pine (coniferous) trees. Many private plantations in the upland contain clove which is also a deciduous tree. The deciduous forest reflects much more infrared energy than the coniferous trees. This will make the teak and the clove appear brighter pink than the pine. The reflectance of the teak will be different from the clove in the dry season, because the teak loses its leaves. On the LANDSAT TM data obtained during the dry season the teak can be distinguished from the clove and other species. In this case both multi-temporal and multi-spectral approaches are applied for the mapping of each plant type.

Agriculture areas are abundant in the coastal plain, but they are also found in the upland and in the sand dune areas. In the coastal plain rice is planted most of the time. Dry crops are planted only in places and in time where water is scarce. Usually in the last three months of the dry season, people plant soya or corn rather than rice. In the upland, most of rice fields are rainfed. Only small portions of agricultural areas are artificially irrigated. Cassava plant is abundant in the Wadaslintang watershed. In the sand flats of the sand dune areas soya is planted most of the time.

Rice can be differentiated from dry crops on LANDSAT TM band 4 (near infrared), or on a composite image containing band 4. The difference between irrigated and rainfed rice fields can be observed in the early dry season when rainfed rice is not planted. If it is planted, the moisture condition for it is not the same as for the irrigated rice. The difference in moisture content results in a different reflectance of the infrared energy (Nellis, 1984). This helps the mapping of these two features. The irrigated rice field can be detected due to the presence of hydraulic structures. However, irrigation structures in the upland are too small to be discernible from LANDSAT TM data. In such cases aerial photographs and/or ground surveys are required.

Barrens can be easily recognized using LANDSAT TM data. Rock outcrops in a vegetated terrain can be interpreted using band 5 of the LANDSAT TM (Energy, Mines and Resources Canada, 1988). Red band, however, has shown different reflectance between rock, soil, and sand barrens, therefore this band can be used to indicate the place and the extent of these features.

Water bodies can be observed clearly on the near infrared band imagery. Large reservoirs can be observed using LANDSAT MSS band 3 or 4. LANDSAT TM band 4 will provide a more detailed interpretation. However, the 30 m resolution of the LANDSAT TM is still too coarse to discern small water bodies such as fish ponds. Small tributaries sometimes can be interpreted through the presence of distinct reflectance of its riparian vegetation. Inventory of tributaries is important to have a complete information on water resources in the watershed. In order to include these small features, thermal or reflective infrared airborne imagery should be obtained.

Wetlands occupy the depression areas in the South Kedu area. The higher parts of the wetlands which are temporarily flooded in the wet season are classified as cultivated wetland. This area can be clearly distinguished from the surrounding agricultural fields from the pattern of the land boundaries. The shape is more irregular compared with the surrounding agricultural fields that are generally rectangular. Distinct reflectance characteristics of stressed vegetation after flooding on a near infrared imagery can also be used to delineate these areas. Parts of the wetlands that are permanently flooded are covered by moss carpet and distinctive pattern of vegetation that appear in different hue from the surrounding on an infrared imagery, therefore LANDSAT TM band 4 can be used for the mapping of these features.

The best band to show cultural features is the red band of LANDSAT TM data (Energy, Mines and Resources Canada, 1986). This type of imagery shows population centres, transportation infrastructures, and large hydraulic structures.

Towns can be detected by their size and their street networks which are clearly observable on LANDSAT TM band 3. However, villages or population centres in the rural areas can only be detected as clusters of trees among agricultural fields connected to each other by roads or highways.

Wide right-of-way of railways make them clearly discernible on an image of LANDSAT TM band 3. Highways and small roads can appear as long bright lines on this type of image. However, in South Kedu these features are often covered by tree crowns planted on each side. They sometimes could be recognized from the presence of continuous lines of trees. In the upland a winding road may have a similar appearance as a drainage channel. A straight pattern in an agricultural area can also be interpreted as a road or an irrigation canal. In such case, knowledge of the area, or a map and large scale aerial photographs may be required.

