MASTER

Design of an assessment method for sustainable micro-hydro projects in Suriname

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Miguel Alvares

Design of an Assessment Method for Sustainable Micro-Hydro Projects in Suriname

M.Sc. thesis in the field of Technology and Innovation Policies for Developing Economies

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Summary

The aim of this research was to explore the possibility for designing an ex-ante assessment method that would help maximize the chances for micro-hydro projects of being able to both function as a source of electricity for a long period of time as well as provide the targeted community with a basis for achieving sustainable development. This research was aimed specifically at the conduction of micro-hydro projects in the inlands of Suriname.

The direct need for this research arose from the difficulties experienced with the execution of a local micro-hydro project. These difficulties were seen as a local manifestation of a global trend with the execution of rural electrification projects in developing countries:

- Developers focus too much on the short term technological and economical feasibility of designing and constructing a plant and neglect the importance of the -long term- operational phase.
- Most projects focus only on the provision of electricity, lacking any extension programs that utilise the electricity for bringing about economic and social development for the community involved.

The research consisted of a theoretical and a practical phase.
In the theoretical phase the results of a literature research was used to design a model that can help to conduct an ex-ante assessment. The model is based on a comprehensive number of critical factors, spanning an array of six categories: organizational, social, technical, economic, institutional and environmental. The model was designed from the perspective of long-term operation and with a focus on the goal of facilitating sustainable development.
The model was translated into a software model for ease of use.
In the practical part of the study, a field research was carried out with three goals in mind. These were fine tuning the model with local data from Suriname, evaluating the model's comprehensiveness for the local setting and applying the model to a practical case to obtain a review on its strengths and weakness as well as obtain an assessment on the subject case.

The execution of the field study led to a number of conclusions. An important conclusion is that there is still a lot of room for improvement of this experimental model.
Two fundamental design aspects require improvement:

- In order to function as an ex-ante method, the modular design of the model is inadequate. A structure of the critical factors following a flowchart design will be needed.
- The model needs some kind of weighting system for objectively weighing the impacts of the different factors. Constructing such a system would require more time for research.

Besides these two fundamental issues, the model possesses a number of practical shortcomings, the solution to which lies in a better software design.
Another shortcoming of the model lies in the fact that for it to be an effective tool, proper institutional surroundings for its support need to be created; a venture requiring time, money and expertise.

As for the case of Palumeu, the project to which the model was applied, and future micro-hydro projects in Suriname, the following conclusions were drawn:

- There are too many aspects wrong with the Palumeu project for it to have a true chance of succeeding - both in the sense of long-term operation as in the sense of bringing about sustainable development.

- There are several factors influencing the chances of successfully executing a micro-hydro project in Suriname. Chief amongst them is the lack of experienced consultants in this field, and any future project would do well to invest in obtaining such consultancy.
- The need for attaching a profitable income generating activity to a micro-hydro project will have to be stressed with any such project deployed in the inlands. In this respect, a further investigation into the possible revenues from ecotourism as a source of income needs to be conducted.

Samenvatting

Het doel van dit onderzoek was het verkennen van de mogelijkheid om een ex-ante evaluatie methode te ontwerpen die kon helpen op voorhand de kansen voor het welslagen van een micro waterkracht project te voorspellen en daardoor een bijdrage te leveren aan het verbeteren van die kansen. Met welslagen wordt hier bedoeld dat de micro waterkrachtwerken in staat moeten zijn gedurende een lange periode te fungeren als bron voor elektriciteit en tevens als basis voor duurzame ontwikkeling voor een gemeenschap moeten dienen. Dit research project was specifiek gericht op micro waterkrachtwerken in het binnenland van Suriname.

De directe aanleiding tot deze studie waren de problemen die werden ondervonden bij het uitvoeren van een lokaal micro waterkracht project in Suriname. Deze problemen konden worden gezien als een manifestatie, op lokaal niveau, van een wereldwijde trend die ervaren wordt bij de uitvoering van rurale elektrificatie projecten in ontwikkelingslanden:

- Project uitvoerders hebben een te nauwe en te korte termijn visie, voornamelijk gericht op de technologische en economische haalbaarheid van het ontwerpen en bouwen van een installatie. Ze hebben maar al te vaak te weinig oog voor -op de langere termijn- de operationele fase.
- De meeste projecten concentreren zich op de elektriciteitsvoorziening en ontberen elke verdere planning of voorzieningen om de opgewekte stroom te benutten voor sociale en economische ontwikkeling in de betrokken gemeenschap.

Het onderzoek bestond uit twee fasen: een theoretisch vooronderzoek en een praktisch (veld-) onderzoek.

In het theoretische deel werd er litteratuuronderzoek verricht. Aan de hand van de resultaten van dit onderzoek werd een model ontworpen om te helpen bij de uitvoering van een ex-ante evaluatie. Het model is gebaseerd op een groot aantal kritische factoren, die zich in zes categorieën laten onderscheiden, te weten een organisatorische, een sociale, een technische, een economische, een institutionele en een milieu categorie. Het model werd ontworpen met het oog op een lange termijn exploitatie, en met de nadruk op het stimuleren van duurzame ontwikkeling. Het theoretische model werd verwerkt tot een computermodel om het gebruik te ervan vergemakkelijken.

De tweede fase, het veldonderzoek, werd uitgevoerd met drie hoofddoelen in gedachte:

- De fijne afstelling van het model met behulp van lokale data uit Suriname.
- Het evalueren van de volledigheid van het model met betrekking tot de lokale situatie.
- Het toepassen van het model op een bestaand project om zicht te krijgen op de sterke en de zwakke kanten van het model en tevens om een evaluatie van het desbetreffende project te verkrijgen.

De uitvoering van de veldstudie heeft tot een aantal conclusies geleid. Een belangrijke conclusie is dat het experimentele model nog op een aantal punten verbeterd kan worden. Twee fundamentele aspecten die verbeterd kunnen worden zijn .

- Om te functioneren als een ex-ante model is de modulaire opbouw niet adequaat. Het werken met stroomdiagrammen zal in dit kader beter voldoen.
- Het gebruik van gewichtsfactoren, om middels een objectieve weging de invloed van de verschillende factoren vast te stellen, is noodzakelijk. Het hiertoe modificeren van het model zal nog heel wat studie vergen.

Naast deze fundamentele aspecten zijn er nog een aantal praktische tekortkomingen aan het model. De oplossingen hiervoor moeten worden gezocht in verbeteringen in het software pakket.
En een laatste tekortkoming in het model ligt aan het feit dat, wil het een effectief instrument worden, de juiste institutionele omgeving en ondersteuning zal moeten worden gecreëerd. Een kostbare onderneming gezien de vereiste expertise, voorzieningen en tijd.

Met betrekking tot de Palumeu case, het project waar het model op is toegepast, en tot toekomstige micro waterkracht projecten in Suriname, kunnen de volgende conclusies getrokken worden.

- Er zijn teveel zaken fout aan het Palumeu-project om een echte kans op succes te hebben, zowel voor wat betreft een goedlopende operatie op langere termijn, als in het kader van het brengen van duurzame ontwikkeling.
- Er zijn verschillende factoren die de kansen voor het succesvol uitvoeren van een micro waterkracht project in Suriname bemoeilijken. De voornaamste hiervan is het gebrek aan ervaren deskundigen op dit gebied. Het is raadzaam dat bij elk toekomstig project voldoende wordt geïnvesteerd om in deze lacune te voorzien.
- Het is noodzakelijk om in de toekomst in elk micro waterkracht project dat in het binnenland wordt uitgevoerd, een inkomensgenererend onderdeel op te nemen. In dit kader moet verder onderzoek worden gedaan naar mogelijkheden van het ecotoerisme als bron van inkomstenverwerving.

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Abbreviations

Abbreviations

ADEKUS	Anton de Kom University of Suriname
BWKW	Bureau for Hydro Power Works
DSS	Decision support system
FDC	Flow Duration Curve
METS	Movement for Ecotourism Suriname
MHP	Micro Hydropower
NPV	Net Present Value
SGP	Small Grants Programme
SRD	Suriname Dollar (currency in Suriname after January 2004)
SRG	Suriname Guilder (currency in Suriname before January 2004)
UNDP	United Nations Development Programme
USD	United States dollar
WLA	Hydraulic Research Division
WMM	Word and Music Ministry

Surinamese names and concepts

Basja	Assistant to the chief of an Inheemse or Marron village
Granman	Chief of chiefs for an Inheemse or Marron tribe
Inheemse	Native Amerindian inhabitant of Suriname
Kapitein	Chief of an Inheemse or Marron village
Kroetoe	Important meeting, group discussion
Kwamalasamutu	Inheemse village, site of solar energy project
Marron	Tribal inhabitant of the inlands of Suriname
Palumeu	Inheemse village, site of current MHP project
Paramaribo	Capital of Suriname
Poketi	Marron village, site of first MHP project
Sipaliwini	District in Suriname
Tapanahony	River in Suriname
Upper Suriname	River in Suriname

Preface

"Tell me and I will forget; show me and I may remember; involve me and I will understand."
A Chinese proverb from 450 BC, demonstrating that the concept of participatory learning has been around for almost two and a half millennia. Yet when it comes to development projects, this concept still seems hard to grasp for some developers.

"Winti waai, Lanti pai"
A Surinamese proverb. Literately translated, it states: "The wind blows, the government pays." It is a humorous referral to the extreme extent to which some Surinamese people extrapolate the concept that it is the government's responsibility to provide for the welfare of its citizens.
Although humorously meant, it is still an indication that any rural electrification undertaking by the government will require an extra effort to convince a community to accept responsibility for the upkeep of such a project.

This graduation thesis represents the conclusion of my years as a student at the TU/e. Reaching this point would not have been possible without the strong support and motivation provided by a large number of people.
First, I would like to thank my three supervisors at the TU/e: Henny Romijn, Krishna K. Prasad and Eddy Szirmai. They kept the belief that I would see this thesis through to the end. Especially Henny Romijn, who despite of having to manage a very stressful period at the faculty still made time to supply me with help and comment, even in the middle of a weekend night.
I would also like to thank: Cornell Wijngaarde and Anand Kalpoe who were my local supervisors and provided me with help and guidance; Stef Niekoop who had a wealth of knowledge and references, Dr S. Naipal, who despite our differences on the Palumeu project provided me with a lot of help and Albert Del Prado who provided me with a lot of useful information on Poketi; all the relatives and friends in both Suriname and the Netherlands, who did their best to help and support me during this graduation research, as well as during the rest of my study years. The list of people I could name here would exceed the length of my literature reference list.

Most of all, I would like to thank the four people who mean the most to me and without whom this final thesis would probably not have been completed: my parents, Joseph and Ellen, my sister, Nicole, and my girlfriend Bianca. They provided me with a warm home to stay during and after my research, on both sides of the ocean, and they have supported me with unquestioning faith.

1. Introduction

This report is aimed at finding an ex-ante assessment methodology that will increase the chances of sustainability for rural micro hydrological electrification projects in Surinam. The end goal is to provide a positive contribution towards the process of sustainable development in Suriname. In this chapter a description is given of the reasons for conducting this research and why the focus lies on the assessment part of the micro hydro projects.

1.1 Rural electrification and assessment

Access to a stable supply of electrical energy can be seen as one of the pivotal necessities for the development process. One cannot imagine significant industrialization, often seen as a measure for economic development, without a stable supply of electrical energy. Electrification, however, is not only a necessity from an industrial development point of view. Access to electrical energy can greatly improve the standard of living and can be a great stimulus for social development.

After the 1940's there has been a great growth in the electricity sector. While many industrial and urban projects around the world succeeded, this success did not spread to the rural areas in developing countries[1]. Electrifying rural areas, especially in developing countries, has proven to be very problematic. This was mainly due to the fact that conventional techniques of central generation and grid expansion could not be efficiently applied to rural areas. As one expert said:

> The orthodox approach of central station generation, which is ideal for industrialized countries and urban centres, may not make sense for rural areas, where the demand per consumer is only a small fraction of a kilowatt [Khatib1993].

This has made the application of technologies that can be used in small scale decentral systems very attractive to agents trying to implement rural electrification projects, especially renewable energy technologies. These systems are popular because of both economical and environmental considerations. In light of the worldwide focus on environmental sustainability, the use of renewable energy sources has become widely popular. The fact that these energy sources are, in theory, both free and unlimited is also a great incentive. There have been very successful projects in utilising bio, wind, water and solar energy. This paper will focus on one of these energy sources, namely hydro-power.

The possibility to use water as a source for electrification has existed ever since the middle of the 19th century, where Faraday's discovery of electricity and the development of the turbine happened around the same time. Hydro technology, both large and small scale, can be seen as a thoroughly developed and proven technology. Small scale hydro projects are one of the many forms of providing rural areas with electricity by means of a small, decentralized power station. Round the year 2000 almost 50 million households in developing countries received energy for lighting, television and radio from such power stations, and close to 60.000 small scale industries[2].

When reviewing the literature on these small scale hydro projects, one will however notice two disturbing facts. One is that although the technology behind micro hydrological plants is fairly mature and well known, a lot of these installations still experience problems or even

[1] Morton, 2000

[2] Martinot, 2002

outright failure once they get beyond the design and construction phase. Most of these problems find their root in non technical issues.[1]
Another problem seems to be that even if the installation functions successfully, the electrification project does not necessarily result in further development of the rural area in which it is deployed. When one considers a rural electrification project, one has to keep in mind that the end goal is not merely to provide a village with electricity. The end goal is to provide the inhabitants of these villages with the means for development. Electrification can be seen as one of these means, but electrification in itself is not the important end goal.

In the past, one of the main reasons for the first problem was the lack of a comprehensive approach to assessment and design of these projects. Frequently the focus of the preparation for these projects would lie on the technical and financial aspects while, especially in rural settings, there are a host of other factors which are of great influence on the success chances of such projects[12]. During the last decade the importance of these other factors, which lie in the social are institutional sphere has gradually become widely recognised. Leading organisations such as the World Bank and the ITDG have become wise to the fact that these other factors are equally important, if not more, to the success of these rural electrification projects as the technical and economical feasibility aspects[13]. Even so, a recent study conducted by the World Bank shows that there are still a lot of projects that run into problems once the project evolves past the initial phase of design and construction. It is mostly during the operational phase, which in the case of a hydro project can last up to several decades, that the project runs into problems. Since most feasibility studies focus mostly on feasibility of the technological phase of designing and installing the micro hydro system, these problems often lie outside of the scope of the feasibility study.
This is also true for the second problem that has been mentioned: The lack of further development of the rural area after completion of the electrification project. For many, this is considered to be the more important goal. However, when assessing the feasibility of installing a micro hydropower system, most developers will focus on the short term feasibility of actually installing and running the plant. The broader goal of achieving long term, sustainable development in the area is not included in the standardised feasibility study.

In light of these two problems, a need can be recognized for a shift in assessment methodology. Instead of the primarily techno-economic feasibility study there needs to be an assessment approach aimed more at the broader objective of achieving long term sustainable development. A methodological approach to designing and executing that would ensure that future projects would not only have a better chance of being built to completion and lasting for more than just a couple of years, but also would ensure that these projects would actually contribute positively towards the desired goal: Development.

One current manifestation of the need for such a methodology can be found in the country of Suriname where at the village of Palumeu, deep in the inlands, there is a micro hydro project under development that has been stuck in between the construction and design phase for almost three years.

1.2 Suriname

[1] Khennas, 2000
[2] Grierson, 1992; Smith, 1994
[3] Mulugetta, 2005; Barnes, 2004

In the 1980's the government of the republic of Suriname decided to try stimulating the development of the tropical forested inlands of Suriname by bringing electricity to the inland villages. One of the main methods of providing electricity was by means of small hydro powered electrical schemes. Suriname's main source of electrical power is the great Afobaka hydro dam, so the people of Suriname were already familiar with the concept of using water as a power source for generating electricity.
Although there was a great deal of enthusiasm for the idea of a couple of independent micro hydro power sites providing enough power for a large number of villages, the results of the endeavour were disappointing. A number of suitable sites were identified and plans developed for several of these sites, but only one of these plans was actually put into action. This station ran for three years before function was ceased mainly due to non-technical reasons. After this project failed, no more hydro projects were deployed until the Palumeu project. This project is a private endeavour that has been experiencing a large number of problems, both technical and non-technical, before it has even reached the operational phase.
The Anton de Kom University of Suriname, which is the supplier of engineering know-how for this project, recognized that in light of the problems experienced with these projects there was a need for a different approach. An approach that would prevent future projects from experiencing the same difficulties.

1.3 Research Objective and Methodology

The objective of this research will be to explore the possibility for the design of an ex-ante assessment method that will help maximize the chances for a micro hydro project of being both functional in the long term as well as providing a basis for achieving sustainable development.
Since the problems experienced by the Palumeu Micro Hydro project in Suriname were the direct reason for the initiation of this project, the method will be initially aimed at the specific case of Suriname.
The objective is translated into the following research questions:

1) What factors would have to be incorporated into an experimental model for a comprehensive (inter-disciplinary) ex-ante assessment of the sustainability[1] of micro-hydro projects in Suriname?
2) What functional properties would this model have to possess to function in such a way that it can improve the chances of sustainability for these micro-hydro projects?
3) From the application of this model on past and present schemes, what lessons can be drawn for its design and for the design and appraisal of other future micro-hydro projects in Suriname (and possibly elsewhere)?

In order to achieve this objective at first a preliminary assessment model was designed based on available literature. The preliminary model included the conventional cost benefit analysis and technology assessment techniques. Literature concerning current appraisal methods, case studies on hydro-projects and available literature on the effects of the 'soft' factors on sustainability of a project were used to further expand the model. A software tool called 'MindMapper' was used to construct an easily modifiable, modular map of these factors.

[1] Sustainability in this case means that the project has to be able to meet people's electricity needs during a long period, as well as providing a basis for social and economical development without compromising the ability of future generations to meet their own needs. This can be conceptualised in terms of the P(eople)-P(lanet)-P(rofit) model: Social, environmental and economic factors all have to experience either a positive development because of this project, or at least not experience any lasting negative effects

During a six month field study in Suriname, this model was fine tuned to the case of Suriname through the inclusion of local data and a review of its comprehensiveness on the basis of two past rural electrification cases. Subsequently the model was applied to the Palumeu project for acquiring insight into the model's ability to function in practice as well as gaining an assessment on that project.
The data for the fine-tuning and the conducting the assessment was obtained through field interviews with the directly involved parties, as well as from additional information gathered from other secondary sources in Suriname.

1.4 Structure of the report

In the following chapters the method and results of the research will be presented. The report is structured as follows:

• *Background and Literature*: In chapter 2 backgrounds will be provided on the subjects involved in this study. This will include

- A review on micro hydrology as the focus technology for the model.
- A review of the critical factors surrounding the sustainability of rural electrification projects, with a specific focus on the micro hydro projects. The literature reviewed in this section supplies the basis for partially answering the first research question.
- A short explanation will be provided on the different approaches to project design that are of relevance to the design of an assessment method.
- Background information on Suriname as the focus country for the research

The literature reviewed in chapter 2 provides the basis for the next part of the research, which is

• *Model Design*: The construction of the critical factors into a comprehensive model as well as the methodology for using this model is described in chapter 3. An explanation is given of how the assessment model should function to improve the chances of sustainability for micro hydro projects, answering the second research question. For practical use the model is translated into a modular map using computer software. The initial model is then filled in with the general data acquired from the literature.

The next two chapters deal with the field research conducted in Suriname

• *Field Research Methodology*: In chapter 4 the research methodology used to fine tune and apply the methodology in Suriname is described.

• *Results*: In chapter 5 the results of the field research are analysed and discussed.

The field study can be generally divided into three parts:

- A local data search in order to make the model applicable to the case of Suriname
- Adjustment of the model on the basis of a review of two past electrification cases.

Here the answer to the first research question is finalised, refining the factors gained from general literature search to the specific case of Suriname.

- The third and final part consists of the application of the model to the Palumeu case, thereby exposing the model to a practical case and obtaining feedback on its design as well as feedback on the Palumeu case.

The report is concluded by the final chapter

• *Conclusions and Recommendations*: The conclusions on the advantages and drawbacks of the proposed assessment methodology on the basis of the theoretical and field research are presented in chapter six, as well as recommendations for further use and development of this methodology.

In order to keep the report itself concise and readable, the more detailed result descriptions and larger tables are presented in the included appendices.

2. Background and Literature

In this chapter first an introduction is given on the general principles of micro hydrology. Next an attempt is made to isolate the factors important in achieving sustainable development through electrification, followed by a short review on some aspects of project design that are important for the design of an assessment model. The chapter is concluded with some background information on Suriname, the country at which the designed methodology will be aimed.

2.1 Micro hydropower: General Principles

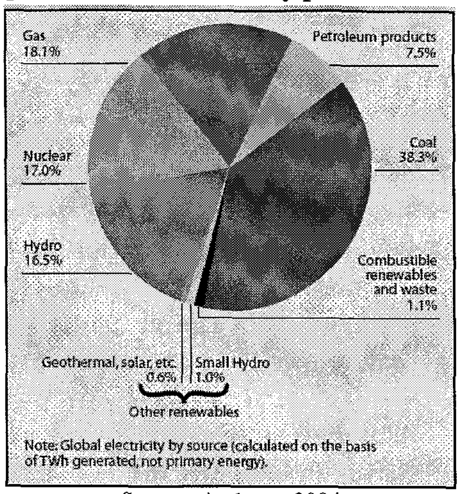
General

Hydropower is the world's most used source of renewable energy generation. In 2003, hydropower accounted for 16% of the world's electricity production. A large proportion of this is generated by large hydroelectric schemes.