Dams and large weirs or barrages can be observable on a LANDSAT TM image, especially on the red band. However, the near infrared band is more useful since the interpretation of such hydraulic structures usually is associated with the reservoir or the created backwater. Small weir can be detected where one or two irrigation canals branch out from the river. Concrete lining of the canal can be easily detected using the red band of the LANDSAT TM data. The water in the canal will enhance the appearance of this feature on the near infrared band imagery. If the structure is too small and it will not be resolved on the small scale imagery, a large scale aerial photography will be required.

7.4.3.4 Impacts of Water Resources Developments

A dam to store water in South Kedu area for irrigation is always constructed simultaneously with a diversion weir in the downstream reach. If a weir has been in existence, usually an improvement is made to meet the design requirement to include the discharge regulated from the reservoir. In order to study the impact of similar developments in the area in the future, impacts of previous developments can be studied using satellite data and other remotely sensed imagery. Table 7-3 shows how the impacts of such developments, as can be experienced in the South Kedu area and other places in the world, may be classified. The emphasis is placed on impacts that can be monitored using remotely sensed data.

Physical Impacts

At the start of a dam construction, access roads, hauling roads, and camp sites are constructed. Changes in land use and land cover result from land clearing, excavation and other earth work. These activities are continued with the excavation of the foundation for the dam and for its ancillary structures. A large scale excavation follows to establish a quarry. Land clearing and all excavations that remove vegetation cover and change the topography will change the run-off regime, because different land cover units have different run-off coefficients (Tao and Kouwen, 1989). In the construction of the Wadaslintang dam this has resulted in slope instability causing frequent land slides. Control of drainage in the camp site and along the roads may prevent slope failure, but still a higher erosion rate may be anticipated. Increase in sediment content in the river is difficult to avoid, since the excavation is in the river body and in its vicinity. This material will be deposited in the downstream reach of the river and in the existing Table

7-3 Environmental impact classification for a dam construction

1 Physical impact
- 11 During construction
  - 111 Change in land use and land cover
    - 1111 in the camp and the construction site
    - 1112 in the surrounding area
  - 112 Increase of sediment discharge in the river
    - 1121 aggradation of the river bed
    - 1122 sediment deposition in the irrigation canals
- 12 Reservoir Impoundment
  - 121 Further change in land use and land cover
    - 1211 in the reservoir site
    - 1212 in the vicinity of the reservoir
- 13 Induced reservoir seismicity
- 14 Bank erosion and slumping
  - 131 in the reservoir shoreline
  - 132 along the river banks downstream of the dam

2 Biological Impact
- 21 During construction
  - 211 change of wildlife habitat
    - 2111 due to change of land cover
    - 2112 due to disturbances (such as noise)
- 22 Reservoir impoundment
  - 221 change of wildlife habitat
    - 2211 new water habitat
    - 2212 due to change of land cover in the reservoir vicinity

3 Socio-economic impact
- 31 During construction
  - 311 change in land use in the camp and construction site, and vicinity
  - 312 stress on agriculture due to change in water quality in the coastal plain
- 32 Reservoir impoundment
  - 321 stress on agriculture due to interruption of irrigation water
  - 322 change in land use in the reservoir vicinity
- 33 After construction
  - 331 change in land use
    - 3311 in the watershed
    - 3312 in the service area
  - 332 change in the agricultural activity

irrigation canals. These impacts were observed during the construction of the Wadaslintang dam.

LANDSAT TM data band 3 (red) is suitable to monitor the disturbance of the land clearing in the camp and construction sites. Slope failure and erosions are discernible on this image, as in this case a portion of the vegetation cover is removed and the exposed soil creates sufficient contrast with the remaining vegetation cover.

The surficial geology map similar to that described previously should provide data on sensitive regions where slope failures are most likely to occur. Further monitoring and protection measures should be concentrated in these areas. LANDSAT TM band 3 may be sufficient to provide information on large slope failures. More detailed information and the detection of relatively small slope failures will require the use of normal colour aerial photographs.

The intensity of sediment content in a water body can be observed using the visible region of the electromagnetic energy (Lillesand and Kieffer, 1987; Lillesand et al., 1987; Choubey and Subramanian, 1990; Lathrop, 1992). However, rivers with sediments in the South Kedu area are too small to appear on the LANDSAT TM imagery. Natural colour aerial photographs of 1:5,000 scale should be acquired in order to observe the turbidity and sand bars created in the river.