In a hydro power generation scheme water pressure is used to drive a mechanical component. The thus converted water energy is used either in the form of mechanical energy, or further converted into electrical energy by means of a generator.

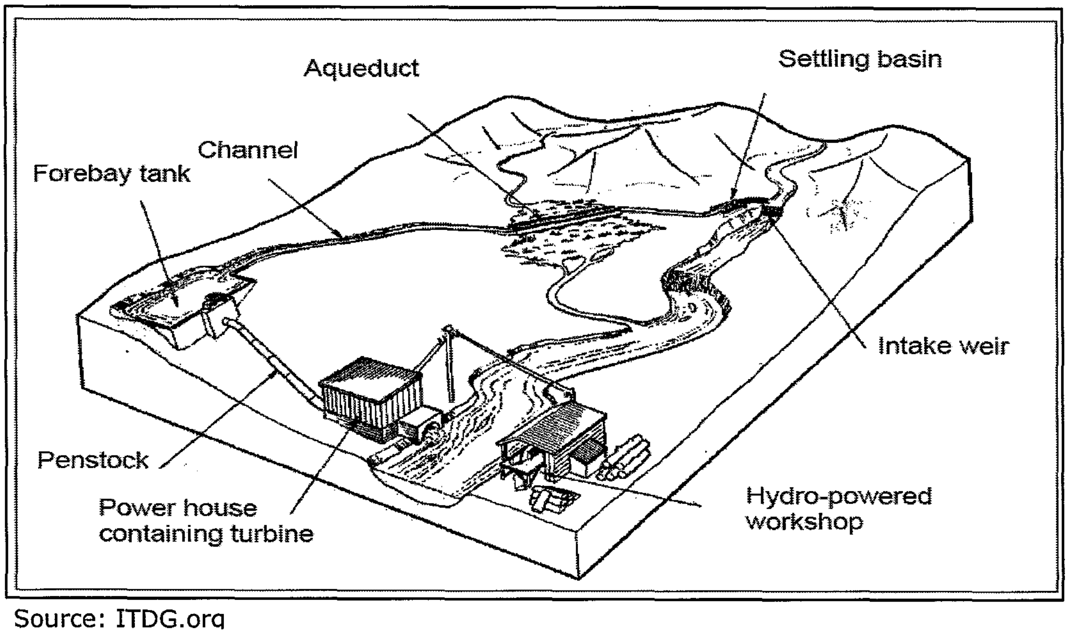
There are several ways of utilising the water pressure. In the case of a large scale hydro generation scheme, often a reservoir is created that will allow for a year round constant supply of energy. In order to create the reservoir a (or sometimes several) waterway is dammed and a portion of the land upstream of the river is submerged. A turbine is used to convert the water's energy into mechanical energy. This turbine can be located at the base of the dam, or the water can be transported from the base of the dam to a distant location downstream where the turbine is situated.

Figure 2.1 World electricity production



Source: Anderson2004

Figure 2.2 Small Hydropower generation scheme



Source: ITDG.org

In the case of a small[1] hydrological power scheme, engineers will try to avoid damming of the waterway. Instead, a portion of the water will be tapped from the river, led down over a certain height difference towards the turbine and then reinserted into the waterway. The energy available for conversion is dependent on the height difference between the intake point and the turbine, as well as on the volume of water transported through the turbine (flow). How much energy is generated is a product of the available energy and the various efficiency factors of the components involved. Converting to mechanical energy as opposed to electrical requires one less conversion step and is therefore more efficient. There are several possible designs for a micro hydropower generation schemes. Figure 2.2 is a schematic of a micro hydro scheme in which most of the possible components are depicted.

At the point where the water is tapped a weir is built to ensure a constant water supply. Water is led from the intake into a channel that leads the water to a point where it can make the drop towards the turbine. Into the channel, silting basins are built to filter out the sediment particles. Basins are built both at the beginning (Settling basin) and at the end of the channel (forebay tank). Where the channel has to cross obstacles such as rivers, marshes or roads an aqueduct can be inserted. At the end of the channel, water is collected into a forebay tank and from there on led trough a penstock towards the location of the turbine. After passing through the turbine, the water is reinserted into the original water flow.
Not all of these components have to be used. In some schemes only a penstock or a channel might be used to guide the water from intake to turbine. The geographical layout of the site, the size of the hydro scheme (in terms of intended power generation) and the available head determine for a large part the amount of civil works necessary. Generally, low head sites require more work to build per amount of power produced than high head sites.

Although small hydropower systems have a greater potential for satisfying small industrial strength electricity needs than wind and solar schemes, they do have an important drawback. Whereas solar systems are easily installed on nearby open fields or on rooftops in any location, a small hydro scheme is site-specific technology. A significant amount of water must travel over a significant height difference within reasonable range for a micro hydropower project to be economically attractive to execute. Furthermore, because there is not a huge reservoir such as with the larger hydro schemes, the water flow must provide enough water year round. This limits the amount of settlements that can utilize small hydropower as an energy source. Villages in flat areas or with extreme seasonal variation in water supply cannot rely on hydropower as a source of electricity. Still, globally, there is a huge potential for small-scale hydropower use.

Micro hydropower in developing countries
Micro hydro is perhaps the most mature of the modern small-scale decentralised energy supply technologies used in developing countries. In the year 2000 almost 50 million households in developing countries received energy from such power stations, and close to 60.000 small scale industries[2]. There are thought to be tens of thousands of plants in the "micro" range operating successfully in China alone, and a significant numbers are operated in wide ranging countries such as Nepal, Sri Lanka, Pakistan, Vietnam and Peru[3].

- In Peru the Inter-American Development Bank provided the opportunity for a number of micro-hydro plants benefiting approximately 10 000 people.

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[1] See Appendix A.2 for size classifications of hydropower systems
[2] Martinot, 2002
[3] Khennas, 2000

- In Nepal the ITDG, along with other organizations, has helped facilitate the development of 1200 micro-hydro schemes, for about one million people.
- In Sri Lanka, 70 schemes have been installed in eight provinces in the last 8 years with the help of the ITDG.

With the number of MHP systems being deployed worldwide and considering the maturity of the underlying technology, one can safely assume that the difficulties experienced with keeping these systems running will most likely not be the fault of the technology behind the system. Rather it is the way that these systems are embedded into the local society which is the main cause of failure. In chapter 2.2 a review will be given into the variety of factors which are of influence on the success or failure of such rural electrification projects.

2.2 Sustainable Rural Electrification: Critical factors

When delving into the literature concerning sustainable rural electrification schemes (including micro-hydro schemes) one quickly discovers that there are a myriad of factors influencing the success or failure of projects. In the following text, a general overview will be provided of the literature used as basis for this report.

Micro-hydro power is a mature technology. There is quite an extensive knowledge base available on its technical aspects alone. Literature ranges from introductory guides dealing with the basics of micro-hydro power systems, to more detailed works providing comprehensive information on how to construct such systems.

The basic principles behind micro hydropower generation are already explained in the previous chapter. The technical design of good micro-hydro system starts with the right choice of location and equipment.

Box 2.1 Technical Factors Overview

- Survey
- Civil works
- Turbines
- Generators
- Control equipment
- Transport and Distribution
- Maintenance

In Penche's 'Layman's guide on how to develop a small hydro site' (Penche, 1997) detailed steps are provided for making these choices. Penche names a number of studies to be undertaken in order to implement a micro-hydro scheme. The ones relating to the technological aspects are:

- Evaluation of the water resource and its generating potential
- Topography and geomorphology of the site.
- Site selection and basic layout
- Hydraulic turbines and generators and their control

For each of these studies Penche gives a detailed guide on how to conduct them. Although they vary in focus and detail, most handbooks on micro-hydro power follow the same principal design as Penche's guide. This is because the technology around micro hydro is pretty well thought out. Using these handbooks, it is not difficult to filter out the factors critical to constructing a technologically sound micro-hydro system. A summary listing of these technological aspects is given in Box 2.1

Evaluation of the water resource, topo- and geographical site evaluation are combined under the label survey, encompassing all the measurements necessary to decide whether the natural setting is capable of supporting and powering a micro-hydro system. Clearly, a micro hydro site cannot be constructed unless the outcomes of these measurements yield a positive result.

Civil works are the hydraulic structures such as the weirs, canals and penstocks needed for guiding the water to the turbine. The civil works are usually the most labour intensive aspects of the micro-hydro system, and have the largest environmental impact. Whether a full range

of structures has to be constructed or only some depends on the size and location of the hydro power plant.
The choice of which turbine will be used is probably one of the most important and therefore most thoroughly discussed subjects. Turbines types are usually divided either by their principal of operation (impulse or reaction) or by the head under which they operate (high, Medium or Low). Penche lists all of the major types, but research literature can be found on each type alone. The size, type and geometry of the turbine are mostly decided by the following criteria: Net head, range of discharges through the turbine, rotational speed, cavitation problems and cost.
The turbines convert the energy from the water pressure into mechanical energy. For micro-hydro schemes aimed at generating electricity, this mechanical energy must be translated further into electrical energy by means of a generator. Choice of the generator is mostly decided by the system that it will provide energy to. In a system designed for battery charging, the goal will be to deliver DC energy. In most other schemes, the purpose will be to deliver AC energy. There are two types of generators to choose from: synchronous and asynchronous.
Although asynchronous generators are cheaper, synchronous systems are technically better suited for stand-alone systems (Penche, 1997; Paish, 2002).
Especially in a small stand-alone system where there may be substantial fluctuations in the load, it is essential to have the right control equipment. Classically, control equipment falls into two categories: turbine control and electrical control. Speed governors for the turbine can be either mechanical or electrical. Electrical control systems need to be installed in order to safely connect the generator to its load and ensure a stable electricity supply.
Transport and distribution of the electricity form the final step in completing the micro-hydro system. Typically, a micro-hydro system will either connect to a larger grid, or be situated close to the village or plant its providing electricity to. When this is not the case, construction of a high voltage transmission line might become necessary. This will greatly increase the cost of a micro-hydro system.
Once construction is complete, the system needs to be kept running. Proper maintenance is the last –but not least- factor important when designing a technologically sound micro-hydro system. Especially in low-tech areas where there is a shortage of qualified personnel, proper maintenance can be a major obstacle.

The technical factors mentioned above are important to all micro-hydro design, irrelevant of its global position. However, when dealing with construction of such a system in developing countries, special considerations have to be made. Foremost reasons for this are the need for cost reduction and the lack of properly trained personnel. The need for cost reduction forces designers to choose for technological solutions that are less reliable but cheaper. Fraenkel's 'Micro-hydropower: a guide for development workers' (Fraenkel, 1991) mentions a few of these: the use of temporary weirs instead of permanent ones, pumps as turbines and alternators designed for diesel-driven generation. Lack of properly trained personnel requires a design that is as maintenance free as possible. This requirement can conflict with the need for cost reduction.
Although a mature technology, there are still some developments occurring in the field of micro-hydro power. Most recent developments are aimed at improving the cost-effectiveness of the technology (Paish, 2002). Improvements can range from low impact improvements (simpler trash racks) to innovations leading to substantial savings in capital investment. The development of variable speed operation, allowing for simple propeller turbines instead of expensive Kaplans is such an innovation. Especially for developing countries, these developments can greatly improve the feasibility of constructing a micro-hydro power system.

Aside from technological issues, Penche as well as other handbooks mention the importance of carrying out a proper environmental impact assessment and implementing mitigation measures. Contrary to large hydropower facilities, most micro-hydro schemes are run-of-the-river designs. There is no need for the creation of large water reservoirs. Therefore, the negative environmental impacts are usually very few. Most important seems to be the protection of the fish stock in the subject river, for which fish ladders or other means of travel past the works have to be constructed. However, if proper care is not taken, initially small impacts such as erosion and sedimentation can have disastrous effects.

Box 2.2 Environmental Factors Overview

- Resources
- Habitats
- Ecosystems
- Air
- Water
- Soil
- Flora
- Fauna
- Aesthetics
- Natural and Cultural heritage

Like the technological factors, the environmental factors concerning micro-hydro construction have been pretty well thought out. It is therefore not difficult to construct a list of factors important to assessing the environmental impact of such a project. In table 2.2 the main categories of environmental impacts are listed

The final issue mentioned in most technical handbooks on micro-hydrology is that of financial sustainability. An economic analysis has to be carried out in order to decide whether the hydro project is financially viable and to compare it to other possible ways of obtaining electricity, such as other renewable energy sources, grid connection or diesel generation. Static analysis can be used to compare the unit electricity cost of the different schemes. Discounting is used to predict the future value of the investment necessary for construction in order to decide whether to invest or not. The methods are well known and straightforward. When using these standard methods, however, the long life of hydro installations turns out to be a negative property. A new hydro installation will typically last for 50 years or more without major reinvestments. Because standard appraisal methods usually use a write off period of 10 to 20 years, hydro installations come over as relatively expensive compared to other options. Still, these methods have to be used as financing has to be acquired through either subsidies or commercial loans, which are subject to standard conventions.

As mentioned above, the technological and environmental aspects of micro-hydro power generation have been pretty well thought out. A typical micro-hydro system should be able to run for more than 50 years without major reinvestment. For micro-hydro systems in developing countries, however, this statement fails to hold true. The reason for this is that besides aforementioned technological and environmental aspects, there are many other factors influencing the success or failure of a micro-hydro plant. These factors are not only of influence on the field of micro hydrology, but on all matters of rural electrification schemes.

When broadening the scope to a more general look at rural electrification schemes, one discovers a disappointing trend. According to Grierson (1992), most rural electrification schemes cease operation within a few years of handover. Even the 'successful' projects are seldom successful from a long-term sustainable point of view. Grierson lists six main reasons for the failure of these projects. Three of them relate to local technological capability: lack of trained personnel, inappropriate equipment and lack of provision for repair and maintenance.
Enhancement of local technological capability, according to Grierson, is one of the key factors to achieving village electrification within the context of sustainable development. Grierson: *Technology [...] must be absorbed locally and mastered in the interests of*

development. It is this capacity to absorb, to manipulate, modify, and eventually replace with local innovation that no nation can hope to develop without.

Smith (1994), in his paper on village hydro-electrification, agrees with Grierson on this subject. Smith mentions a number of factors relating to local technology capability, such as the training of local engineers and the local manufacturing of components. Smith also looks beyond the technical components. Dependable local financing, a strong coordinating organization and further economic development of the village are also key factors in the rural electrification scheme. However, one of the most important factors mentioned by Smith is the importance of community involvement. According to Barnes (2004), Smith (1994) and Khennas (2000), local communities should be involved from the very beginning of the project. In his designed framework for evaluating sustainable development programs, Mog (2004) uses the character of this participation as one of his main evaluating criteria, thereby demonstrating its importance to sustainable development programs in general. Smith (1994) surmises, based on experiences from 15 electrification schemes in North Pakistan, that the most successful projects were the ones where the villagers not only contributed labour, but committed community funds towards the project as well.

Financial contribution of the community as a key factor has become a well-documented factor (Barnes, 2004; Smith, 1994; Khennas, 2000). It is mostly agreed that coverage of the capital costs is seldom possible without some kind of outside aid. Coverage of operational and maintenance costs, however, should be achieved independently by the rural communities. A World Bank study on rural electrification programs (Barnes, 2004) lists cost recovery as: *[...] probably the single most important factor determining the long-term effectiveness of rural electrification programs.*

The financial independence and early local community involvement are very important for the enforcement of the notion of "local ownership". This means that the project is not viewed as some outside project which is being deployed in the local community, but that the local community is in fact the owner of this project and therefore responsible for the wellbeing of the project.

The World Bank report lists a number of factors crucial to the success of rural electrification schemes. It warns that schemes will fail if certain preconditions (such as security of land tenure, availability of agricultural inputs, access to health and education services, reliable water supplies and adequate dwellings) are not met. Besides the economic factors (cost recovery, realistic prices) the report also warns against the dangers of political involvement and mentions the importance of an effective institutional structure. Although the exact form of the structure seems not important, it should include essential elements such as a high degree of autonomy and accountability.

The element of leadership is also listed as an important factor. This factor is difficult to measure. In his work on community organization and rural development David Korten recognizes flexible organization and leadership as the most important factor in successful development programmes. Rural electrification projects are also subject to this fact.

Effective organization as a critical factor can also be found in 'Best Practices for Sustainable Development of Micro Hydro Power in Developing Countries' by Khennas and Barnett (2000). According to their report, micro-hydro schemes not only require business like organization in order to properly survive in the long term, but also a businesslike approach when it comes to choosing the primary goals of the electrification project. An electrification scheme should be carried out with a clear goal, preferably a profitable one such as creating small profitable enterprises and providing them with electricity. Later on, the project can than

be extended to improve social circumstances by providing services such as lighting or power for communal buildings. This should be much easier than the other way around. Or, as they put it; '*Making the 'Profitable' Social is Easier than Making the 'Social' Profitable.*'
Khennas' (2000) findings provide a substantial source on key factors useable in the model. Their research is aimed especially at micro-hydro projects but the lessons learned are well applicable to all types of rural electrification schemes. One of the very important lessons learned (also supported by Barnes (2004) and Smith (1994)) is that no rural electrification scheme should be undertaken as a stand-alone project. In order to obtain sustainable development, such a scheme should be integrated with other projects, forming a true development program.

One last factor worth a separate mention is the importance of a pilot project. Smith (1994) mentions this specifically. The first project should serve as an example and be a source of encouragement for other electrification schemes. On such a pilot scheme, it is therefore best to use a conservative design, avoid cost cutting and use an engineer with previous micro-hydro experience. Once the pilot is successful, later projects can be executed less conservatively.

Box 2.3 Main categories

- Technical
- Environmental

- Organizational
- Social
- Economic
- Institutional

Study of the literature results in quite a list of factors. In order to form a useable framework, these factors need to be arranged into a survey able set of categories.
The guiding handbooks on micro-hydropower lead to a subdivision of three easily identifiable main categories: Technological, Environmental and Financial.
Broadening the view to all factors influencing rural electricity in developing countries, many more factors are introduced. Arranging all into different categories proves more challenging. Painuly and Fenhann (Painuly, 2002) in their paper on the implementation of renewable energy technologies make an even more detailed subdivision: Institutional, Technical, Market, Capacity, Awareness/information, Social, Financial, Environmental,
Economic and Policy factors. The World Bank, when evaluating rural energy projects, uses a less extensive subdivision into the following categories: Economic, Financial, Technical, Institutional, Environmental and Social factors.
In her thesis on renewable energy systems in Bolivia (Koper, 2005), Koper reviews several types of classifications and compiles them into the following list: Technological, Economic, Social, Ecological, Organizational and Governmental.
Assembling a list of categories that is succinct and therefore easily arranged into a model, but still offers enough distinction to allow all of the factors to be classified into different categories, is not easily achieved. One of the reasons for this is that most factors can be assigned to multiple categories. For example the need for agricultural input can be used as an Economic factor (income generation), a Social one (way of living) or an Environmental factor (use of land). Based on the subdivision used by the World Bank, with added input from other types of classification, the following six main categories were chosen: Organizational, Social, Technical, Economic, Institutional and Environmental. Since it will be the purpose of the model that all categories are used and thus, all the factors are considered, the arrangement of the factors should not diminish the comprehensiveness of the model.

2.3 Approaches to project design

As becomes clear from the discussion in the previous paragraph, there are a great number of factors that have to be taken into account in the design and preparation of a MHP project for a developing country in order for it to succeed.
Equally –if not more – important to a project's chances for success, especially keeping in mind the end objective of achieving sustainable *development* rather than just providing electricity, is the approach used for the process surrounding the design and execution of the project. This is illustrated by the discussion on blueprint versus process approach.
During the 1980's there was a general lobby to move away from the traditional approaches to planning and management of project designs (Bond and Hulme, 1999) and to adopt a more "process" approach to the implementation of these projects. Many felt that the traditional blue-print approach with its rigid emphasis on detailed pre-planning and time bounded projects did not function satisfactory in developing countries. This approach impeded the achievement of the true end goal: development (Korten, 1980). The process approach focused more on the participatory aspects of development orientated projects, holding the view that the learning experience obtained from participating in such projects could be seen as a form of social development in its own right.
The call for a 'process' approach initiated many attempts to be made at adopting a more flexible design in project execution (Korten, 1980; Bond and Hulme 1999). There are a number of drawbacks to the process approach, however, that impede its application in practice. Leaving room for learning and participation can severely slow down the execution of a project and requires flexible, intensive management. In addition, because of its nature as a learning process, a true process approach could not be assigned a set time period.
Fortunately, the choices for project approach are not strictly limited to either the blueprint or the process approach. There have been several approaches designed which try to incorporate the best of both approaches. Bond (2002), in his paper on planning and management, describes several such approaches and presents a visual schematic of how a process approach applied to a project cycle could lead to an increase in effectiveness, efficiency and scale of output with each cycle [Figure 2.3a].

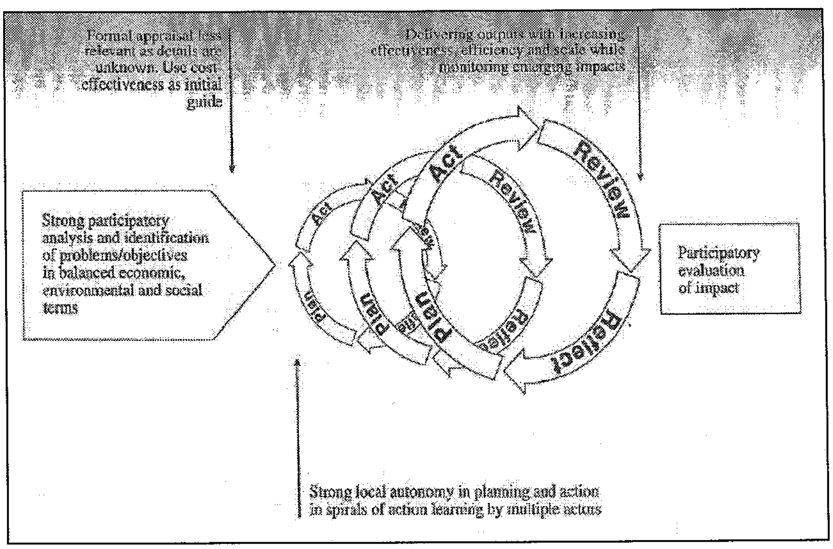
The discussion on blueprint versus process approach leads to the conclusion that an ideal design for the application of MHP projects with a developing goal in mind should not simply follow a blueprint approach, but should somehow also try to incorporate the advantages of using the process approach.
The purpose of this research is to the design an ex –ante assessment methodology that should function as an aid for project developers, leading to improvement in design and execution by pointing out the strengths and weakness in a proposed project. A model for executing such assessments should therefore also try to follow this guideline

An essential aspect of the process approach essential to the design of an assessment model is the need for proper backward linkages within and between the different phases of a project life cycle. This need can be clarified by Rosenberg and Kline's (1986) work on innovation modelling. In their work they point out the weaknesses of the classical way of modelling innovation through the use of a linear model [Figure2.3b]. The linear model uses a top down way of modelling the process of innovation from research to the marketing. In reality, this path is seldom followed. Rosenberg and Kline propose that the best way to model innovation would be through a model that demonstrates the backward linkages that exist between the consecutive stages of innovation. Innovation should be seen as form of change to a whole system.
When viewing a project life cycle, the same need for a non linear approach to modelling applies. In a linear model of a project life cycle such as depicted in the upper half of Figure

2.3c, the cycle starts with the conception of a project and ends with its final evaluation (Labuschagne, 2005). In reality, there are always backward linkages between the stages of a project. Difficulties in the development stage lead back to a reassessment of the feasibility, and problems in the execution stage link back to development.
In an ideal project design, the possibility would exist for complete backward linkage [lower half of Figure 2.3c] meaning that the results of the end evaluation could be linked back all the way to the first stage, allowing for the project to continuously follow the cycle and reduce the error of its output. In practice, such a level of backward linkage would not be feasible. If one runs into problems very early in the execution phase, there might be some leeway to go back a phase, adapt the design and restart the execution. However, in the case of for example a micro hydropower project, it would be technically and financially quite difficult once a whole system has finished construction, to go back to the feasibility stage and decide that it would be better if the system was constructed elsewhere.
One can compensate for the lack of backward linkages by trying to predict what will happen in following phases and try to adapt the current phase accordingly. This prediction could be based on intuition, knowledge of similar past projects, or by the use of a predictive model (Douthwaite, 2002). If the purpose of the assessment method is to help the developer approach the ideal project design as much as possible, it should somehow incorporate this need for backward linkages from the whole of the project chain.

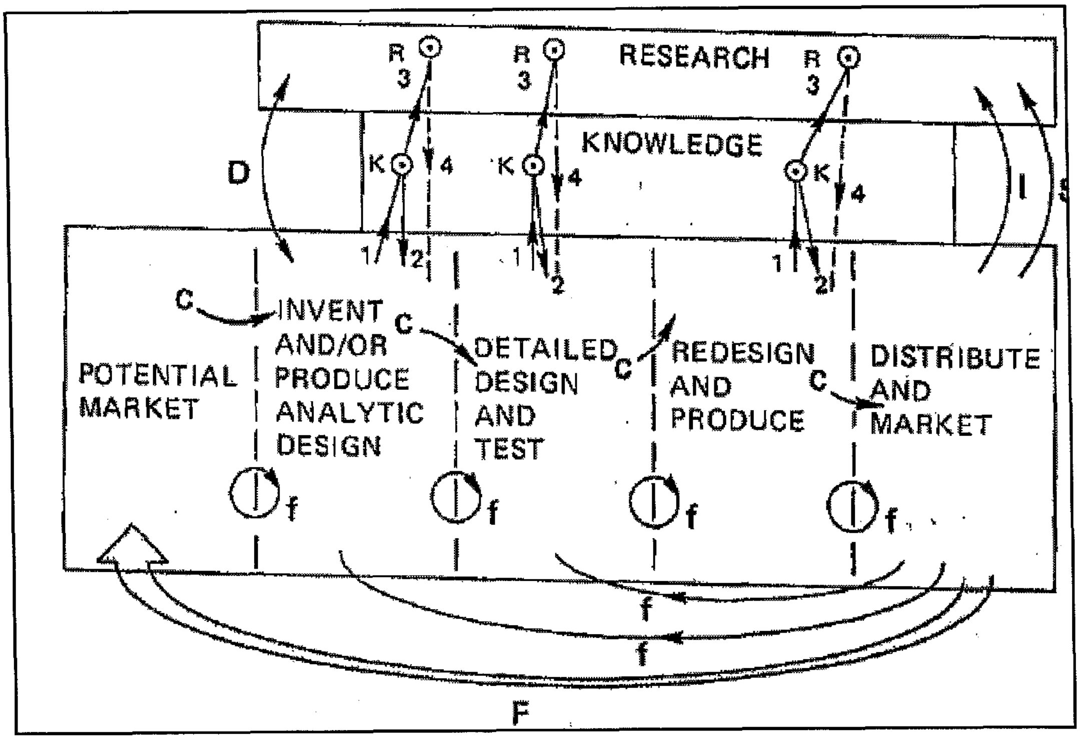
In the upcoming chapter 3 an attempt will be made to design a model that not only incorporates the factors found in the previous section, but also tries to embrace the information on project design presented in this section.

Figure 2.3b: Innovation process



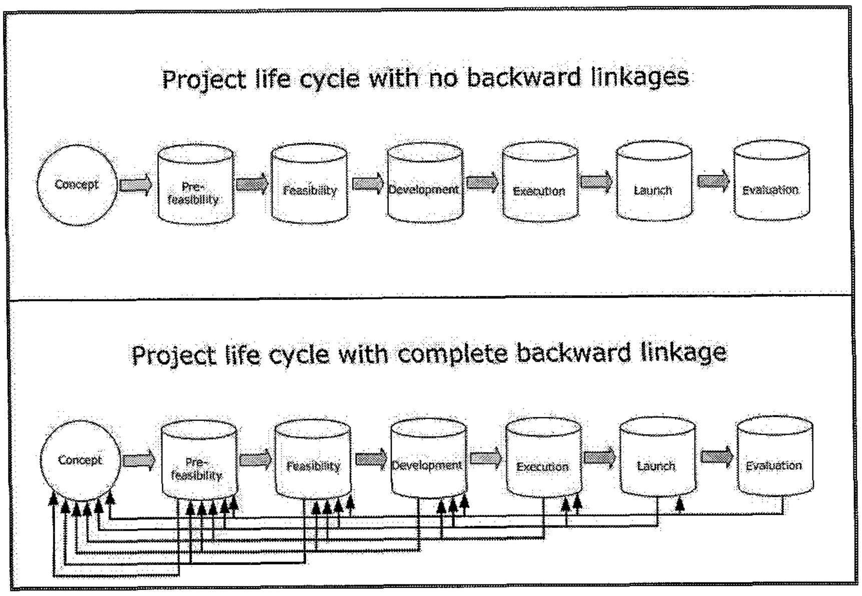
Source: Bond, 2002

Figure 2.3b: Innovation process



Source: Kline, 1986

Figure 2.3c: Project life cycle with and without backward linkages



Source: Adapted from Labuschagne, 2005

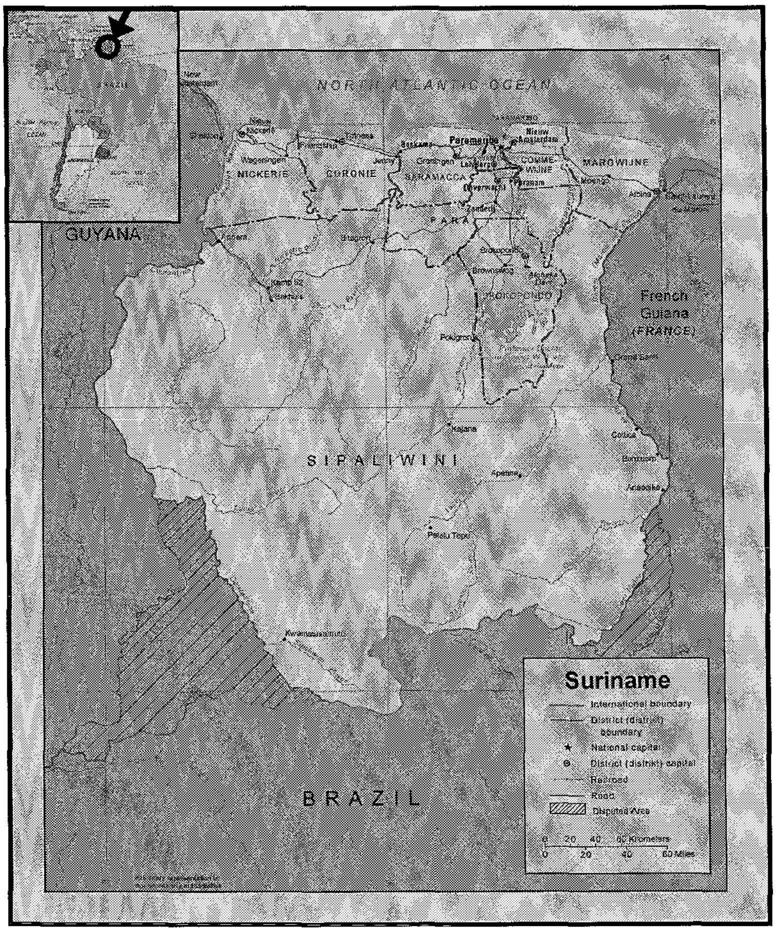
2.4 Suriname

Suriname is a country covered mostly in tropical rainforest. Through most part of the country, the population is very thinly spread and providing them with electricity has proven to be a cumbersome and expensive process. Currently, Suriname is looking towards off grid micro-hydropower as one of the solution to its energy problems in the inlands. Past experiences with micro hydro projects have, however, not been very successful. This chapter goes into Suriname's energy problems and the reasons why it looks towards micro hydro as a solution.

General Information

The country of Suriname[1] is located on the north east coast of South America. It borders on

Figure 2.4 Political Map of Suriname



Source: Adapted from http://www.lib.utexas.edu/

Brazil to the south, Guyana (formerly British Guyana) to the west and French Guyana to the east. Suriname is a former Dutch colony that gained its independence in 1975 but still has strong

[1] General information on Suriname gleaned from Bakker (1998), ABS (2005), Tractebel (2000), Adama (1984), Libretto (1990) and the 2005 World Development Indicators presented in Appendix A.5

social, political and economic ties to the Netherlands. The official language is Dutch.

Suriname covers an area of about 160 thousand square kilometres[1] and is populated by less than half a million inhabitants. The country is divided into ten districts. The capital city of Paramaribo and its outskirts form the smallest district. The largest is Sipaliwini, which covers an area of 130 thousand square kilometres. Almost half the population of Suriname resides in Paramaribo. The rest is mostly vested in a narrow strip along the coast with the Atlantic Ocean. Sipaliwini, which covers four fifths of the country, is also the least densely populated. This is in part due to the fact that Sipaliwini is almost totally covered with tropical rainforest. This rainforest is a part of the much larger Amazonian rainforest.

Box 2.4 Statistics on Suriname

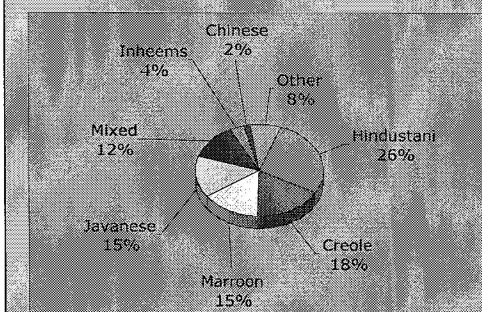
Table 2.1 General Statistics

Indicator	Value
Population	493 thousand
Surface area	163,8 thousand km²
Population per km²	3,0
Population growth	0,9 %
Life Expectancy	70,3 years
Literacy rate	89,6 %
GNI per capita	US$ 2.230
GDP	US$ 952,1 million

Table 2.2 Population spread

District	Population	Area in km²	Density
Paramaribo	242.946	183	1.327,6
Wanica	85.986	443	194,1
Nickerie	36.639	5.353	6,8
Coronie	2.887	3.902	0,7
Saramacca	15.98	3.636	4,4
Commewijne	24.649	2.353	10,5
Marowijne	16.642	4.627	3,6
Para	18.749	5.393	3,5
Brokopondo	14.215	7.364	1,9
Sipaliwini	34.136	130.567	0,3
Total	**492.829**	**163.820**	**3,0**

Figure 2.5 Ethnicity



Sources: ABS2005, WDI2005

With a per capita Gross National Income of US$ 2.230, Suriname rates as a lower middle income country according to the World Bank classification scale. Its main sources of income are the export of rice, sugar, and income from the mining industry; gold, oil and bauxite. Bauxite and its end product, aluminium, account for about 70% of the tax revenues. Bauxite has been Suriname's major export product ever since World War II, when aeroplane production made aluminium a valuable product. In 1960, in order to facilitate the aluminium industry, construction was started on a dam in the Suriname river. In this dam, a hydropower generator was placed that would provide enough energy to power an aluminium smelter, allowing Suriname to export aluminium instead of bauxite (its principal ore), thus increasing export revenues. The dam also provided electricity to the EBS, the Surinamese electricity company, which in turns provides the capital Paramaribo and other settlements with electricity.

Suriname is inhabited by people from many different racial and cultural heritages. This is a reminiscence of the colonial period, when the Inheemsen (Native American Indians) were deemed unusable as labour force for the plantations and the Dutch had to acquire their labourers through slave trade and later immigration. Most groups have their own dialect, but almost everyone also speaks Dutch and Sranang tongo. Sranang tongo is a mixture of languages and dialects that is used as a common language. All races and cultures are noticeable represented

[1] Part of this territory is disputed territory. Suriname possesses disputed borders with Guyana to the west, between the upper Corantijn, the Curuni and the Kutarie river as well as with France (France Guyana) to the east, between the Litani and the Marowijne river.

in Paramaribo. In the Sipaliwini, the Marrons (descendents of runaway slaves) and the Inheemsen are the most prominent inhabitants. There are virtually no roads into the interior, and most villages are only reachable by boat are aeroplane. Because of a geological exploration program named Operation Grasshopper, which was instigated in the sixties, several small airfields were opened up in the interior of Suriname. Through this program and the efforts of several religious and social organisations, most of the inhabitants of the interior have long ago come into contact with western society. Several schools and a network of medical outposts have been established. Still, the remoteness of these areas causes them to lapse behind in socioeconomic development compared to the coastal areas. Most villages live in a subsistence economy, there are no facilities for secondary education and access to electricity is sparse to almost non-existent.

Electricity

Energy distribution in Paramaribo and the coastal areas is mostly handled by the energy utility company EBS. They have an agreement for the purchase of electricity from the SURALCO. SURALCO (Surinam Aluminium Company, a subsidiary of the ALCOA, American Aluminium Company) operates the hydropower plant at Afobaka. Electricity is transmitted from Afobaka to Paranam and from there on to Paramaribo by means of a high voltage transmission line[1]. EBS purchases about 65 MW of energy from the SURALCO and produces the rest with its own diesel-operated power plants. The areas connected to the grid are Paramaribo and parts of Wanica, Para, Commewijne and Saramacca. Several other areas are provided with electricity through independently run diesel generators. The largest is situated in the district of Nickerie, which is run by an independent subsidiary of the EBS.
For the villages situated further into the interior, the responsibility for electricity supply falls under the rural electrification department of the Ministry of Natural Resources. Here, electricity is provided by small diesel generators (10-60 kW).

When the Brokopondo lake was build many inhabitants (mostly Marrons) that lived along the upper Suriname river had to relocate to either further up the stream or to new settlements in the Brokpondo and Para area. They could not, however, profit from the benefits of the Afobaka dam, as the electricity was routed from the dam straight to the aluminium smelter at Paranam, and from there on to Paramaribo. In order to provide both the Marron and the Inheemse villages with electricity, the Surinamese government placed diesel generators in some of these villages. Free of charge, the government provides both the diesel to run these generators as the fuel needed for transportation of the diesel. This operation is both pricey and environmentally unsound. The diesel needs to be transported to the villages by either small canoes or airplanes, which in themselves use large amounts of fuel for this transportation.
Villages are supposed to receive a monthly supply of diesel that is rationed to enable running the generator for lighting and some light appliances in the evening hours. Although the government is responsible for supplying the fuel to the interior, there are often gaps in the delivery due to monetary or fuel shortages. Electricity is therefore in short supply in these villages.

Solutions

In the past, Suriname has looked towards several scenarios for enhancing access to electricity, both urban and rural. Extension of the current grid towards the inlands is not a feasible option from an economic point of view, except for those villages already situated close to the transmission line. Other villages are to sparsely populated and remote for such a scenario.

[1] In February 2006 a new 161 kV transmission line from Paranam to Menckendam(Paramaribo) was finished.

There have been several attempts made to solve the energy problems in the rural districts by using renewable energy technology. Small solar systems have been in use in Suriname for more then a decade. Medical outposts all through the inlands use solar systems to power radio transmitters, small cooling units and in some cases electron microscopes for checking blood for diseases such as malaria. In one case an entire village along the Sipaliwini river in the south of Suriname was provided with solar home systems in the course of a development project. In the eighties, the main focus of attention was on the possibility of new large-scale hydro projects. The biggest would involve the creation of another large water reservoir and hydro power system with an installed capacity of 800 MW.

Because most of the inland villages are located along the rivers in Suriname, micro hydrology was also considered an option. Micro hydropower as a source of energy was first used in the eighties, when the government built the Poketi hydropower installation near the Gran Holo rapids to provide five villages with electricity and power a small wood mill. Unfortunately, this installation only lasted for a couple of years. The technological design of the Poketi hydropower structure itself was a sound one and at first it functioned properly. However, after only three years Poketi had stopped running. A number of problems, mainly non technical, caused the cessation of operations. In the following years the installation completely withered away.

The Surinamese government is currently, twenty years after Poketi, reassessing the possibilities for providing the inlands with electricity by means other than the current - expensive and environmentally unsound - means of a series of diesel powered generators. As mentioned, studies proved a grid extension into the inlands to be too expensive because of the low population density within the thickly forested inlands. Although other forms of energy generation (such as solar and wind) have been considered, the attention has recently once again become focused on small hydropower schemes.

In 2002 the Palumeu Micro Hydro project was conceived. This time the scheme was not a government initiative, but the idea came from the inhabitants and people with close bonds to the community of Palumeu. This is an Inheemse village deep in the tropical jungle in the south of Suriname. The idea gained sponsors in the form of the UNDP, a tourist organisation with a residence located at the edge of the village and the Anton de Kom University of Suriname, which would provide the technical know-how.

The Palumeu Micro Hydro project in Suriname is supposed to function as a pilot scheme for future small-scale hydro electrification schemes in the inlands of Suriname. However, at the end of 2005, three years after the conception of the scheme, the micro hydro project had not been finished yet. Just like the Poketi project, it was experiencing a large number of unforeseen problems, this time both technical and non-technical. The presence of these problems led to the initiation of this research.

3. Model Design

In this chapter the design of the preliminary theoretical model is discussed. The objective is to design a model that is comprehensive, basing its assessment on a broad array of factors. The design also needs to work in such a way that the resulting assessment is provided on the basis of long-term, sustainable development, meaning the model should look beyond the design and construction phase. The literature reviewed in chapter 2 will provide the basis for this model design.

3.1 Design approach

The design of the model can be subdivided in to three parts:

- *Theoretical Map*: First a theoretical map containing all the critical factors found in the literature research is constructed. These are arranged into a number of main categories and subdivided into main factors and sub factors.
- *Functionality*: In the second part an attempt is made to translate the theoretical map into functional design as assessment tool.
- *Software model*: As a final step the assessment tool is translated into a software model to make it easily useable and amendable.