The LANDSAT TM will provide information on the impact of this high sediment content in the agricultural areas. The reduced capacity of the irrigation canals may also create stress to agricultural plants. Near infrared band can be used to monitor the areas with reduced supply of water. The vegetation (rice) may reflect less infrared energy in these areas compared with other places having sufficient irrigation supply, therefore, delineation and quantification of the stressed areas can be made on this imagery.

As the dam is completed, the reservoir impoundment is started. The impoundment changes the flowing water into still water. River banks are inundated to an extent that is determined by the slope of the bank, the longitudinal slope of the river bed, and the height of the dam. All these terrain features prior to the start of the impoundment can be observed on LANDSAT TM data as discussed previously. The extent and the rate of impoundment is best observed on near infrared band (Gupta and Banerji, 1985; White, 1977). Either LANDSAT MSS band 3 or 4, or LANDSAT TM band 4 can be used.

Some dams in the world have experienced an induced reservoir seismicity during the initial impoundment period (Thomas, 1976). Therefore, the reservoir should be filled up with a slow rate instead of a sudden impoundment to provide adjustment of the reservoir bed. The stress resulting from the water mass may be released through fault movements. A sudden load increases the possibility of an earthquake. The bedrock and structural geology map, specially prepared for the reservoir and dam site area, should provide data on location and extent of faults including their latest movement. Such data are compiled using satellite imagery (Drury, 1987). An experienced geologist should determine the sensitivity of the faults in producing the seismicity.

Shore line establishment may include slumping and other types of slope failures due to wave attack and change in soil moisture. The material, the slope, and vegetation cover will determine the resistance of the bank. The reservoir width and prevailing winds will determine the seriousness of wave attack (Thomas, 1976). The sensitive areas to erosion should be highlighted on the surficial geology map. Preventive measures can be designed based on this map if the shoreline is to be protected.

Most of sediment that used to be carried by the river will be trapped in the reservoir. The change in sediment discharge downstream of the reservoir will result in less deposition of sediment in the river bed. Erosion will take place and river bed will degrade (Galay, 1983). Slumping of river bank will occur before a new equilibrium state is reached. Regulated water released from the reservoir may reduce the magnitude and frequency of floods. Reduction of water level in the river will make slumping of the river banks more serious. Deposition of sediment may elevate the river bed farther downstream (Shalash, 1986).

Similar to the case of the shoreline establishment, detailed mapping of surficial geology should include sensitive areas along the river banks, to determine the location and method of protection measures. Aerial photographs, similar to the one for monitoring water turbidity along the rivers during construction, should be acquired to monitor the reverse phenomenon after the construction period.

Increase of population in the catchment area, due to relocation from reservoir area or from other sites attracted by the development will result in land use changes. The changes in land use or land cover may change the run-off coefficient (Tao and Kouwen, 1989). Further impact is the change of the hydrology and the sediment regime in the watershed. It is natural that the amount of water can be stored in the reservoir will be less over time because of the sediment deposition. However, with a higher rate of sediment deposition the life span of the reservoir will be shortened.

The actual use of remotely sensed data used for land use and land cover observation has been demonstrated previously. Further, run-off and erosion related phenomena such as the change in the hydrology and sediment transport regime in the watershed can be assessed by an expert in this field using the data provided by the interpretation of the remotely sensed imagery.

Biological Impacts

During construction, the change in land cover and land use will eliminate or alter biological habitat. Noise from machinery, blasting operations and other disturbances created by the construction workers will further eliminate the site for wildlife use. An example in the Sempor dam and Wadaslintang dam showed that monkeys that used to be in the trees around the project site are never seen after the completion of the dam. This impact should be temporary, however, the migration of more people into the project area makes this impact permanent.

After the reservoir impoundment, permanent cha: ·e of land use occurs in the reservoir area. Some habitats of wildlife will be eliminated. The dislocation of wild animals, may endanger their population status, besides also endangering local residents.

Changing of forested lands into agriculture will be more serious due to relocation impacts. This will reduce the wildlife habitat in the catchment area.