3.2 Theoretical Map

In chapter 2 literature search was carried out in order to identify the factors critical to the success or failure of a micro hydropower project. These factors will form the basis for the model. The literature mentioned in chapter 2 was reviewed with two main goals in mind:

- Identification of the critical factors relating to micro hydropower, rural electrification and sustainable development.
- Identification of known solutions to the problems surrounding these critical factors.

The role of each of the topics within developing countries was where the focus of the literature search was laid.
This literature search resulted in a large number of critical factors spanning a variety of fields. A summary review of these factors has been presented in section 2.2 of the previous chapter.

The list of factors extracted from the literature is not immediately usable as map or guideline. These factors first have to be classified and organised in a usable structure. At the end of chapter 2.3 several possible options are mentioned for the classification of factors that have an influence on rural electrification.
When choosing a classification three issues are to be kept in mind:

- *Surveyability*: In the software model, the factors will have to be arranged into a surveyable map. This means that a classification is preferable where the number of categories is kept to a minimum. Too high a number of categories would lead to a map that was not easily surveyable.
- *Comprehensiveness*: Although a minimal number of categories is preferable from a design point of view, the model needs to be comprehensive. A balance has to be found between keeping the number of categories low, while still providing the user with a comprehensive array of factors.

- *Point of reference*: The purpose of the model is to aid in the design process of a micro hydro project and increase awareness on a managerial level. Classification of the factors will therefore be considered from the point of view of those functioning on that level, namely: local developers.

Keeping these three issues in mind, the following main categories were selected:
- Organizational
- Social
- Technical
- Economic
- Institutional
- Environmental

These six categories are defined as follows:

Organizational
The organizational category comprises all factors relating to the management approach and structure of the project, during all stages, from conception to operation. Included are the goals and aims of the parties involved, the structure of the corporation between parties, management structure and personnel. Also included are the factors relating to promotion of the project and the learning process.

Social
In this category the factors pertaining to social development, involvement and capability are summarized. The impact of the project on development is measured through livelihood indicators. The level and extent of involvement of the community are assessed, as well as the available capability of the community for carrying the project. Also included in the social category are the demand and willingness of the community for executing the project, and the social aspects of the projects end use.

Technical
In the technical category those factors pertaining to the technical aspects of the project are combined. These include:
- The technical feasibility study
- Design and engineering of the system
- All material components relating to the construction of the micro hydropower system
- Material components needed for operation and maintenance of the construct
- Requirements pertaining to the technical personnel involved

Economic
The economic category contains the economic and financial aspects of the project. The cost benefit analysis is preformed within this category to ascertain the financial revenues of executing the project as well as the ability of the project members to carry the costs for this project. Additionally, the options for loan financing and funding, the economic aspects of the projects end use and the effects of the scale of the project are also included in this category.

Institutional
In this category most factors which fall out of the scope of the local developers' or community's influence are combined. These include factors such as legislation surrounding

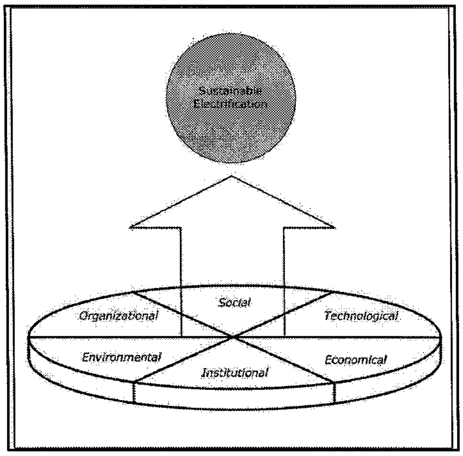
tariff setting and water rights, governmental policies on rural electrification and renewable technologies, the influence of development agencies and political interference.

Environmental
The impact the project has on the local natural environment and the regulations surrounding these impacts are summarized in this category.

The critical factors found in the literature search are arranged into one of the categories listed above. In Appendix C.1 this is represented in the columns three to eight of the table, where the factors are cross represented against the six categories. During the arrangement of the factors and the categories some considerations were made. These considerations concern the following topics:

Weight and order:
One of the main objectives of the model was to provide a comprehensive approach, encompassing several different categories. The literature review in chapter 2 leads to the conclusion that from a long-term sustainable point of view, each category plays a pivotal role in the success of a project. Therefore, each category is given equal weight in the assessment [Figure 3.1], as opposed to assigning more importance to one category than another. Still, in order to keep this report orderly, the categories are presented in a certain arrangement which will be kept constant throughout most of this report.

Figure 3.1 Equal weight of factors



Rather than choosing an arbitrary arrangement based on randomness or alphabet, the choice for arrangement was made as follows:
First comes the organizational category. This is because the model is aimed at the local developers managing such a project. Second comes the social category, because these two aspects are closely related through community involvement. The technical category comes third because micro hydropower is mature technology and the critical factors pertaining to this factor are most easily identified. The costs and benefits of the project are based mostly on the outcome of the technical category, which is why this category is followed by the economic category. Next come the institutional aspects, which mostly lie out of the range of influence of the local developer. The project will mostly be on the receiving end of influence exerted from this category, rather than vice versa. The environmental category is last in the arrangement, as micro hydro projects are deemed to have a very low environmental impact. However, I have to stress the fact that this arrangement does not constitute a way of assigning importance to categories, and that all categories are given equal weight.

Table 3.1 Critical Factors

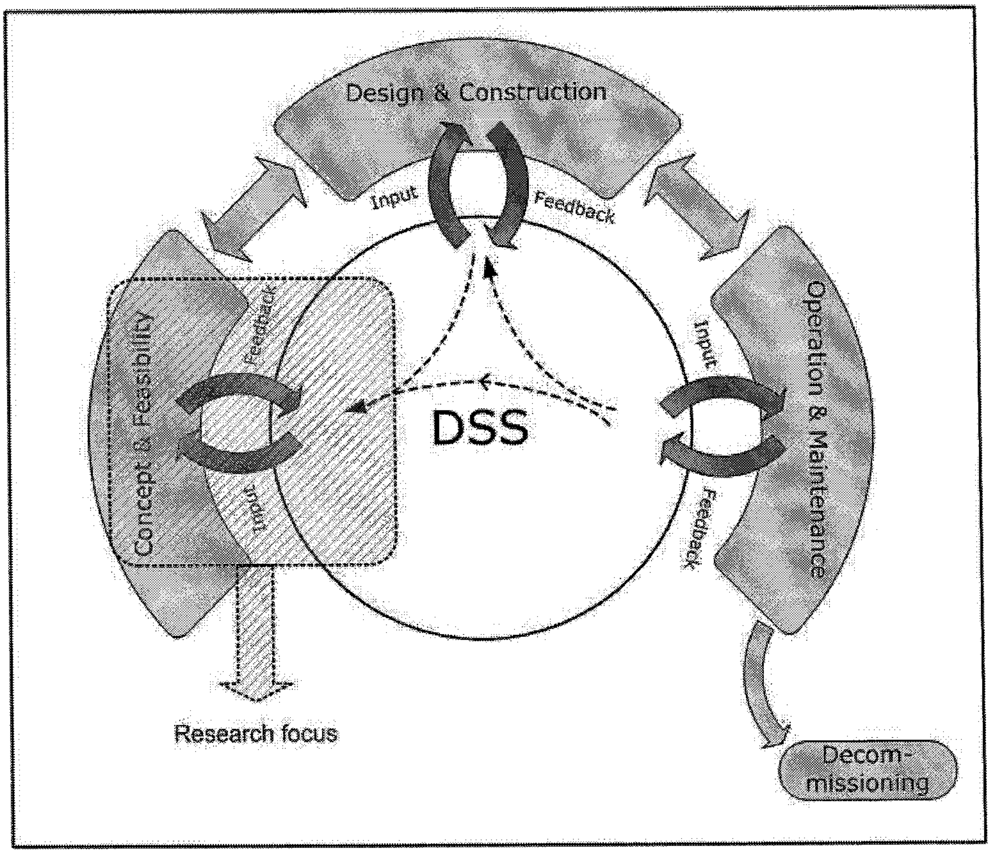
Category	Critical factors	
	Factor	**Subfactor**
Organizational	Objectives	Organisational objectives
	Project Management	Leadership
		Structure and capacity
		Autonomy
		Accountability
	Plant Management	Ownership
		Approach to plant management
		Management Personnel
		Technical Personnel
		Administrative Personnel
	Promotion	Promotion of project
		Promotion of pilot
	Learning process	Local Knowledge
		Former experience
		Evaluation
Social	Demand	Need for MHP generated electricity
		Willingness to pay
		Ability to pay
	Technological Capability	Availability
		Enhancement
	Community involvement	Character
		Extent
	Livelihood	Poverty
		Health care
		Educational facilities
		Gender aspect
		Housing
	Orientation towards sustainable development	Orientation towards sustainable development
Technical	Application	Designated end use
		MHP design
	Potential	Water Potential
		Site evaluation
		Power estimate
	Power demand	Volume
		Variation
		Growth
	Civil Works	Storage and Intake
		Waterways
	Hydroelectric equipment	Turbines
		Generators
		Control Equipment
	Transport and distribution of energy	Transmission
		Distribution
	Operational procedures	Operational procedures
	Major maintenance procedures	Major maintenance procedures

	Personnel Requirements	Engineers
		Operators
		Maintenance personnel
	Material requirements	Quality
		Availability
Economic	Costs and benefits	Cost benefit analysis
	Income generation	Income generating schemes
		Incentives
	Funding	Availability
		Extent
	Loan Financing	Local availability
		Suitability of loans for long term MHP investment
		Training of local institutions
	Economy of scale	Programme size
		Available capacity
		Outside stimulation
	Focus on poverty reduction	Aptness of tariffs
		Access promotion
		Inflation
Institutional	Development Programme	Integration of development programmes
		Aims
		Clarity of aims towards community
	Political involvement	Political involvement
	Government Policy/Legislation	Legislation
		Promotion RET
		Standardization
		Grid supply
	Development agencies	Development agencies
Environmental	Impacts	Resources
		Habitats
		Ecosystems
		Air
		Water
		Soil
		Flora
		Fauna
		Aesthetics
		Natural and Cultural heritage
	Reserved/Residual flow	Provisions for necessary residual flow
	Regulation	Environmental regulation

Table 3.2 Interaction and function of model with life cycle phases

Micro hydropower project	Model	
Life cycle phase	Direction of interaction	Function
Concept and Feasibility	Input	*Source for ideas on project concept*
		Guidelines and tools for feasibility
	Feedback	*Results of feasibility study*
		Data for storage
Design and Construction	Input	*Guidelines for project design*
		Solutions to known problems
	Feedback	*Feedback on effectiveness of guidelines for adaptation of model*
		Encountered problems and solutions for inclusion in database
Operation and Maintenance	Input	*Guidelines on operation and maintenance*
	Feedback	*Evaluation on project for use on future projects*
Decommissioning	*No interaction with this stage*	

Figure 3.2 Ideal design and research focus



Multiple appearances:
Some factors appear in several categories in one form or another. This is unavoidable. Most of the factors found can be assigned to different categories, depending on from what point of view that particular topic is approached. This can also be seen in the table listed in Appendix C.1, where several factors are cross referenced against more then one category. In most cases a choice can be made for which category the factor relates to the strongest, thereby keeping multiple appearances to a minimum. Sometimes, however, it is necessary to mention a topic in several categories. In each category, the corresponding aspect of that factor is taken into account.

Interrelationship:
All factors pertain to the design, construction and operation of a sustainable micro hydro project. This means that many -if not all- of the different factors are somehow interrelated. For factors within the same category, the relationship is more evident then the relationship between factors of different categories. An attempt to visually map out these interrelationships would result in an unsurveyable array of cross-links. This would defeat one aim of the model, which was to provide the user with a surveyable map of the critical factors. Still, in some cases, it is useful to explicitly point out an interrelationship. This is done in the practical design by means of references and links within the map. An example is the link between a social survey on living conditions and a technical factor on power demand, or a link between the technical components such as the turbines and the generators and the cost benefit analysis.

Once all the factors have been assigned a category, the list of factors is sorted by different categories. The factors are collated and organised into a usable map of factors and sub factors. The resulting map of factors and sub factors is represented in Table 3.1. This map forms the basis for the model design. The link between the factors found in the literature and the organised map can be reviewed in Appendix C.1 where the last three columns of the table form the critical factor map.

3.3 Functionality

In the section on project design in chapter 2, some requirements are discussed for what functional aspects would have to be incorporated into the design and use of a model. The model would need to somehow incorporate backward linkages from all of the different stages of the project and attempt to integrate the advantages of both a blueprint and a process approach.

Aim
The aim of this research is to design a model to aid in the assessment of projects aimed at long term, sustainable development. This means that the model must be able to look beyond merely the project cycle ending with the construction of the micro hydropower installation. The model should be able to provide its assessment based on feedback linkage from the stages of design, construction and operation/maintenance[1].

[1] For more details on the choices made for modelling the life cycle of the project, see Appendix A.3.

Figure 3.3 Use and growth of DSS

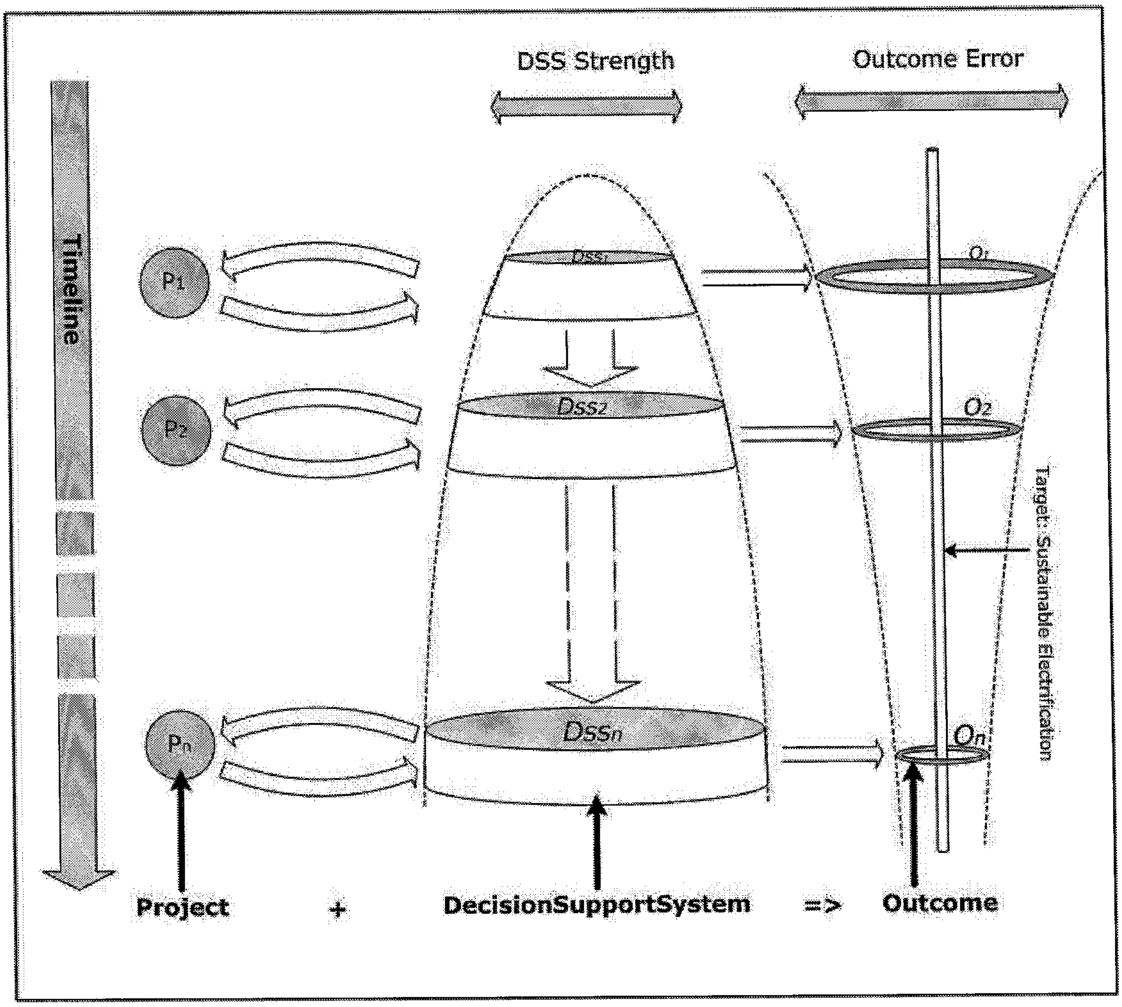
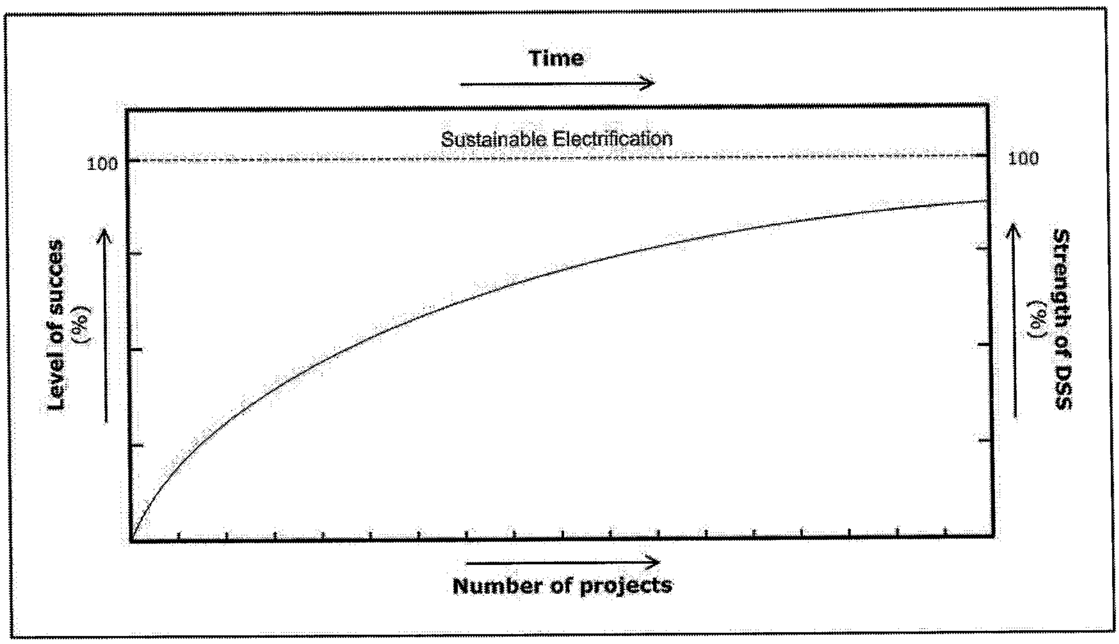


Figure 3.4 Progression project success level



Ideal design

In ideal circumstances, an assessment model with such aims in mind would not function in a stand alone capacity. Instead it would be an integrated part of a broader decision support model or system, which would be able to directly interact with all stages of a MHP project, providing the means for forward and backward linkages within as well as between these stages. A conceptual form of how such a support system would interact with the different phases of the project, is depicted by Figure 3.2 and Table 3.2. The interaction between the system and the life cycle stages of a project is displayed in the form of arrows. Table 3.2 explains what the different functions during these interactions are. The ex-ante assessment model would form one of the tools for feasibility study, deriving input through the linkages provided by the rest of the system.

The support system would interact with all stages of the life cycle except for the decommissioning stage. Hydropower systems have an exceptionally long lifetime. More often than not, there will not be a decommissioning stage until the system has outlived its usefulness. Instead, separate parts of the system will be replaced or refurbished during its lifetime. Refurbishment or replacement is included into the operational phase.

Besides providing feedback on the project, the decision support system would also have to incorporate feedback on its own effectiveness, allowing the possibility of a learning curve to enter the system design. Feedback on the difference between the predicted (and desired) outcome would allow for adaptation and growth of the system. This should in turn lead to an improvement of the outcome of the project using the system. A graphical representation of this is given in Figures 3.3 and 3.4.

A functional representation of such a decision support system would need to be based on three main pillars: A collection of guidelines for the execution of the different project functions, a collection of tools for executing assessments, monitoring and evaluation, and a database for storing information from previous projects [Figure 3.5]. This database would provide a simulation of backward linkages on project stages that have not yet been reached, by providing substitute information from other projects.

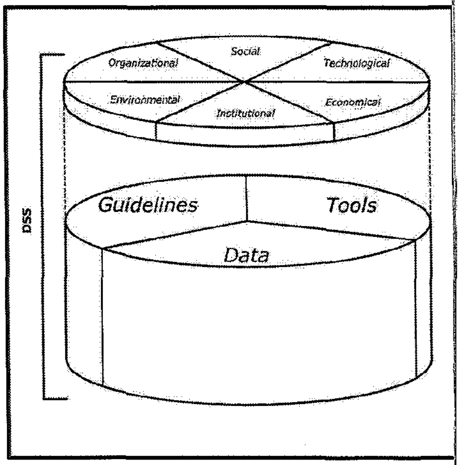
Research limitations

The practical design (let alone the testing) of such an ideal decision support system falls far outside of the scope and capabilities of this thesis. In Figure 3.2 the shaded part of the schematic depicts the research focus of this thesis and with it the limitation of the design. Effectively, this research can be described as a single loop through the interaction arrows between the first project stage and the model: An assessment will be provided on the Palumeu case, and feedback on the model will be provided from the execution of this assessment.