A map of wildlife habitat can be made based on the land cover/land use map combined with the physiographic map. The areas of concern for an EIA of a reservoir impoundment project are the construction area and camp sites and surroundings facilities, the reservoir site and the watershed. The specific wildlife species, especially endangered species, should be inventoried. Based on these data, mitigation measures to provide the least disturbance to those species can be designed.

Socio-economic impact

Socio-economic related impacts that can be interpreted from remotely sensed data are the change in land use, and the presence of new cultural features caused by relocation of people and by people attracted to the area due to the development. This may occur in the catchment area as well as in the service area.

With the increasing population, and with the limited availability of land in the catchment area, the capacity to provide people with food will be reduced. People attracted by the development may cause the reduction of the irrigated land in the service area. This impact is significant in the South Kedu area. Another problem is that people move into the developed area to open new rice fields. This may result in shortage of irrigation water supply (Wheeler, 1987).

New cultural features that can be observed on the remotely sensed imagery may comprise enlargement and addition of population centres and roads. Some previously isolated population centres in the catchment area in Wadaslintang have been connected by new roads left by the development. Negative and positive socio-economic impacts resulting from this isolation breaking can be studied further by an appropriate expert.

8. Summary, Conclusions, and Recommendations

Environmental Impact Assessment (EIA) is the process of identifying the likely consequences of implementing particular activities such as industrial development or the enactment of legislation. The consequences concern the physical, biological, and socio-economic conditions of the area being developed. An EIA process includes baseline studies, impact predictions, and mitigation measures. Besides scientists and experts, the involvement of the public is important as they are the ones that are usually adversely affected. In order to determine the valued ecosystem components that have to be examined in the baseline studies, the opinions, ideas, preferences, and problems raised by the public or that exist in the society have to be considered. Therefore, exchange of information between the proponent and the public regarding the development is crucially important.

8.1 Problems in Conducting Environmental Impact Assessment in Indonesia

During the conduct of EIAs of water resources developments in Indonesia, the following problems exist.

1. Recent water resources developments in Indonesia have resulted in confrontations between the proponent and the public. These problems appear to be the result of

shortcomings in the Indonesian EIA process that may exclude the conduct of effective exchange of information between the proponent and the public, and the conduct of active public review.

2. Another problem exists concerning the cultural characteristics of Javanese people who are passive and acquiescent, usually finding it difficult to express opposition to "respected" people. Special public participation methods such as active/participation research should be applied to encourage people to express their concerns, ideas, and problems concerning the development, and to conduct an effective exchange of information.

3. Remote sensing is an excellent tool to carry out studies pertaining to environmental impact assessment. A satellite ground receiving station, that is able to receive and process LANDSAT MSS and TM and other satellite data, exists in Indonesia. However, only a limited number of scientists presently use remotely sensed data for water resources developments. Land and population pressures that exist in Indonesia, especially in Java, urge the utilization of remotely sensed data for monitoring the environment and for EIA of water resources development. The use of remotely sensed data for assessing developments needs to be encouraged.

8.2 Fulfilment of Objectives

Current environmental concerns in Indonesia are described in this thesis. Future concerns are also discussed through suggestions of solutions to current problems in the Indonesian EIA process and practices.

Due to time constraints, and to the lack of remotely sensed data from Indonesia the evaluation of the current use of remotely sensed imagery is based on a literature review, on the experience gained by interpreting the Churchill River imagery, and on the civil engineering background of the author in water resources development. The thesis would have been strengthened considerably if Indonesian imagery have been available. Nevertheless, a procedure for using remotely sensed data in the conduct of EIAs of water resources development is included in section 7.4.2.

8.3 Review of the Environmental Impact Assessment Processes

Main points arising out of the review of the Indonesian Environmental Impact Assessment Process are presented as follows.

1. The confrontations between people and proponents following water resources developments have been due to an inadequate participation of the public in the

solution of their concerns prior to the developments. This is thought to be a result of shortcomings in the present Indonesian EIA regulations as outlined in the following.