Functional design

For the functional design, first an operationalisation of the critical factors found in the theoretical map is made. This operationalisation is represented in the first half of the operational table in Appendix C.2. Next, on basis of best practice lessons for MHP project design found in the literature, a criterion is assigned to each operational indicator in order to judge the status of these indicators. This is represented in the second half of the operational table in Appendix C.2. To provide input for these criteria, a number of measurement tables are constructed, which are represented in Appendix C.3. With the data collected in these tables the outcome of the criteria can be calculated or decided and a value can be assigned to the operational indicator.
For this (experimental) design the possible values for the indicator are kept to a minimum: Positive, to indicate a positive influence on the chances of long-term sustainability of the project,

Figure 3.5 Functional design



Negative to indicate a negative influence and Cautious to indicate the inability to assign an uncontested Positive or Negative (e.g. because of a lack of accurate data). The value of the indicators used to decide the outcome on the sub factors, which in turn decide the outcome of the main factors. Weighing the effect of the different indicators is done based on best practices and locally acquired information.
The information acquired in order to determine the outcome of the criteria will be stored within the model, thereby allowing the model to increase its database with each run.

3.4 Software

The translation of the map of factors into a usable model was done through the use of computer software. The software[1] in question is called mind mapping software. It is software designed especially to visualize brainstorming sessions, map out and coordinate management processes and manage information surrounding the various topics and processes involved.
In the software model, the critical factors are presented in a graphical map consisting of six subtopics (the main categories) leading to the main goal: Sustainable Electrification.
The map is a modular one; each category represents a separate module, and within each category the factors themselves are represented as separate modules. The modules can all be separately collapsed or expanded, as per the users' preference.
By selecting a category a separate window is opened providing access to the measurement tables for the factors within that category. Selecting the factors and sub factors provides access to a text window containing the criteria for the various operational indicators and, if applicable, links to other software tools such as a voltage drop calculator or spreadsheet for load and cost calculation. Knowledge collected during the use of the model can be edited into the model in the form of a text, links to documents or references to knowledge bases. Through the use of icons the status of the operational indicators and the factors (positive, negative or neutral) can be depicted in the graphical map, allowing for easy surveyability of the project status and identification of the problem factors.
The three screenshots provided in Figures 3.6a-c show what the software model looks like Figure 3.6a shows the map fully collapsed, displaying only the main categories. Figure 3.6b displays the map with all the categories fully expanded. The final screenshot, Figure 3.6c,

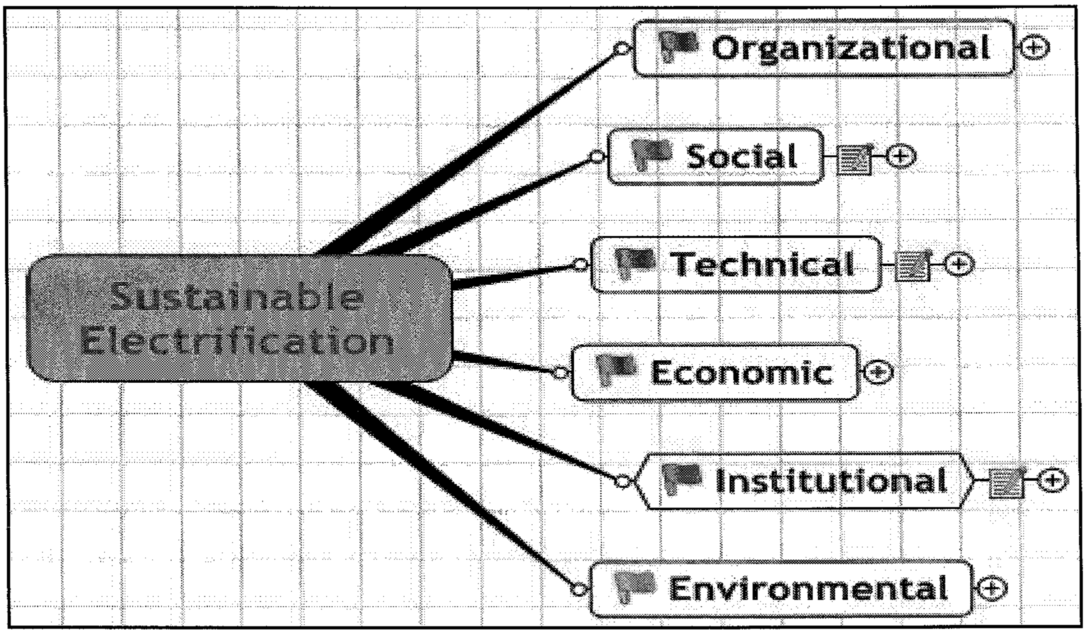
[1] The tool in question used was Mindmanager Pro 6 (copyright Mindjet LLC)

displays the map with one category selected, thereby opening the window containing the measurement tables.

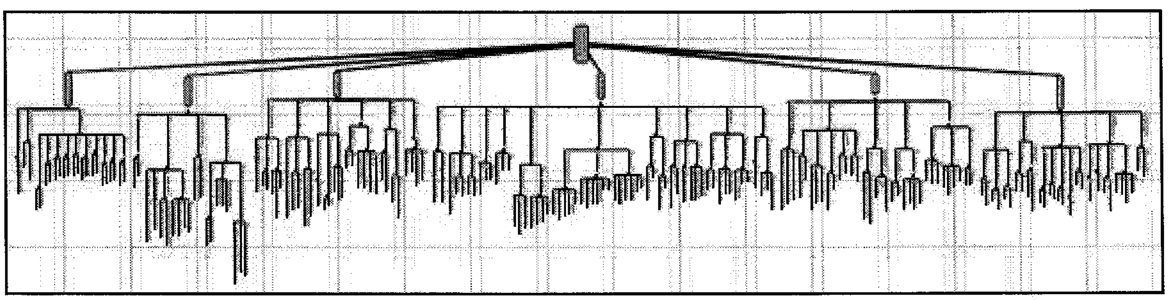
3. 5 Summary

Using the information found in the literature, a map was constructed of the critical factors pertaining to the design and execution of MHP systems in a developing country. A functional design for using this map was build by operationalising the critical factors, constructing measurement tables for obtaining input for the model and assigning a criterion for each operational indicator, based on the best practice experiences also obtained from the literature. The design was then translated into a software model that presents all the factors in a modular map sorted by category. Data on each factor, obtained from use of the model, can be stored either directly within the model or through use of linkages to documents.

Figuur 3.6 a Collapsed view of software model[1]

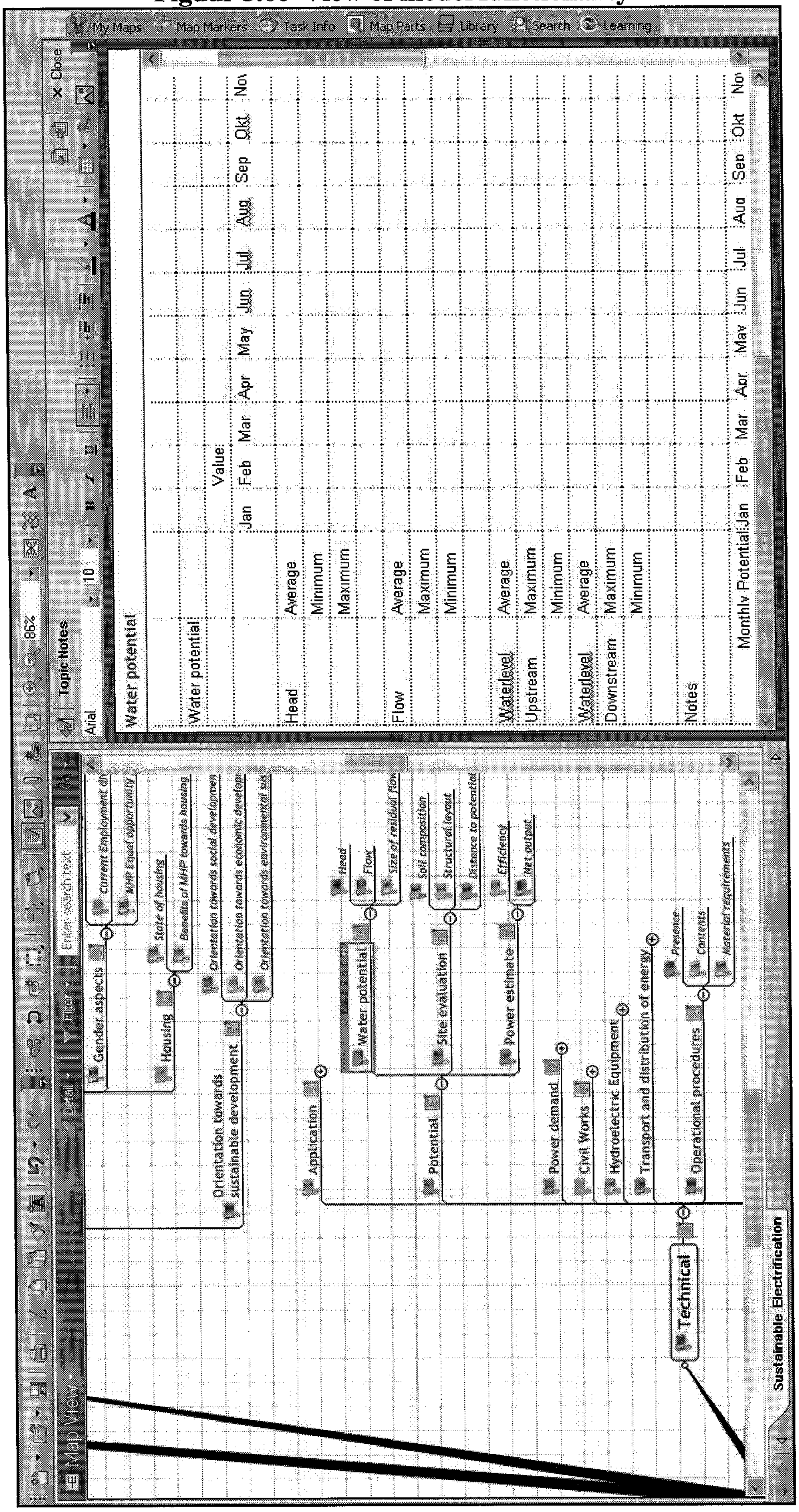


Figuur 3.6b Fully expanded view of software model[2]



[1] Output example of the Palumeu case, discussed in further on in this paper [chapter 5, section III]
[2] Rotated and minimized to fit in this paper. Actual software view can be expanded to a readable level

Figuur 3.6c View of model functionality



4. Field Research Methodology

This chapter describes the method of field research utilised on location in Suriname. The first part of the field study consisted of a search for local archives and other sources of information in order to fill in the model. The second part of the study consisted of an evaluation of the comprehensiveness of the model on the basis of two past cases of sustainable energy projects in the inlands of Suriname. The model is then modified according to the information gained from these studies. The third part consists of application of the revised model on the current case (the Palumeu MHP) to gain feedback on the models ability to function in a practical environment and to provide an assessment on the Palumeu case itself. This chapter describes the methodology for executing these studies

4.1 Available local data

4.1.1. Objective

The preliminary model given in chapter 3 was designed on the basis of literature from various international sources. In order for the model to be applicable to the case of Suriname the model had to be fine tuned for the local conditions. The objective of the first part of the research was to collect data specific to the local conditions in Suriname, especially data pertaining to the inlands.

4.1.2 Methods of data collection

Local data was collected both through a local archive search and through interviews with various local experts.

4.1.2.1 Local archive search:

This entailed

- Locating and inventorying local archives which contain data and/or statistics necessary for input into the model
- Reviewing local archive material for what descriptive or statistical data was available on the local situation in Suriname that could be attached to the critical (sub) factors in the model. Reports, books, brochures and general archive material were used as source material
- Data acquisition from the located archives: Incorporation of as much as possible data from the aforementioned sources into the model. Because of the time restriction with the field research the priority lay with data that would be useful to the Palumeu case.

This is represented in Table 4.1. The table containing the critical factors is already represented in Table 3.1: Critical factors.
All of the archives were located in the capital city Paramaribo. Possible non-standard (unlisted) archives were located mostly through referral by contacts made at the university or during one of the several interviews conducted.

Table 4.1: Structure of archive search

Subject	Data collection
Category (Organisational, Social, Technical, Economic, Institutional, Environmental)	Presence of database or information archive with available data on the critical (sub)factors in this category relating to the situation in Suriname
	Descriptive information available on the critical (sub)factors in this category relating to the situation in Suriname
	Statistical data available on the critical (sub)factors in this category relating to the situation in Suriname

4.1.2.2 Data collection through interviews:

Data and information on the diverse categories is also gathered through interviews with various local experts knowledgeable on said categories. Some of the interviewees were interviewed both on general local data as well as case specific information for the second and third part of the research. In Table 4.3a a list is of interviewees and the subjects on which they were interviewed is given. In the cases of interviewees possessing case specific information the interview length in this table refers only to the amount of time spend on collecting general local data/information.

The general structure for each of the interviews conducted with the experts was:

- Introduction: A short explanation of the purpose of the research: construct an assessment model for sustainable energy projects in Suriname
- Open interview: The subject was encouraged to divulge what knowledge he or she had on their particular expertise that would be useful for such a model.
- Explanation of the model: A summary explanation of the model is given to the interviewee
- Structured interview: With the critical factor map of the model [Table 3.1] as a checklist the interviewee is asked whether he or she has knowledge pertaining to the factors mentioned in the operational table. The length and depth of this part of the interview is dependent on the range and depth of knowledge displayed by the interviewee in the first part of the interview.

4.2 Evaluation of past projects

4.2.1. Objective

On the basis of the general literature reviewed in chapter 2, a number of critical factors were found to be of influence on the success or failure of these projects. These factors were found on the basis of studies done on rural electrification world wide. The second part of the research is to assess whether the model based on these factors is comprehensive enough, meaning: are there any factors of influence on rural electrification projects in Suriname, which lie outside of this model.

4.2.2 Method of research

The comprehensiveness of the model is assessed by reviewing two past cases of rural electrification in Suriname. The Poketi Micro Hydro Project and the Kwamalasamutu Solar Electrification Project. With each case it is reviewed what were the factors of influence on these cases, whether these factors are already represented in the model and whether or not it is probable that these factors are generally applicable to the case of Suriname. This is represented in Table 4.2

Table 4.2 Evaluation of old electrification cases

Subject	Indicator	Operational
Comprehensiveness of model	Factors of influence on electrification project	Factors of influence during conception
		Factors of influence during design and construction
		Factors of influence during operational phase
		Factors of influence during decommissioning
	Model shortcoming	Factors of influence not represented in model
	Need for adaptation	General applicability of lacking factors

4.2.3 Method of data collection

Data for this part of the research was collected by reviewing case files and conducting interviews with the lead designers of the two electrification projects and two former members of the BWKW. The interview details are represented in Table 4.3b.

4.2.4 Past Electrification Cases

The Poketi Micro Hydro Project

The Poketi project was a MHP project which was finalized in 1981. It was build near the village of Poketi, alongside the river Tapanahony in the south-east of Suriname.
The Poketi project was chosen as case study because up until the Palumeu project, it was the only micro hydropower project ever implemented in Suriname. Other projects were considered or even designed but none were realised. Information on the workings and failures surrounding this project are therefore valuable input for testing the model.

The Kwamalasamutu Solar Electrification Project

The Kwamalasamutu project encompassed the design and construction of solar energy units to provide the village of Kwamalasamutu with electricity. The units were installed in 1994. Kwamalasamutu is located alongside the river Sipaliwini, in the south west of Suriname, close to the border with Brazil.
Although the current assessment model is designed specifically for MHP, the Kwamalasamutu project was chosen as a test case. It is the only example of a large scale sustainable rural electrification project which was actually build and ran satisfactory for a longer period of time. The technical component (solar power) does not match the models specific Technical component (hydro power) the model was designed for. However, the non technical issues surrounding rural electrifications are still of value in testing the model. Since no other MHP projects besides the Poketi MHP was implemented, Kwamalasamutu was chosen as a suitable substitute

4.3 Application of the model to the Palumeu case

4.3.1. Objective

The objective of the third part of the study was to gain feedback on the models ability to function as an assessment tool for a practical case and to produce an assessment on the chances for sustainability of the Palumeu case.

4.3.2 Method of research

The assessment study on the Palumeu case was done by applying the model, which has been attuned to the case of Suriname, to the Palumeu case. Data and information was filled into the model and each factor was assigned a negative, positive or cautious indicator. On the basis of the indicators a conclusion was drawn on the effect of each of the main categories on the sustainability of the Palumeu project. Observations on the strengths and shortcomings of the models were noted during the application of the model.
An operational representation of the model including all indicators as well as the operational measurement tables is presented in Appendix C.2 and Appendix C.3.

4.3.3 Method of data collection

Data for input in the model was collected through:
- Review of case material: Data was collected from the available case files and field reports of the university project team.
- Structured observation: A four day visit was made to the Palumeu village, including a one day visit to the construction site at the Panato creek. Observations were made on the technical status of the project as well as several indicators relating to the energy demand situation. Information received from a kroetoe (group conversation) with the kapitein, basjas and local foremen was compiled and entered into the model
- Interviews: Several structured interviews with members of the project committee and people otherwise connected to the project or the village. The details of the conducted interviews are represented in Table 4.3c

4.4. Additional information

Stationing
The field research was conducted in cooperation with the Faculty for Technical Sciences of the ADEKUS. This researcher was stationed at the university for six months under auspices of the department of Electrical Engineering. Most of the research was conducted in the capital city Paramaribo. Research on the Palumeu case was conducted in cooperation with the lead university coordinator of the Palumeu project team. Besides the excursion to the Palumeu site the researcher also undertook a four day observational tour along the Marron villages along the Upper Suriname river and a visit to two proposed MHP sites.

Language
Most interviews were conducted in Dutch (official language of Suriname). Exceptions to this rule was one interview conducted in Sranang tongo (common native language in Suriname) and one conducted in English.
Since the researcher, being of Surinamese birth, is fluent in all three languages, a translator was not deemed necessary.

4.5 Notes on data collection

The original purpose of the research was to focus the study on the case of Palumeu and besides delivering an assessment on the information available, an attempt would be made to perform a survey to gather what information was missing for making a sustainable design. There were to be three visits to the Palumeu site. One initial orientation visit (which was executed), one visit for a thorough survey of the local situation and if possible perform some metering at the MHP site, and a final visit for delivery of feedback to the local community.
During the orientation visit, it was clear that there were severe communication and trust issues between the local community and the design team in Paramaribo. This situation severely prohibited the researcher's ability to ask questions without losing neutral status. After the initial report on the local situation, the project committee decided to discontinue other two excursions. The data for performing the assessment on the Palumeu case is gathered from the first observational visit and what secondary sources of information could be located outside of Palumeu.

Table 4.3a Interviews for Local Data Search

Interviewee	Subject Categories	Case specific information	Location	Interview length (Approximate)
Designer/Main engineer Poketi project	Technical, Social	Poketi	Paramaribo	30 minutes
Former Ministry of Interior/BWKW representative	Institutional	Poketi	Paramaribo	30 minutes
Project leader of the Palumeu Project/Anton de Kom University representative	Technical, Economic, Institutional	Palumeu	Paramaribo	1 interview 30 minutes
Director METS; Ecotourism organisation	Economic	Palumeu	Paramaribo	15 minutes
Chairman of VIDS, Organisation of Inheemse chiefs	Social	-	Paramaribo	30 minutes
Director of IMWO (Institute for social research at the ADEK)	Social	-	Paramaribo	15 minutes
Kapitein (chief) of Inheemse village Langamankondre	Social	-	Paramaribo	1 hour
Chairman of Hiawata, foundation for Inheemse women of Marijkedorp	Social	-	Albina	1 hour
Missionary of the World Team Mission, a religious organisation active in Inheemse territories	Social	Palumeu	Paramaribo	30 minutes
Chairman of StiBop, foundation for the Marron village Botopasi	Social	-	Paramaribo	1 hour
District Commissioner to Sipaliwini	Institutional, Economic, Social	-	Paramaribo	30 minutes
Representative of Community Development Fund Suriname	Institutional	-	Paramaribo	30 minutes
Two representatives of Ministry for Regional Development	Institutional, Economic	-	Paramaribo	1 hour
Head Education of the Jan Starke Institute; Training centre for Interior inhabitants	Social, Environmental	-	Paramaribo	15 minutes
Director of REMACON, engineering company for the Palumeu project	Technical, Economic	Palumeu	Paramaribo	15 minutes
Former head of Bureau Waterkrachtwerken (BWKW)	Technical, Institutional	Poketi	Paramaribo	1 interview 1 hour, several discussions (15-30min)

Table 4.3b Interviews for Evaluation of Past Electrification Cases

Interviewee	Subject: Case study	Location	Interview length
Designer/Main engineer Poketi project	Poketi	Paramaribo	1 interview 2 hour, 1 interview 1 hour, several discussions on case file(15-30 minutes)
Former Ministry of Interior/BWKW representative	Poketi	Paramaribo	30 minutes
Former head of Bureau Waterkrachtwerken(BWKW)	Poketi	Paramaribo	1 interview 1 hour, several discussions on case file(15-30 minutes)
Designer/Executing engineer of Kwamalasamutu project	Kwamalasamu tu	Paramaribo	2 interviews 1 hour

Table 4.3c Interviews for Model Application to the Palumeu Case

Interviewee	Subject Categories	Location	Interview length
Project leader of the Palumeu Project/Anton de Kom University representative	All	Paramaribo	Several interviews and discussions during whole of field research period
Chairman of Word Music Ministry, foundation representing Palumeu village	Social	Paramaribo	15 minutes
Director METS	Organizational, Economic	Paramaribo	30 minutes
METS Resort Manager Palumeu	Organisational, Social, Technical	Palumeu	30 minutes
Basja of Palumeu	Organisational, Social	Palumeu	30 minutes
Missionary of the World Team Mission	Social	Paramaribo	15 minutes
Director of REMACON	Organisational, Technical, Economic	Paramaribo	30 minutes

5. Results and Evaluation

In this chapter the results of the field study in Suriname will be presented and evaluated. The chapter is divided into three major parts. First the results of the search for local data needed for amendment of the model to the local situation is performed. In the second part the two historical cases are evaluated to check the model for comprehensiveness. In the third and final section the model is applied to the Palumeu case with the twofold goal of assessing the current situation of the Palumeu project and obtaining information on the model by application on a practical case.

I Local data search

Since this research was a first stage test of the model, the database contained only general data gained from the literature search. In order to properly use the model, data needed to be collected on the local situation in Suriname. An effort was made to collect local data relevant to each of the categories involved. Because time constraints of this research and in view of the objective of applying this model to the Palumeu case, the focus of the data gathering was laid on information pertaining to the inlands, especially relating to the Trio and Wayana. For future purposes however the model must also be able to perform outside of this area. Therefore, in the local data search, the attention is focussed on both locating sources of information that can be useful as data sources for the model, as well as the required data.

5.1 Local data sources

Local data on the different factors were acquired through:
- Local archive and database search
- Interviews

5.1.1. Databases

Obtaining data from reliable databases proved to be a cumbersome task. This was due to two reasons:

- Scarcity of data: There is very little useful data available pertaining to the inlands, especially pertaining to the Inheemse tribes of the Trio and the Wayana and the area they live in.
- Accessibility of data: In some cases useful information was not (easily) accessible, such in the case of the Bureau for Hydropower Works and the Sescon library.

In Table 5.1 a list is presented of the archives located that can serve as potential data sources for the model, the category of information available and a short description of the database. A more extensive description is provided in Appendix B.14 on databases in Suriname.
If the data available is reviewed by category, the following can be surmised:

Organizational category:

As this category is highly dependent on the project it applies, this category can only be filled in with evaluation data of previous projects. There are however little or no evaluation reports on the nature of the organisation of past projects, since this is one aspect that tends to be neglected by most project organisations. Information for this category had to be acquired from interviews[1].

Social category:
In the social category, the data available on the inlands is often outdated or insufficiently specified. This is mostly because of the nomadic nature of the Inheemse tribes, the turmoil caused by the inland wars and the discrepancy between the official registration and the actual situation. In the case of the Wayana and the Trio tribe, lack of data on social factors is caused by the fact that very little social research has been conducted on these tribes[2].

Technical category:
Hydrological and geological data is available from several government services, but most of the data available only pertains to the coastal areas, not to the inlands. One useful archive was the BWKW, but this bureau is being disbanded and most dossiers and case files are no longer accessible. Another useful database is the Sescon library, which is however not accessible to the general public and is at the moment still being constructed.
This situation makes technical data useful for MHP in the inlands either scarce or inaccessible.

Economic category:
The same situation as the social category applies to the economic when it comes to data for the inlands; data is either out of date or non-existent. One potentially useful source would be the Foundation for Tourism in Suriname, as ecotourism is an upcoming source of income for the inlands.

Institutional category:
No specific databases were located for this category. The information gathered for this category was gathered only through interviews.

Environmental category:
For this category two potential sources of information were located, namely the environmental department of the Faculty for Technical Sciences and the Conservation International Suriname. However, due to research constraints, the information for this category was gathered only through interviews.

Table 5.1 Database sources

Source	Category of available information	Summary description
Faculty for Social Sciences of the ADEK University	Social	Contains a social research institute with some literature on social factors in the inlands. Little to no data available on the Trio and Wayana tribes
General Bureau for Statistics (ABS)	Social, Economic	Has statistical data on social indicators such as population density, growth etc. There are inaccuracies in data on the Inheemsen caused by nomadic behaviour and turmoil of the inland wars.
Bureau for Hydropower Works(BWKW)	Technical	Former bureau responsible for hydro research in Suriname. Contains some technical data from past assessments, but most data lost due to the fact that the bureau is being decommissioned

From interviews conducted:
[1] WongLoiSing; Artist
[2] Akrum

Central Bureau for Arial Survey (CBL)	Technical	Possesses detailed aerial maps of the inlands useable for measuring distances to potential sites.
Sescon Library (private)	Technical	Private library containing useful data on energy projects in the inlands. The library is still being constructed and data is not (yet) accessible to the general public.
Geological Survey Department	Technical	Contains data from geological surveys. The data available is limited to the coastal areas and portions of the Suriname river and the two border rivers
Ground Registration and Land Information System (GLIS) (under development)	Technical	New land information system in which various databases pertaining to land information will combined and digitalized. This system is still under development
Hydraulic Research Division (WLA)	Technical	Contains hydrological data on the Surinamese waterways. Data limited to the coastal, downstream portions of the rivers.
Meteorological Services Suriname (METEO)	Technical	Contains meteorological data on Suriname, including data from airstrips throughout the inlands. Due to the inland wars there are laps in current data
Faculty for Technical sciences of the ADEK University	Technical, Environmental	Contains literature and expertise on local environmental and technical setting. Currently actively involved in MHP research.
Central Bank of Suriname (CBvS)	Economic	Data on inflation statistics and price indexes
The Foundation for Tourism in Suriname (STS)	Economic	Data on tourism statistics in Suriname and potential revenues from ecotourism in the inlands
Conservation International Suriname	Environmental	Data on environmental setting in the inlands

5.1.2 Interviews

Local data was also collected through interviews with local experts on the several categories. In Table 4.3a an overview of the interviews conducted is presented.
These interviews were very useful in providing data that could not be obtained through database search.
There are two drawbacks that come from relying on these interviews for the provision of data:

- Figures derived from these interviews were often ballpark figures, delivered from memory. Therefore they are not an accurate source of data and introduce a measure of uncertainty in the model. The level of uncertainty can vary greatly, ranging from data based on single observations to data based on years of experience and intimate involvement with the subject data.
- Statements from the interviewees are often prone to bias because the interviewees had either a singular perspective on past projects, or had an active interest in biasing the results for the current (Palumeu) project. Because of the limited amount of time and experts available it was not always possible to cross reference the statements and figures mentioned by the interviewees

Despite these drawbacks the lack of sufficient data from reliable databases makes these interviews an indispensable source of knowledge.

5.2 Results and evaluation of local data search:

The evaluation of the local data search follows the division into the six major categories and subsequent division into factors and sub factors as represented by the mapping of critical factors in chapter 3 on model design [Table 3.1]. The results for each category are evaluated in the next paragraphs.

5.2.1 Organizational category

With the organizational category, the local data search yielded notable information on the following topics:
- Leadership
- Ownership of the plant
- Personnel for plant management
- Former experience

Leadership[1]
Suriname has little to no experience with micro hydrology. Although there were big plans in the eighties for the deployment of MHP projects, only one project was actually carried out (Poketi). There is at present only one engineer with experience in building a MHP site. This means that finding a local leader with the correct qualification will prove to be a difficult undertaking.

Ownership of the plant[2]
The ownership form of the plant might prove to be an obstacle. The preferred form of ownership structure in Suriname is by forming a foundation. The drawback to this form is that a foundation only has a board that has sole power of attorney. This is unlike a cooperative form where members can have voting rights. In the inlands where the family interest still plays a deciding role, this can have very negative influence on the correct conduct of the foundation board.

Personnel for plant management
One problem lies with obtaining skilled personal for plant management. This is because of the following factors[23]:
- Brain drain towards the capital city: There are no educational facilities beyond grade school in the inlands. Students have to move to the capital to obtain a higher education, and tend to stay there.
- The capital city offers much better chances for job opportunity and higher income.
- The inaccessibility of the inlands make it an unpopular place to work as stationing in the inlands often means that one will be cut off from travelling to the capital for long periods of time.

Another drawback lies in the traditional lifestyle of the Inheemsen. Traditionally, their approach to organisation and employment is governed by direct, short-term needs. Adjusting their mentality to undertaking a project that will require long-term planning, maintenance and investment will require extra efforts[2].
These two drawbacks mean that extra resources and time will have to be taken in order to train local personnel for the management of the plant
One positive factor of note is the mechanical aptitude of boatmen in the inlands[4]. The inlanders depend on outboard motors on their boats for transport and fishery. These outboard motors are a very important commodity in their everyday lives. Because of this, there are local inhabitants who have developed proficient knowledge and skill to keep these motors running, as well as other mechanical equipment such as chainsaws and small generators. This

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[1] DelPrado; Niekoop; NgATham
[2] Artis; Lytle
[3] ABS, 2005
[4] DelPrado; Seedo

aptitude could be useful in training personnel for the regular maintenance of the MHP structure.

Former experience
As mentioned before, there has only been one previous MHP in Suriname, which only ran for a couple of years before stranding. This means that there are no local experiences with MHP projects that can be used as a reference.

5.2.2 Social category

With the social category the local data search yielded notable information on the following topics:

- Need for electricity
- Willingness to pay
- Ability to pay
- Enhancement of technical capacity
- Health care
- Educational facilities

Need for electricity[1]
- Along the river Upper Suriname and its source rivers, 27 of the approximately 52 villages[2] have access to electricity through diesel generation. This means that 48 % of the villages do not have access to electricity unless through privately owned generators. Exact size numbers for the villages are not known. An overview of the different counts by different organisations performed in 1996-97 gives an idea of the inaccuracy.

Table 5.2 Inhabitants of the upper Suriname by different sources[3]

Inhabitants of Upper Suriname according to:	Count
Central Bureau for Registration (1996)	7,612
MZS(medical outposts)(1997)	28,000
Village administrators(1997)	34,500

The probable causes for error in these numbers are:

- CBR: The data banks of the CBR were still very much in disarray in 1997 and were only expected to be updated after the next census was taken. This did not take place until 2004.
- MZS: These numbers were probably the most reliable in 1997. The error that comes into this count is that the MZS did not have insight into what portion of the villagers was registered simultaneously at different outposts, which is not uncommon amongst the Marrons. This leads to a total count that is probably higher than the actual count.
- Village administrators: A higher number of villagers could lead to a higher diesel quota and possible benefits from political parties, especially during election years. This gave village administrators a high incentive to estimate numbers on the high side.

[1] Strijk, Seedo, Ramses, Banai
[2] See Appendix B.7 for an overview map of villages along the Upper Suriname
[3] Nurmohammed, 1998

According to a recent survey done by the Census bureau[1], there are about 15,000 people living among the Upper Suriname. By using the counts provided by local administrators in 1997 to estimate proportional division of these inhabitants throughout the different villages, the villages connected can be assumed to account for approximately 55% of the villagers along the Upper Suriname. This means that about 8,300 villagers have access to electricity along the Upper Suriname, and 6,700 do not. Using the average household number of Suriname (3.94) this comes to about 1,700 households.
For the households that are connected, approximately 0.72 kW of electrical power is installed[2].
- In the Inheemse village of Langamankondre set in the coastal area, the community arranged to buy extra diesel on top of government allowance to ensure a year round stable supply of electricity. The presence of this stable supply caused an explosive increase in electronic equipment such as laundry machines, freezers, DVD players and microwaves. The installed capacity was increased from 30kW to 150 kW and is still lagging behind the demand. This indicates that estimates for power requirements in a village should take into account the inhabitants desires for such equipment.

Willingness to pay[3]
- In Langamankondre the villagers did not indicate great willingness to pay for the fuel themselves. According to the Kapitein, it took several kroetoes and a lot of convincing to get them to agree to this. Actual collection of agreed fees is still a cumbersome task as most villagers do not make a budget for their expenses and do not always have money on hand. The close family ties within the village make it difficult to exercise punitive measures in such cases.
- Langamankondre is the only village in Suriname that has arranged for continuous electricity by paying for it themselves. Similar initiatives suggested in villages along the Upper Suriname have met with resistance as most of the Marrons assume it is the governments duty to provide the electricity for free as it has been doing up till now.
This indicates that getting a community to pay for their own electricity will take a lot of convincing.

Ability to pay[4]
- The village of Langamankondre has a steady flow of income thanks to the fact that the village receives a lot of tourism and gets an allowance for nature preservation: The beach of Langamankondre is one of the rare places where sea turtles come to lay their eggs. On top of this, the village is situated opposite of the river of French Guyana and many villagers also possess the French nationality granting them welfare benefits in European currency. According to the Kapitein, the proximity to French Guyana is also used to trade goods without going through customs. All these factors give Langamankondre an income benefit above other villages. Assessment of ability to pay on basis of this village might therefore not be applicable to other Inheemse villages.
-Most communities in Sipaliwini live on a subsistence basis[5]. Hunting, fishing and farming are the main activities, which are done almost purely for own consumption. Commercial activities include trade, forestry, woodcarving, gold mining and digging for gravel. No actual income statistics are known for these activities.

[1] ABS, 2005
[2] See Appendix B.8 on Government Expenditure
[3] Ramses, Artist, Seedo
[4] Strijk, Baghwandas, Ramses, Seedo
[5] Molendijk, 1995; Nurmohammed, 1998

An upcoming form of income is formed by Ecotourism. Along the Upper Suriname there are about 27 tourist lodges. No figures on income statistics are known. See also in the Economic category under the heading "options for income generation".

Enhancement of technical capacity
- Experts[1] on Inheemse culture point out that abstract thinking, especially concerning monetary issues, is a difficult concept for most Inheemsen living in a traditional society. Extra training will have to be provided to explain concepts such as depreciation and reinvestment.
- The Jan Starke Institute[2] in Paramaribo, Suriname, is a government-sponsored institute that specializes in training people from small communities in the inlands to use technical appliances. This ranges from small wood chopping equipment to driving tractors and running mobile saw units. The director of the institute indicates that the institute would be open to the possibility of extending its learning program to maintenance on MHP sites, but that instructors would first have to be trained in the specifics.

Health care[3]
The MZS is a foundation that has situated 52 medical outposts through the inlands of Suriname. At present most of these outposts function on a combination of solar and diesel generated electricity. The solar equipment is long overdue for replacement. An internal report written in 1997 for the PAS, which is one of the participants of the MZS, lists a number of drawbacks with the use of solar equipment in the inlands and recommends looking into other forms of energy generation. This indicates the MZS might be interested in taking part in MHP projects to supply their outposts with electricity as a replacement for the solar units. A map with the location of the current outposts is provided in Appendix B.6.

Educational facilities[4]
There are only primary schools situated in Sipaliwini. For a higher education children have to travel to Paramaribo. Due to the travelling distances and difficulties, there is a major brain drain towards the capital, leaving a shortage of capacity for local personnel with a higher education. The distance and difficulties are also the cause for a shortage of teachers for the inlands. The comforts offered by a constant electricity supply could go a great way towards lowering the resistance of teachers for being stationed in the inlands and thus offer an improvement to education in the inlands.

5.2.3 Technical category

With the technical category, the local data search yielded notable information on the following topics:

- Water potential
- Demand volume
- Civil works
- Distribution
- Engineers
- Maintenance personnel

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[1] Artist; Lytle
[2] Hewit
[3] www.medischezending.sr
[4] Strijk

Water potential

-After the turmoil of the revolution in 1980, stream flow measurements in the Surinamese rivers were stopped for a couple of years. Measurement was picked up again in 1984 for some stations, but the inland rebellion of 1986 put a complete stop to measurements in the inlands and most measurement stations were lost either through decay, destruction or theft.

According to the WLA there is data available on the downstream portions of the rivers from 1961-81 and from 1984-86. However, data concerning the upstream parts was lost due to the disbanding of the BWKW.

The mean monthly discharge graphs of the station at Pokigron[1], first village along the Upper Suriname shows a high variance in discharge throughout the year. This applies to the other rivers as well. This means that design of a MHP station should take into account the probability of a high stream flow variation.

-There are rainfall measurements available from the METEO, which conducts measurements for the diverse airstrips situated throughout the inlands. The discharge variations for the Surinamese rivers are closely related to the rainfall variation. Coupled to stream flow statistics these rainfall measurements could be useful for estimating discharge variation throughout the years[2].

- The rivers and creeks in the inland are the main transportation arteries in the inlands. Furthermore, fishing is one of the main sources of food for inland communities. This means that the design of a MHP in the inlands will be strongly dependent on whether the river or creek, in which a dam or weir is being built, is one of these main arteries. Local needs for a residual flow will have a great influence on the possible potential.

-A report on the energy options in Suriname for the Ministry of Natural Resources[3] lists a number of potential micro hydro sites in the inlands and the size of the stations that could be installed there[4]. This list is also cited in a more current energy report on Suriname done for the EBS. There are, however, no references as to how these figures were derived and how the mentioned capacities of the stations involved are linked to the actual potential. Therefore, this list can ,at most, be used as a list of *suspected* locations.

Demand volume

- Numbers from the Ministry of Natural Resources reveal that along the Upper Suriname approximately 0.72 kW of electrical power is installed per household. This means that if the generators would function year round 4 hours per night, each household would use about 1MWh per year.

Table 5.3 Total electricity statistics along the Upper Suriname[5]

Total installed capacity	1516 kW
Approximate households	2100
Average installed capacity per person	0.72 kW
Average running hours	18:00 -22:00
Daily usage per household	2.9 kWh

These figures are based on installed capacity. This gives no evidence as to the actual usage and what the demand might be if 24 h electricity becomes available[6].

[1] See Appendix B.4 .2 for a graphical overview
[2] Contents of WLA library; WLA, 1969
[3] Tractabel, 2000
[4] Appendix B.13
[5] Banai
[6] Further details presented in Appendix B.8

Civil works
-Transportation of heavy machinery and materials to the inlands is cumbersome because of the inaccessibility. There are no roads past the Brokopondo lake at Afobaka, and transportation is done by canoes because of the many rapids and rocks in the river. Suriname does not possess helicopters for heavy freight. This means that heavy equipment to the more remote locations will have to be transported by aircraft. Commercially a Twin Otter DHC-6 with a maximum weight capacity of 1400 kg belonging to a local company is the airplane with the highest freight capacity that is capable of landing on airstrips in the inlands. An overview of commercial prices for inland flights is represented in Appendix B.9.

Distribution[1]
-In the villages along the Upper Suriname, which have been supplied with generators from the government, the ministry has also installed meters for the connected households. Although these meters are not monitored (as the government does not charge any money), they are available. This indicates that, in case of electrification, a portion of the connection fees might be spared because metering is already available.

Engineers[2]
- MHP projects cover a diverse number of scientific fields: civil, mechanical and electrical engineering, hydrological, environmental and social research and economic feasibility.

The Anton de Kom University used to have an advisory bureau in which all of these disciplines were combined. This bureau was available for consultancy at less than normal commercial fees. This bureau was however disbanded due to internal issues.

This indicates that the University has the capacity for providing consultancy on such projects, provided these internal issues can be resolved.

Operators[3]
- As mentioned in the organizational category under the heading "personnel for plant management', in most communities in the inlands there are several boatmen whose skill with outboard motor technology can be extended to the skills necessary for daily upkeep of a MHP plant. This means that acquiring personnel for technical operation of the plant should be feasible.

Maintenance personnel[3,4]
- There are no electrical or mechanical companies situated in the inlands equipped for conducting major maintenance on turbines or generators. Maintenance personnel will have to be flown in from Paramaribo.

5.2.4 Economic category

In respect of the economic category, the local data search yielded notable information on the following topics:

- Costs and benefits
- Options for income generation
- Funding and subsidies
- Economy of scale

[1] Seedo
[2] Niekoop
[3] Delprado
[4] Akker

- Tariffs
- Inflation

Costs and benefits

The usage statistics from the Ministry of Regional Development supply the costs for running the generators along the Upper Suriname. The costs come from the diesel allocated to a village, the gasoline needed for transport by boat and the lubrication oil for the outboard engines. There is no specification for labour costs. It is an expected tradition that the boatmen get more gasoline then is actually needed for transportation, and what gasoline is left after transportation plus the fact that the village has access to electricity, is viewed as payment.

Table 5.4 Annual Expenditure of Government in on Electricity for the Upper Suriname[1]

Government annual expenditure	SRD	USD
Diesel	1,635,600	594,764
Gasoline	327,360	119,040
Oil	57,600	20,945
Total	2,020,560	734,749
Total per household	962	350

Using commercial rates the government spends about 350 US$ per household per year for electricity along the Upper Suriname. This averages about 0.33 US$ or 0.91 SRD per kWh. For comparison: EBS tariffs in coastal areas are between 0.054 and 0.152 SRD per kWh for home users[2].