- There is a lack of facility for independent review in the EIA process.
- Although the opportunity for the public to express ideas, opinions, and concerns about developments is acknowledged, the obligation of the proponent to conduct an information exchange program with the public is not adequately stated.
- Opportunities for the public to participate in the review process is provided through their representatives on the EIA Commission, however the membership of the adversely affected people and non-governmental organizations (NGOs) are under the full discretion of the Minister of the initiating department (MID) of the project or the governor of the province.
- Even though the adversely affected people and the NGOs are represented on the EIA Commission, they are a minority amongst other members who may have an interest in supporting the proponent.

These problems may lead to minimal attention given, or even ignorance of, the concerns of adversely affected people by the proponent, the government , and the EIA Commission.

2. The Indonesian EIA review process is a self assessment within the initiating

department. This review process is considered adequate in reviewing proposals of private companies. However, in the case of water resources development, in which all the proponents are government agencies in the initiating department, there is a great tendency for a bias towards the proponent to occur. In order to minimize the bias, the EIA review process should be carried out by an independent party.

3. In order to have an independent review for the EIA process at the national level in Indonesia, it is suggested that the Minister of Population and Environment (MPE) should have authority for the EIA process. At the provincial level the authority could remain with the Governor of the province. The composition of the EIA Commission may be similar to that at present with the exclusion of the proponent, the adversely affected people and NGOs.

4. Information dissemination to the public about a development has to be comprehensive, communicated in timely manner, and understandable. It is recommended that there be a requirement for an information exchange program in the Indonesian EIA regulations. The program should be designed to ensure that the public understand the proposal and encourages people to express their opinions and concerns. In Javanese society, it can be difficult to obtain information from the public concerning the development because of the cultural characteristics of the people.

5. In order to obtain people's concerns and to investigate their problems with regard to the proposal, action/participation research might be used. This research emphasizes the involvement and participation of people who will benefit by the research. The involvement of NGOs in this research is an advantage, since they usually know the conditions under which the people live, and the proper way to approach them. With close interaction between the proponent, the (adversely affected) people, and the NGOs, the exchange in information regarding the development can be well managed.

6. Current concerns regarding developments indicate that problems concerning adversely affected people should be alleviated. The decision-making process in Indonesia tends to sacrifice a small number of people for the welfare of a larger society as a justifiable consequence of a development. It is suggested that developments should include all efforts to minimize adverse impacts.

8.4 Use of Remotely Sensed Data for the Environmental Impact Assessment of Water Resources Developments

This thesis provides a learning experience in using remotely sensed data. The main points arising out of this effort, especially in the application of the remotely sensed data for the South Kedu area, can be summarized as follows.

1. Remotely sensed data enables its users to describe the environment of large areas with only limited ground reconnaissance. Remotely sensed data also provide information on inaccessible and remote areas where ground surveys are difficult to conduct. Another important advantage is that the remotely sensed data can be acquired periodically. This allows the terrain environment to be continuously monitored, so that any serious changes can be promptly recognized and any mitigation measures, if needed, could be implemented immediately after notification.

2. The literature review as listed in Table 6-3 provides information on the use and on interpretation methods of various remotely sensed data applicable for environmental monitoring concerning water resources development. Many of the types of imagery and methods were not utilized in this thesis. Nevertheless, the comprehensive list provides references and illustrations of the extent of the use of remotely sensed data in this field.

3. In order to have a successful interpretation of remotely sensed data, multiple view approaches are recommended:
   - multi-spectral remote sensing, in which data of a particular site are acquired simultaneously in several spectral bands,
   - multi-stage remote sensing, in which data of a particular site are acquired at different altitudes,

- multi-temporal remote sensing, in which data sets of a particular site are acquired at different times.

Multi-spectral remote sensing uses several types of sensors including photographic and video cameras, thermal scanner, multi-spectral scanner and RADAR. Multistage remote sensing is concerned with the platforms carrying the sensors such as satellite, aircraft, and helicopter. Multi-temporal remote sensing is essential in an EIA, since it may provide data on environmental changes of the terrain.