There are two side notes to the average expenditure of US$ 350, per household:

-The government subsidises diesel and gasoline in Suriname, so actual government costs will be higher

-The average price is deceptive, as the price per household is dependent on the distance the fuel has to travel and the number of households being provided with electricity from one generator. From the closest village to the furthest, the cost of transportation ranges from 5.5% to 62% of the cost of the diesel being transported. The costs for supplying the furthest village (Stonuku) is 2350 US$ per household, 6.7 times higher than the average[3].

-Villages, for which diesel transport by boat is unfeasibl,e have to be supplied by airplane. Of these villages, Kwamalasamutu is the most expensive from a transport point of view. Transport costs are 492 US$/barrel diesel. This is 2.3 times the cost price of a barrel diesel in Paramaribo.

For Palumeu transport costs equal about US$ 314 per barrel, about 1.5 times the cost price of a barrel diesel[4].

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Options for income generation[5]

- According to the district commissionaire, the most likely source of revenue for a MHP project would be from forestry. There is a steady demand for timber, both from the national and the international market. Access to cheap electricity would allow local communities to set up their own sawmills and gain a higher revenue from selling (half) processed timber than from unprocessed trees. Due to the high transportation costs the district commissionaire does

[1] Banai
[2] Appendix B.11
[3] Appendix B.8
[4] Appendix B.9
[5] Strijk; Seedo; STS, 2005

not expect such an endeavour to be profitable for communities that are situated so far inlands that they do not have direct access via waterways to Paramaribo or other coastal settlements.
- An upcoming source of income that might benefit from MHP would be the tourist industry. According to the STS, about 31% of tourists in Suriname undertook trips to the interior in 2004. The district commissionaire estimates an increase of tourist lodges (ranging from primitive to luxurious) along the Upper Suriname to have increased from 7 in 1997 to 27 in 2005. About half of these are considered to be stable tourist lodges.
Providing these lodges with electrical energy from a MHP plant would be both beneficial for the stability of these lodges- as energy prices would not be so highly dependent on the fuel prices in Paramaribo- and the promotion of ecotourism, as these lodges would now make use of a renewable energy source.
There is some discussion as to what portion of eco tourism revenues actually stays in the local community. Most tour operators are situated in Paramaribo. In some cases the lodges used by them belong to the local community, in others the lodges are built and owned by the operators, limiting the amount of revenue that the local community receives.
The STS has yet to complete their analyses on the economic revenues of eco tourism.

Funding[1]
Currently the government pays for the diesel and transport of that diesel to the inlands. The total expenditure for supplying the Upper Suriname, which accounts for about 50% of the inhabitants of Sipaliwini, is approximately US$ 735,000 per year. The government is looking into MHP as a source of energy to lessen these expenditures and would be willing to transfer at least a portion of the current expenditures towards subsidising the operation of MHP plants (or other forms of energy generation) if this eliminates the need for government sponsored fuel.

Economy of scale[2]
At present, the Palumeu MHP project is the only MHP project being built in Suriname. There are, however, indications that more hydro power projects can be expected.
The ministry of Natural Resources is looking into building a new MHP station at the Gran Holo rapids where the Poketi project was also built. This time three 100 kW units would be installed to deliver a total of 300 kW to 18 villages alongside that portion of the Tapanahony river.
The communities at Gunsi and New Aurora along the Upper Suriname have requested a survey by the Faculty for Technical Sciences of the ADEKUS into the possibility of constructing a MHP station near these villages.
These initiatives indicate a positive chance for the existence of a steady demand in MHP related goods and services.

Tariffs
- The costs of using electricity from the EBS in the coastal areas are partially sponsored by the government. At the time of research it was a topic of political discussion, as neither the government nor the EBS will reveal the extent of the subsidy provision. Therefore the relation between these tariffs and the actual cost of generating electricity for the EBS is unknown[3].

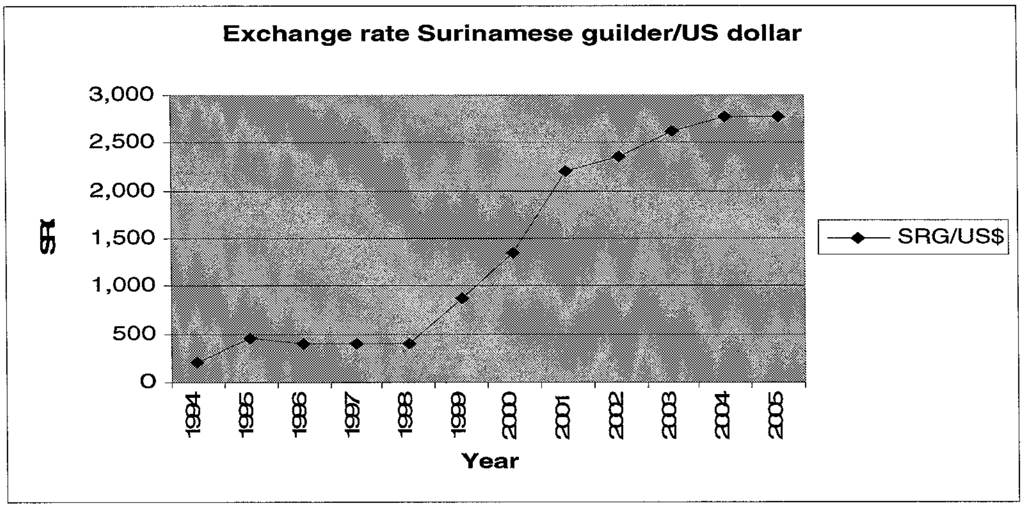
Inflation

[1] Abini;Banai
[2] Naipal; Abini; Akker
[3] See Appendix B.11 for EBS tariffs

- Political instability in Suriname has let to a high inflation rate over the last decade. This trend is reflected in the exchange rate between the SRG (Surinamese currency up until January 2004) and the USD (United States dollar). The exchange rate rose 500% in 4 years[1]. The current government has been working on stabilising the Surinamese currency. Per January 2004 the Surinamese guilder (SRG) was exchanged for the Surinamese dollar (SRD) at a rate of 1000 SRG: 1 SRD. The SRD was coupled to the US$ at a fixed rate of 2.75 SRD per US$. For now the stabilisation seems to have worked. Currently the Surinamese Bank incorporates a 7% inflation charge in its commercial loans

The inflation rate is clearly very much dependent on the stability of the government. In the beginning of the 1980's the exchange rate for the SRG was approximately 1 SRG: 1 USD. This rate has risen and stabilized each time with political instability until it reached a course of around 2750 SRG: 1USD. Although the current course seems stable, it would be wise that tariffs set for a MHP not only account for the *current* inflation rate, but to ensure against sudden increases in this rate by coupling tariffs to a more stable, foreign currency. An example of this is the EBS, which has divided its connection fees into a component in local currency and a component in US dollars.

Figure 5.1 Exchange rate of the Surinamese guilder vs. the US dollar[1]



5.2.5 Institutional category

With the institutional category the local data search yielded notable information on the following topics:

- Development programmes
- Political interference
- Legislation on land tenure
- Promotion Renewable Energy Technology
- Development agencies

Development programmes

- Organisation instituting development programs in the inlands seldom coordinate their programs with each other. This means there is less chance of an integrated development

[1] Appendix B.10

programme being instituted that will cover a wide area of both social and economic development goals[1].
- The Community Development Funds of Suriname (CDFS), which funds small development initiatives in both the coastal areas and the inlands, indicates that a recent change in IDB policy has led to the focus on sponsoring projects that have a productive output. This means the CDFS could be beneficial when it comes to finding incentives for coupling a MHP project to a productive scheme[2].

Political interference
- The Kapitein of a village is the chosen head and representative of that village. The Surinamese government recognizes the authority of these Kapiteins by making their appointment official and granting them a government commission. Officially, they are paid government employees. According to the CDFS, it is policy of the development organisation that sponsoring can only be given to non-governmental organisations, meaning the Kapitein cannot be (officially) involved in a project sponsored by such an organisation. This has led to authority issues and conflict within some projects of the CDFS[3].
- A positive example of political interference comes from the village of Botopasi, where the community used political connections to get the position of local rice mill operator designated as a public function, thereby ensuring that the person operating the mill got a government commission. That way the incentive was high enough for the person trained on the mill to stay in the village[4].

Legislation on land tenure[4]
- Suriname is one of the few countries that does not officially acknowledge native property rights. Although land can be bought from the government, it is common practice that Marrons and Inheemsen in the inlands live on what is officially government property. The government, however, has never actually interfered with native property rights. There is a long standing lobby in Paramaribo for the government to acknowledge these rights.
Along the Upper Suriname there have been some difficulties on this issue where a tourist resort was built by someone from outside the village on what the villagers themselves considered to be village property.
This indicates that land tenure might be a future cause for concern.

Promotion of Renewable Energy Technology
- Although the government of Suriname is interested in replacing the diesel generators in the inlands with renewable energy sources, it does not actively promote the use of these sources[5].

Development agencies
-A list of development agencies and foreign embassies active in development can be found in Appendix B.12 on development agencies active in Suriname. Due to time constraint the further nature and primary aims of these organisations were not investigated.

5.2.6 Environmental category

[1] WongLoiSing,; Seedo; Artist
[2] WongLoiSing
[3] WongLoiSing; Lytle
[4] Seedo
[5] Banai

With the environmental category, the local data search yielded notable information on the following topics:

- Impacts
- Environmental regulations

Impacts[1]
Most impacts will be considered low by local population as long as it does not interfere with livelihood. If the MHP is constructed in a main waterway the most important impacts to be considered would be the effects on the local fish population, as fish is a major food source for most inhabitants of the inlands.

Environmental regulations
The CIS manages a nature reserve of 1.6 mil. ha. In west-central Suriname. This area of land is protected by the Surinamese government to preserve biodiversity of the tropical rainforest. Deploying a MHP in this area would be against regulation. Outside of this area the government does not impose any environmental regulations on the local population[1].

5.3 Summary of local data search

The results of the local data search can be summarised as follows:

- Much of the data present in the databases located was either outdated, did not extend to the inlands or was not specified enough to be of practical use.
- Most data was obtained through interviews rather than from the database search. The data obtained from this information can vary very much in accuracy, depending on the experience and expertise of the interviewee.
- Most of the data obtained is descriptive in nature. This is an almost unavoidable consequence of the research being conducted in a country with a developing economy and about an area in which very little statistical research is done unless performed in light of a specific project. Still, although lacking in statistical quantity and quality, the data obtained provides valuable insights on the factors that have to be accounted for in a good project design.
- Some factors found which can have a significant negative impact on the conduction of a MHP project in the inlands are:
  - The lack of experienced consultants in the field of micro hydrology
  - The lack of hydrological data for assessing potential MHP sites
  - Expected difficulties relating to willingness to pay
  - High transportation prices to the inlands, impacting on the costs of civil works
- Some factors found which can have a positive impact on the execution of a MHP project in the inlands are:
  - The willingness of the government to find a replacement source of energy to reduce their high expenditure on diesel for the inlands
  - The rise of ecotourism as a source of income for the inlands, increasing the potential ability to pay for electricity

The information obtained from the local data search is added to the model, where it will be usable for assessing the impact of the subject factors.

[1] Hewit

II Evaluation of past cases

In this section an evaluation is done of the most important factors that either had an impact on or were a consequence of the two past electrification projects Poketi and Kwamalasamutu. These factors are extracted from the interviews and discussions held with the interviewees mentioned in chapter 4.2 [Table 4.2].
The evaluation follows the division into the six major categories on which the theoretical model has been based. In paragraph 5.2.3 the extracted critical factors will be reviewed to decide whether they merit a separate inclusion into the model.

5.4 Poketi[1]

The first historical case evaluated for critical factors involved, is the Poketi micro hydro project. First a project summary is given, followed by an evaluation of the factors.

5.4.1 Case summary

General overview of the Poketi Micro hydropower project:

Location:	1 km from the Marron village of Poketi, near the Gran Holo Soela, Tapanahony river[2][3].
Power output (max):	40 kW (127V/60Hz)
Head:	3 m
Design flow:	1.5-2 m3/s
Turbine:	Cross-flow (Ossberger)
Construction costs[4]:	SRG 1.200.000 /U$ 670.000, -[5]
Year of construction:	1979-1981
Primary targets:	• The provision of electricity for lighting and household appliances in the village of Poketi. • Demonstration of the ability to provide electricity with hydropower • Replacement of local diesel generators and fossil fuel use
Targets added during construction:	• Provide electricity for four more villages: Dritabiki, Juasa, Mainsi and Moitki • Provide electricity for a cassava mill and a saw mill
Current status:	The Poketi MHP ran for less than three years. After operations ceased, it was never started up again

The Poketi project was an initiative of the Surinamese Ministry of Natural Resources. It was designed and built by Surinamese engineers in the service of the BWKW, who were sent abroad for training especially for this project.
At first, the project succeeded in meeting its primary targets. Every house in Poketi was provided with electricity from the micro hydropower unit. However, the system broke down because of several reasons and was never rebuilt. In the end the diesel generator that was

[1] Information for Poketi case obtained from DelPrado, Niekoop, NgATham and DelPrado, 1981
[2] Travelling distance to Paramaribo: 2 hour inland flight/10 days by boat (dependent on season)
[3] See Appendix B.1 for location of Poketi and Appendix B.3 for schematics
[4] including a 10 km High voltage line
[5] 1980 exchange rate 1 U$= 1,80

meant to be replaced, once again became the only source of electricity for the communities near Poketi.
In the next paragraphs a summary of the main factors that impacted on the Poketi case subdivided into the six main categories is presented.

5.4.2 Evaluation of critical factors

Organizational category
In the organizational category the key factors that can be identified as having an impact on the outcome of the project are

- Hierarchical issues
- Proper training and preparation

Hierarchical issues:
Hierarchical issues between the engineering team responsible for the design and construction of the MHP and representatives of the Ministry of Natural Resources, have led to several shortcomings in project preparation and the final design. This can be derived from several comments in the case file:

- The design engineers commented on the lack of hydrological data and requested more measurements. The representative for the ministry deemed this unnecessary. The project was carried out on the basis of the measurements at hand and amended with estimations based on local experience.
- There are several suggestions made by the project team for a survey by the faculty of social sciences of the ADEKUS in order to determine the true demand that the system would have to satisfy. These suggestions were put off by the ministry.
- The original design for the MHP included three separate sand collecting devices to prevent sand entering the turbine. The ministry deemed that a cheaper, less thorough sand catch would be sufficient and the design was changed accordingly.

In the end, the main engineer was removed from the Poketi project after the construction of the waterways and power house were completed.
In theory, the BWKW was responsible for the design and construction of the MHP plant at Poketi. Because the project involved several government services and electrification of the inlands was officially the responsibility of the ministry of NH, a representative of this ministry was official coordinator of the whole project. Conflicting views on the design and construction had a negative impact on the sustainability of the MHP by leading to a less than optimal design.

Proper training and planning:
One factor that had a positive impact on the Poketi project was the decision to use part of a grant obtained from the OAS to send four engineers of the BWKW abroad to several European countries to study and learn how to design a proper MHP station. Based on the experiences gained during this period, a design was made that was conservative, using proven technology and mostly according to standard MHP guidelines. Best practice lessons in MHP learn that in pilot cases (such as Poketi) this is the best design approach to take.

Social category
In the social category the main factors identified as impacting on the outcome of the project were

- Lack of involvement of local population

- Lack of social pre studies

Lack of involvement of local population:
The idea for building the micro hydropower station at Poketi was conceived in Paramaribo. The possibility of using micro or mini hydropower in the inlands had been passed around in government circles a number of times, and when the opportunity for receiving an OAS grant for a sustainable energy project presented itself, the Poketi project was conceived and a proposal was drafted. The local population was briefed on the upcoming MHP project only after the plans were drawn up. The involvement of the local population was mostly a passive one. They supplied help in the form of labour for transport and boating. However, there was never any attempt made to promote a sense of ownership or responsibility in the local community for the MHP station. This led to the continuation of a passive attitude towards the MHP after the construction phase. Breakdowns in the system were viewed as a government problem and not something the local population should interfere or help with.

Lack of social pre study:
A social pre study into what the needs and preferences of the local population were was not carried out. There are several requests in the Poketi case file to remedy this by having such a study done during the design process. This lack of pre study had a negative impact on the MHP project in at least two ways:
- The local need for electricity reached beyond the village of Poketi and during the construction phase it was decided that four more villages, a saw mill and a cassava mill were to be added to the system. As the system was only designed to deliver 40 kW of power to the community of Poketi, it could not handle the additional load. (see also the institutional factors for this)
- The cassava mill was placed on the uninhabited island on which the MHP plant was constructed. As cassava milling is a woman's job and women are restricted to manual rowing for transport (the use of outboard motors is reserved for the men), this meant that the women could not easily access this cassava mill independently, thereby rendering it almost useless.

<u>Technical category</u>
In the technical category the main factors identified as impacting on the outcome of the project were
- Insufficient hydrological pre study
- Lack of locally available technical personnel

Insufficient hydrological pre study
The lack of proper hydrological pre study is mentioned several times in the case file. The project designers used local knowledge of water levels and added a safety margin to ensure that the turbine house would not be flooded when water levels exceeded the water levels obtained from available hydrological data. In 1983 an unforeseen drought caused the water level to go below the minimum expected levels. A combination of design cuts and unavailability of experienced technical personnel to take proper precautions then led to sand entering the system, in such a degree that the system broke down.

Lack of locally available technical personnel
When the drought in 1983 threatened to cause sand to enter the system, the turbine had to be properly shut down and the channels had to be cleared from sand and debris before they were

started up again. All BWKW technicians, however, were stationed in Paramaribo. Local operators were not trained for this kind of situation.

Economic category

In the economic category the main factors identified as affecting the outcome of the project were

- High transport costs
- Costs for transmission line
- Development of local market.

High transport costs

The transport of equipment to the Poketi site was done by military transport airplane to the nearest landing strip and from there by boat to the MHP site. The transport costs are estimated at SRG 600.000,- totalling almost 50% of the total project costs. This placed a strain on the budget for the MHP, causing the Ministry to save expenses elsewhere, namely in the pre study and design of the MHP.

Costs for transmission line

After it was decided to extend the project to include four more villages, a high voltage transmission line with a length of 10 km had to be constructed. This again meant a sizeable increase in budget, which was not prepared for at first.

Development of local market:

The project was extended to include the use of a cassava mill and a saw mill. Especially the saw mill was supposed to be a stimulus for the local economy, opening the opportunity for employment in the wood processing industry. However, besides the installation of the saw mill no further incentives were provided to stimulate the actual development of such a market. There is no data available on what use was actually made of the saw mill, but the BWKW did not note a significant growth of the local wood processing industry.

Institutional category

In the institutional category the main factors identified as impacting on the outcome of the project were

- Influence of the local Granman
- Inland wars
- Presence of development aid

Influence of the local Granman

The Granman is the chief of chiefs for a certain Marron or Inheemse tribe. The Granman of the Marron tribe that inhabits the area around the river the Marowijne (the eastern border of Suriname) and its source rivers, which include the Tapanahony and therefore Poketi, had his residence in the village of Dritabiki, 10 km from the Poketi MHP site. The Granman holds considerable sway over the local population, and it was at his insistence that the government had to change the design to extend the grid to Dritabiki. If this demand was not satisfied, the local population would be prohibited from cooperating with the construction of the MHP.

Inland wars

In 1986 an internal war between Ronny Brunswijk's Jungle Commando and the Surinamese's national army wreaked havoc throughout the inlands, causing the area to become unsafe. This war caused the cessation of most non-military government activities in the inlands. Cautious plans to bring the Poketi project back online never came to fruition. By the time the war had ended and the government returned its attention towards the development of the inlands, the system had worn down so much that it was deemed unfeasible to try and repair it.

Presence of development aid
It was the possibility of obtaining an OAS aid that stimulated the conception of the Poketi project. The OAS gift covered 20% of the final budget and without this gift it was highly unlikely that the government would have proceeded with the project at that time.

Environmental category

There were no environmental factors that had a notable impact on the project. The grant from the OAS was given in light of its policy on attaining its goals for environmentally sustainable development. The OAS gift has however already been covered in the institutional factors.

5.5 Kwamalasamutu[1]

The second historical case evaluated for critical factors involved is the Kwamalasamutu solar system project. First a project summary is given, followed by an evaluation of the factors.

5.5.1 Case summary

General overview of the Kwamalasamutu solar system project:

Location:	The Inheemse village of Kwamalasamutu, alongside the Sipaliwini river in the south west corner of Suriname[2]
Solar panels:	152 (type unknown)
Batteries:	154 (12V-100 Ah)
Number of connections:	252 units
Total installation costs:	Sf 790.000, - (440.000 US$)[3]
Year of construction:	1994
Primary targets:	• Elimination of costs of diesel generated electricity for the village • Increased reliability of electricity provision for the villagers of Kwamalasamutu
Current status:	The solar systems ran for four years until the batteries gave out. After that the systems slowly degraded or were dismantled. Currently the solar systems are no longer existent at Kwamalasamutu.