4. Multi-stage remote sensing in this thesis is applied starting with NOAA imagery at the smallest scale (1:9,000,000) and leading up to natural colour aerial photographs at the largest scale (1:12,500). The large coverage of NOAA imagery includes the whole Churchill River watershed which is more than 90,000 km^2. Land cover and geological features are discernible and can be mapped using this image. However, the spatial resolution, which is 1.1 km at nadir allows large features only to appear on the image. This limitation makes it difficult to describe terrestrial features in Indonesia, especially in the South Kedu area, Central Java, where all terrain features are relatively small. Therefore, the use of NOAA imagery for EIA of water resources development in the South Kedu area is not recommended.

5. Considering the existence of the satellite ground receiving station in Indonesia, LANDSAT MSS and LANDSAT TM data are recommended for use. For water resources development work, these data are available from the PUSDATA office of the Ministry of Public Works. LANDSAT MSS data also meet the requirement for displaying large rivers in the South Kedu area, which are 50 m to 80 m wide. With its 80 m spatial resolution LANDSAT MSS data provide adequate information about land cover and geology. Small rivers and other small features will be discernible on LANDSAT TM imagery which have 30 m spatial resolution. As shown by the similar images of the Lower Churchill River and the vicinity, roads of about 15 m wide are discernible due to their high contrast against the surroundings terrain features.

6. An airborne remote sensing is considered expensive to use in the South Kedu area. Usually, such a program is incorporated into a special development project, such as a dam construction, or when detailed investigation of a limited area is urgently needed. Aerial photographs, either infrared or natural colour and black and white photographs provide detailed data of terrain features. The detail that can be observed on and the coverage of these imagery depend on the scale and the flying height. Aerial photographs are often required to eliminate uncertainties of satellite data interpretation. In such cases, they can be taken occasionally and focused on the limited area of concern.

7. Computer assisted interpretation procedures usually involve considerable computer time. This problem may be overcome in the future with development of hardware and software, and the use of computers in remotely sensed data interpretation may not be avoided. For the scope of work in the South Kedu area at the moment, visual interpretation on hard copy imagery should be adequate. With the acquisition of special digital image analysis, hardware and software, the use of computer assisted image interpretation will have to be explored and appropriate procedures developed.

8. Part of this thesis includes a recommended procedure for the use of remotely sensed data for EIA of water resources development in the South Kedu area. This procedure is based on the knowledge of the author about the project area and of several environmental studies in the area. Since there is no imagery of the South Kedu area available when the procedure was prepared, a consideration of various remotely sensed imagery should be included as they become available.

9. Persistent cloud cover is a common characteristics of tropical areas. To combat this problem, JERS-1, a Japanese satellite equipped with a SAR (Synthetic Aperture RADAR) has been launched this year. The coverage of this satellite includes the South Kedu area. This satellite operates under all weather conditions providing imagery through clouds. An example of a SAR image is also provided in this thesis, however utilization of this type of data is not included in the

procedure for the South Kedu area. It is suggested that RADAR imagery should be used whenever they are available.

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APPENDIX A

Major Remote Sensing Systems

A.1 Optical-mechanical Multi-spectral Scanner

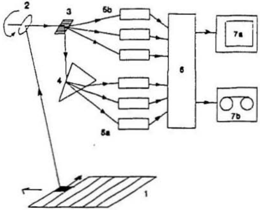

Figure A-1
Rotating Mirror Multi-spectral scanner (MSS) system schematic (Lillesand and Kieffer, 1987)

Legend:

1. Scanned ground
2. Rotating mirror, moves the field of view of the scanner along a scan line perpendicular to the direction of flight
3. Dichroic grating, to separate non-thermal (ultra violet, visible, and reflective infrared) from thermal wave lengths
4. Prism (diffraction grating)
5. Detectors
   a. for thermal wave lengths
   b. for non-thermal wave lengths
6. Electronics
7. Display (a) and recorder (b)

The multi-spectral scanner is used in airborne and satellite remote sensing. The LANDSAT series of satellites carries two such scanners, the first is called MSS (abbreviation of multi-spectral scanner) with a resolution of 80 m and the second is called TM (thematic mapper) having a resolution of 30 m. Images of this satellite are used in this thesis.

A.2 Linear Array Scanner

Legend:

1. Linear detector array.
2. Optics.
3. Projection of array on ground.
4. Direction of motion.

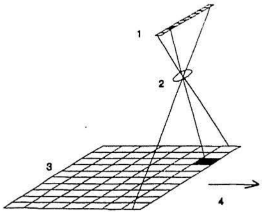

Figure A-2 Linear array camera scanner system (push broom) (Lillesand and Kieffer, 1987)

The push broom scanner is another type of multi that uses detector arrays of charge coupled devices (CCDs) for image data acquisition. A CCD is a micro-electronic silicon chip that detects the intensity of reflected electromagnetic energy (0.3-1.2 μm). This system is used by SPOT, IRS, and JERS satellites. The IRS satellite carries this kind of sensor which is called LISS (Linear Imaging Self Scanning Sensors).

A.3 Active Side Looking RADAR

Legend:

1. Transmitted microwave energy
2. Reflected (back scattered) energy
3. Pulse length

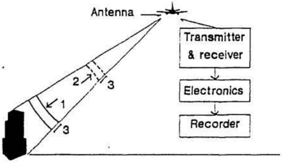

Figure A-3 Operation schematic of active RADAR

The active RADAR sensor is used in airborne and satellite remote sensing. In this system, microwave energy is transmitted from an antenna in very short pulses. After reaching the ground, the energy is returned (reflected) and received by the same antenna. Intensity of the reflected energy depends on the followings terrain characteristics (Lillesand and Kieffer, 1987).

- incidence angles (topography),

- surface roughness in term of used wave length (for example, smooth surface will reflect the energy away from the antenna),
- complex dielectric constant of an object being sensed (indicator of reflectivity and conductivity of various materials).

A.4 Types of Platforms

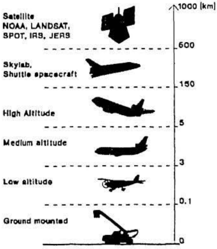

Figure A-4 Platforms and their locations

This figure illustrates the types of platforms used in Remote Sensing, which constitutes to multi-stage remote sensing. The area coverage of a single frame increases as the altitude increases, but the ground resolution of the system decreases.

APPENDIX B

LANDSAT TM (Thematic Mapper) Spectral Bands[1]

Band 1 (blue): 0.45 - 0.52 μm

This band was designed for water body penetration. Therefore, it is useful for coastal water mapping. This can be used for soil/vegetation discrimination, forest type mapping, and cultural feature identification. However, the image is generally of poor contrast due to its sensitivity to haze. Therefore this band is not recommended for use alone.

Band 2 (green): 0.52 - 0.62 μm

This band was intended to measure the green reflectance peak of vegetation, to distinguish various vegetation, and for vigour assessment. Cultural features identification can also be carried out. Similar to TM band 1, this band is sensitive to haze. Therefore it is not recommended for use alone.

Band 3 (red): 0.63 - 0.69 μm

This band can be used to differentiate plant species by sensing the chlorophyll absorption. Cultural features can be identified using this band. Roads, bare

1 This list is referred to Lillesand and Kieffer (1987), and Energy, Mines, and Resources, Canada (1986, 1987, 1988).

soils, rock outcrops, and non vegetated areas can be identified using this band.

Band 4 (near infrared): 0.76 - 0.90 μm

This band is intended for determining vegetation types, vigour, and biomass content. Coniferous forest can be distinguished from deciduous forest. Burnt forest can be delineated. This band is best for delineating water bodies and discrimination of soil moisture.

Band 5 (mid or shortwave infrared): 1.55 - 1.75 μm

This band is used for determining vegetation moisture content and soil moisture. Due to high penetration capability of this band through haze, good overall contrast of the image results. Water bodies, variation in forest composition, roads, and rock outcrops are discernible.

Band 6 (thermal infra red): 10.4 - 12.5 μm

Terrestrial thermal mapping can be carried out using this band. This band is useful for vegetation stress analysis, and soil moisture discrimination.

Band 7 (mid or shortwave infrared): 2.08 - 2.35 μm

This band is still in the reflective part of the spectrum. It is intended for discriminating mineral and rock types. It also has strong potential for soil analysis.