The Kwamalasamutu project provided 249 homes and some communal facilities with electricity. The village was inhabited, officially, by 900 Inheemsen of the Trio tribe. Kwamalasamutu is however a village subject to a fluid population, as the inhabitants travel back and forward across and along the south border of Suriname for long periods of time. At the time of traditional celebrations the community is estimated to exceed a population of 1500.

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[1] Information on Kwamalasamutu project obtained from DosRamos
[2] See Appendix B.1 for location of Kwamalasamutu
[3] Official exchange course 1 U$= 1, 80 Sf. At the the time the rate for non government projects was 201, 97 Sf/US$ and climbing

The preparation and installation of the solar system was done by a local consultancy agency for the Ministry of Natural Resources. The project was funded with the help of the European Union.

5.5.2 Evaluation of critical factors

Organizational category

In the organizational category the main factors identified as impacting on the outcome of the project were

- Planning, speed and execution
- Promotion

Planning, speed and execution

The planning and preparation of the project took almost a year. Several excursions were made to the Kwamalasamutu site to ensure that the local community was kept up to speed and all necessary on site preparations were made. The actual transport and installation of the solar equipment was done in a week's time. This saved on the personnel expenses for the technicians that had to be flown in from Paramaribo. Because of the relatively short construction period the strain on the local population, which supplied the labour force where necessary, was kept to a minimum.

Promotion

A great deal of effort went into the promotion of the project. Several kroetoes were held with the local community, and each project phase was explained in detail. In addition several of the labourers were offered the opportunity to travel to Paramaribo with the transport planes as a reward for their input in the project. This led to an active involvement of the community in the project, reflected both in labour efforts as well as in ideas for obtaining local material (see the technical category, under "local availability of tropical hard wood").

Social category

In the social category the main factors identified as impacting on the outcome of the project were

- Ability to pay from local wildlife sales
- Fringe benefits towards social development

Ability to pay from local wildlife sales:

A requirement for obtaining the grant for this project was that part of the budget was covered by the local community. As Kwamalasamutu thrives (mostly) on a subsistence economy, a standard solution was that the villagers cover their part of the budget through labour contribution. During the research phase of the project, it was discovered that the forests near Kwamalasamutu housed quite a lot of tropical birds and serpents that had a high market value in Paramaribo. By allowing the villagers access to the capital on the transport flights this allowed them to generate income by selling these on the market in Paramaribo. This increased the community's ability to contribute to the project and to buy additional electronics for themselves.

Fringe benefits towards social development

The execution of the project had several unintended benefits for the community of Kwamalasamutu, which were viewed as socially beneficial by the local community. These included:

- Increased contact with Paramaribo: The trade of birds and reptiles ensured regular contact (and trade) with Paramaribo.
- Introduction of the wheelbarrow: This replaced the matapi (an Inheemse stretcher) as means of transporting small to medium loads. Having a nomadic lifestyle, this was no small advantage for the inhabitants of Kwamalasamutu, who travel great distances by boat and on foot to other Trio villages in Suriname and across the border to Brazil.
- House numbering: All the houses were connected to a numbered solar unit. The villagers adopted these numbers as their housing numbers, enabling them to have individually registered addresses when communicating with the government or the medical aid foundation.

Technical category

In the technical category the main factors identified as impacting on the outcome of the project were

- Local availability of tropical hard wood
- Lack of distilled water and replacement batteries

Local availability of tropical hard wood

The knowledge of the community on locally available materials made it possible to acquire enough tropical hardwood for the construction of all necessary protection and supports for the solar installations. This had several advantages:

- Saving on material costs: The local population harvested the wood from the nearby forest for free, eliminating the need to buy the necessary material.
- Saving on transport costs: Because of the local availability of the hardwood, a great deal was saved on transportation costs.
- Maintenance: Hardwood is of such a durable quality that by using it the need for maintenance on and replacement of the support structures would be greatly reduced.

Lack of distilled water and replacement batteries

The Ministry of Natural Resources remained the official owner of the solar systems and responsible for supply of necessary materials for maintenance. This included the delivery of distilled water for the batteries. The government did not supply the village with the necessary water. This caused premature failure of the batteries. After several years the batteries had either run completely dry or were damaged by the use of non distilled water. The government did not supply the village with new batteries and the system was rendered useless. In hindsight the project leader indicated that he would have chosen to include a distillation unit into the project requirements to remedy such a situation.

Economic category

In the economic category the main factors identified as impacting on the outcome of the project were

- Absence of funds for upkeep
- Recession of solar related market
- Development of private entrepreneurship

Absence of funds for upkeep

The project did not include an arrangement that involved the local community in saving up for the maintenance and inevitable replacement costs for the project. The community was completely dependent on the government for supply of equipment. When the ministry failed to supply the necessary replacement equipment, the local community did not have any funds saved up that would allow them to cover the necessary costs themselves.

Recession of solar related market
At the end of the 1990's political unrest had a negative influence on the economic stability in Suriname (which is reflected in rise of the exchange rate for the US$ [Figure5.1]). This reflected on the market for solar related products, and the few retailers for these products that were in Suriname dwindled away. This meant that solar equipment and special solar batteries had to be imported, making the upkeep of a solar system the size of the Kwamalasamutu project expensive and beyond the reach of the local community.

Development of private entrepreneurship
The Kwamalasamutu project did not include any schemes that would utilise the provision of solar electricity for job creation and/or profitable output. Nevertheless, several inhabitants started using the solar electricity for the operation of small sewing machines. At first production was for local needs, but the help of non-profit organisations in Paramaribo opened up the possibility to sell traditional clothing on the market in Paramaribo.

<u>Institutional category</u>
In the institutional category the main factors identified as impacting on the outcome of the project were
- Insufficient coordination between agencies
- Influence of the local Granman

Insufficient coordination between agencies
One of the facilities to which energy was to be provided, was the medical outpost of the MZS. There was however no coordination between the Ministry of Natural Resources and the MZS on activities in the area. A coordination of activities might have been beneficial for the sustainability of the project, as the MZS conducts regular flights to Kwamalasamutu and could therefore have aided with the transport of maintenance supplies.

Influence of the local Granman
The Granman for the Trio tribe resides in Kwamalasamutu. The project team made sure to obtain the Granman's approval and cooperation for the project. This effort led to the enthusiastic support of the Granman, who went so far as to designating the project team leader an honorary Trio. The project leader indicates the support of the Granman as being essential on several fronts. Requests to the population, relayed to the Granman, were carried out without question or delay. Furthermore, the support of the Granman was very effective in ensuring that, after completion of the project, the local population adhered to the rules that the solar systems should not be tampered with, or that no excessive loads were to be added to the system.

<u>Environmental category</u>
In the environmental category the main factors identified as impacting on the outcome of the project were
- Less stress on local wildlife population
- Absence of battery recycling arrangement

Less stress on local wildlife population
The continued operation of a central refrigeration unit meant that it was possible for the Trio to store meat for longer periods of time. This meant that after a hunt the catch was no longer in danger of spoiling and excess meat did not have to be thrown away. This meant that the villagers could afford more intervals between hunts, causing less stress on the local wildlife population.

Absence of battery recycling arrangement
There was no arrangement made for the recycling or environmentally friendly removal of the batteries from Kwamalasamutu once they needed to be replaced. This was not related to the Kwamalasamutu project. In Paramaribo there were no provisions for this either. It is unknown what happened to the batteries afterwards, but at the time it was considered common practice to melt battery lead for bullets and dispose of unusable remains by throwing them into the river or through burial. This would not constitute an environmentally sound solution and contrasts with the project image of instituting an environmentally friendly way of providing energy.

5.6 Evaluation of critical factors in past cases in relation to the model

The factors abstracted from the two historical cases are evaluated to decide whether they merit separate inclusion into the model.
First the factors emanating from the cases are compared to the factors already present in the model. The result of this is presented in Table 5.5. The last column indicates whether the factors found are already represented in the model and if so by which factors or indicators.
Four factors can be found to be not represented by the model:

- Planning, speed and execution
- Fringe benefits towards social development
- Absence of battery recycling arrangement
- Influence of the local Granman
- Inland wars

Planning, speed and execution
This factor is not specifically represented in the model. However, proper planning and execution can be seen as a consequence of a good organizational structure. Rather than choosing for a separate inclusion of this factor into the model, the choice is made to leave the model as it is and hypothesize that there is a causal relationship between this factor and those already included in the organizational category. If all the requirements for the factors in the organizational category to be set as positive are fulfilled, proper planning and a speedy execution should be a natural consequence.

Table 5.5 Factors found from case studies cross referenced against model

Category	Factor from Case study	Case	Factor representation in model
Organizational	Hierarchical issues	Poketi	Leadership, Autonomy
	Proper training and planning	Poketi	Leadership, Structure
	Planning, speed and execution	Kwamalasamutu	***Not specifically represented***
	Promotion	Kwamalasamutu	Promotion
Social	Lack of involvement of local population	Poketi	Character/ Extent of involvement
	Lack of social pre studies	Poketi	Need
	Ability to pay from local wildlife sales	Kwamalasamutu	Ability to pay
	Fringe benefits towards social development	Kwamalasamutu	***Not specifically represented***
Technical	Insufficient hydrological pre study	Poketi	Water potential
	Lack of locally available technical personnel	Poketi	Personnel requirements
	Local availability of tropical hard wood	Kwamalasamutu	Material availability
	Lack of distilled water and replacement batteries	Kwamalasamutu	Maintenance
Economic	High transport costs	Poketi	Financial feasibility
	Costs for transmission line	Poketi	Financial feasibility/Technical: Transmission
	Development of local market	Poketi	Incentives for market development
	Absence of funds for upkeep	Kwamalasamutu	Financial feasibility
	Recession of solar related market	Kwamalasamutu	Economy of scale
	Development of private entrepreneurship	Kwamalasamutu	Income generation
Institutional	Influence of the local Granman	Poketi/ Kwamalasamutu	***Not specifically represented***
	Inland wars	Poketi	***Not specifically represented***
	Presence of development aid	Poketi	Available funding/ Development agencies
	Insufficient coordination between agencies	Kwamalasamutu	Development programme/ Integration
Environmental	Less stress on local wildlife population	Kwamalasamutu	Impact on fauna
	Absence of battery recycling arrangement	Kwamalasamutu	***Not specifically represented***

Fringe benefits towards social development

The fringe benefits towards social development mentioned by the project leader in the Kwamalasamutu case were an unplanned consequence of the execution of the program in the area. Although a pleasant benefit for the local community, these can be seen more as benefits made from contact with outside people rather than a specific consequence of the deployment of an electrification project. For this reasons this factor does not merit specific inclusion into the model.

Absence of battery recycling arrangement

This factor is of specific importance to a solar electrification project, as this makes use of batteries. A MHP project does not utilise batteries, and this factor is therefore not appropriate for inclusion into a model on MHP.

Influence of the local Granman

The influence of the local Granman is stressed by both project leaders as having a major influence on the outcome of the project; a positive one in the Kwamalasamutu case and a negative one in the Poketi case. The Granmans are considered the heads of society by the Marron and Inheemse tribes in the inlands (tribes in the coastal area do not have Granmans). Although the Marron and Inheemse are Surinamese citizens and therefore subject to Surinamese law, the practice is that there is no practical extension of the legal system to the inlands. The Kapiteins of a village are the keepers of order on a village level and the Granman fulfils this task for the whole of the tribe[1].
Because of the influence a Granman exerts the need for their consent can be seen as a vital factor for the success of any project deployed within their jurisdiction and should be added to the model.

Inland wars
During the inland wars much destruction was caused to infrastructure all over the inlands. Although this factor has without question had an impact on the possibility for restarting and continuing the Poketi MHP, the inland wars can be seen as a one time occurrence caused by external forces, which (hopefully) will never happen again. As such this factor can be seen as not being generally applicable and therefore does not merit a separate inclusion in the model design.

5.7 Conclusions on past cases

From the Poketi and the Kwamalasamutu case several factors can be found in all six categories that have had an impact on the sustainability of these projects. When reviewed against the factors already present in the model, most of the factors found are concluded as already represented in the model in one form or another. Of those factors not specifically represented, only one justifies a separate inclusion in the model: The influence of the local Granman.

The choice is made to add this factor as a sub factor to Political Involvement in the Institutional category. The indicator will be whether the Granman has given his support to project. The rules for setting the indicator will be:

- Indicator Positive: If consent is given.
- Indicator Negative: If consent is denied.
- Indicator Cautious: If consent has not yet been requested or is given conditionally.

In the model the sub factor will be incorporated as follows:

Table 5.6 Inclusion of Granman's influence into model

Category	Factor	Sub factor
Institutional	*Political Involvement*	*Consent of Granman*
		Other Political involvement

[1] Lytle; Libretto, 1990

III Model application to the Palumeu case

The goal of applying the model to the Palumeu case is twofold. One is to obtain an assessment on the sustainability of the Palumeu case, the other to obtain useful information from the practical application of the model in the field.
Due to the fact that the Palumeu case is stuck in mid construction, it is not possible to truly test the model as an ex-ante assessment method. Therefore, the assessment study on the Palumeu case will be based on the situation as encountered during the field study. This section starts with a general overview of the Palumeu project followed by the assessment. The experiences encountered during the application of the model will then be discussed in section 5.11.

5.8 Case summary

General overview of the Palumeu Micro hydropower project:

Location:	At the mouth of the Panato creek, 4 km from the Inheemse[1] village of Palumeu in the south east Suriname[2]
Power output (design):	5 kW
Head:	1.5-2 m
Design flow:	0.5 m3/s
Turbine:	Propeller
Construction costs[3]:	US$ 99.950 (US$ 194.000 if transmission line is included)
Year of construction:	2002-
Primary targets:	• The provision of electricity for lighting and household appliances in the village of Palumeu and the lodges of the METS (ecotourism organisation) • Reduction/elimination of fossil fuel use • Demonstration of the ability to design and construct a MHP plant using local expertise and resources
Current status:	The Palumeu project started in 2002 with the first kroetoe to discuss the plans for the MHP with the local community. In 2005, the project was stuck in the beginning of the construction phase due to several problems.

The original initiator of the Palumeu project is considered to be a Dutch citizen with a long time affiliation with the village of Palumeu. The initial purpose was to provide the village with hydro powered electricity by diverting water from the Upper Tapanahony river a couple of hundred meters from the village and redirecting it back into the river through a turbine. For technical advice contact was made with the ADEKUS, where a team from the department of infrastructure took on the responsibility for design and construction of a MHP project for Palumeu. At the teams advice the original plan was abandoned and a new site was chosen at a small rapid in the Panato creek, approximately 4 km from the village of Palumeu. A foundation was established, the Word and Music Ministries, which would represent the community of Palumeu. Also an agreement was made with the METS, which would sponsor

[1] Inhabited by both Trio and Wayana
[2] Travelling distance to Paramaribo: 2 hour inland flight/2 weeks by boat (dependent on season). See Appendix B.1 and B.2 for maps on Palumeu.
[3] Currently the need has been recognized for construction of a high voltage transmission line, estimated at US$ 94.000

the project (mainly by providing transport on the regular tourist flight) in exchange for access to part of the electricity generated at the Panato. A grant from the Small Grants Program of the UNDP was obtained that covered half of the budgeted costs.
The construction of the MHP started in 2003 with the collection of local materials and construction of a preliminary dam in the Panato creek. Since then, construction has come to an almost complete stop. Several reasons are mentioned by the project team, including financial issues and problems with material supply. At the time of the research the project was still at a standstill.

In the following section the results of the application of the designed assessment methodology on the Palumeu project will be evaluated.

5.9 Assessment

Data for executing the assessment was obtained through the methods described in section 4.3. The model, amended with information obtained from the local data search and past cases, was then filled in order to obtain an assessment of the Palumeu case. The assessment follows the division into the six major categories, which are further subdivided into factors and sub-factors as described in chapter 3, the chapter on model design [Table 3.1]. That model has been further modified with the factor on the Granmans [Table 5.6] and amended with the data from the local data search [chapter 5 part I]. The model is applied as described in that chapter.

From the application of the model it can be deduced that in all but one category the MHP project does not possess the characteristics necessary for becoming a long term sustainable electrification project. The only exception is the environmental category. In the following section the results of the Palumeu assessment will be discussed for each category. First a summary evaluation is given of the most important factors impacting on the Palumeu project. A summary of the model results for each factor and sub factor is represented in a table at the end of each category. The total detailed results of the Palumeu assessment including all indicators can be found in Appendix D: Output of the model application to the Palumeu project.

5.9.1 Order of evaluation of the categories

The model is designed to provide an assessment based on a full range of factors from all categories. In the original design the order in which the assessment is preformed is left up to the preference of the user, allowing the user the choice of which parameters to set first. For example:

- If primary interest is in the MHP having to be conform to local, national or international environmental prerequisites, the user can start with the environmental section, making sure variables in the environmental section are set to positive before proceeding with the other categories.
- If primary interest is in the MHP having to power a profit earning scheme, the economic category is the starting category, setting the financial boundaries in which the MHP project can be executed.

In the assessment of the Palumeu case, it turned out that there is a high probability that the project is not at all technically feasible. This basic fact would render the entire project useless. If this model was used as an ex-ante model, this would mean that the assessment would stop after the technical section until a new location for the MHP site was found that was deemed technically feasible. In the light of this, the technical category is chosen as the category with which to start the assessment. In order to be able to apply the model to the remaining factors, the potential power of 5 kW estimated by the project design team will be used. For the rest of the assessment, the order chosen in chapter 3 and maintained throughout the rest of the paper, will be used.

5.9.2 Technical category

In the Palumeu case the main negative impacts in the technical category on the project were caused by

- Insufficient evidence of water potential
- Demand exceeding estimated power supply
- Problems with experimental turbine
- Transmission issues

Insufficient evidence of water potential
There is evidence that the site at Panato creek is unsuitable for powering a micro hydro power plant due to two reasons:

- Insufficient head during the rainy season
- Insufficient flow during the dry season

There is no exact measurement of the available head at the site at Panato creek.
Project files cite a head difference of 2-2.5 meters in the design plans. However, there is strong evidence opposing this claim.

- From water level measurements conducted at the site by the university itself it can be concluded that the water level naturally varies between 1 meter in the dry season and 0 m in the rainy season.
- The design calls for construction of a dam around a rock located in the rapids. This would increase the head difference, as the head difference between the top of the rock and the downstream flow varies between 2.5 and zero meters. However, the Panato creek flows into the (much larger) Tapanahony river. The level of this river will rise 4 meters during the rainy season. The flow at the mouth of the Panato creek is inverted and the level of the Panato creek also rises, with the level of the downstream section rising further than that of the upstream section. A local foreman indicates that in the rainy season, the upstream and downstream section of the Panato creek are level and the rapid is no longer visible, meaning there is no head at all. This fact was also observed during the observational visit.

The head difference is clearly severely dependent on the flow and can be expected to equal zero in the rain season, meaning that no power generation is possible.

Regarding the flow at the Panato creek, initial project files used for assessing the potential cite three measurements. Two of less than 0.5 m^3/s, which were calculated by conducting a cross sectional velocity measurement. There is also a value of 4 m^3/s listed. However, no details are given on how this last figure was obtained, and later case files only mention the first two measurements. The minimal design flow for most turbines is more than 10 m^3/s. This means that the measurements fall well below any design specification.

Figure 5.2a Power supply and estimated load graph for basic (no growth) scenario

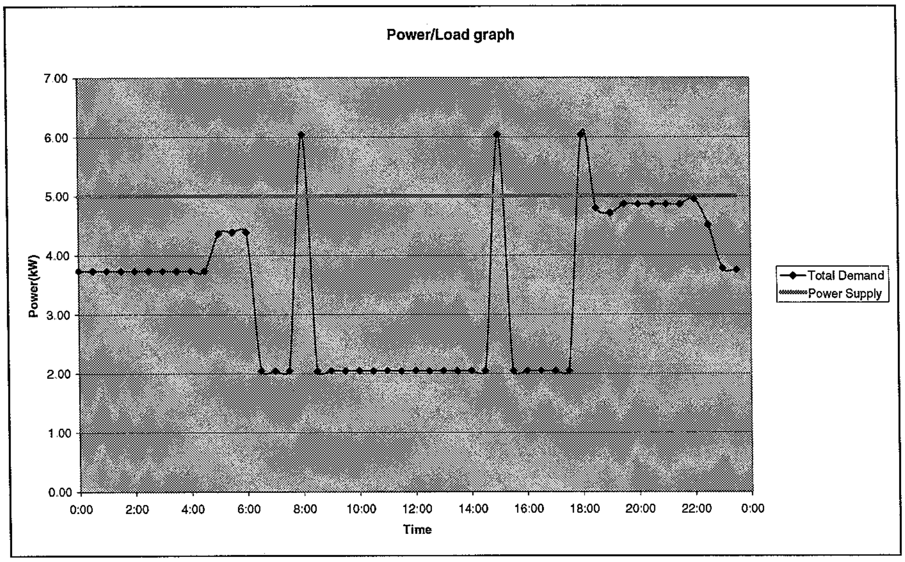


Figure 5.2b Power supply and estimated load graph for small growth scenario

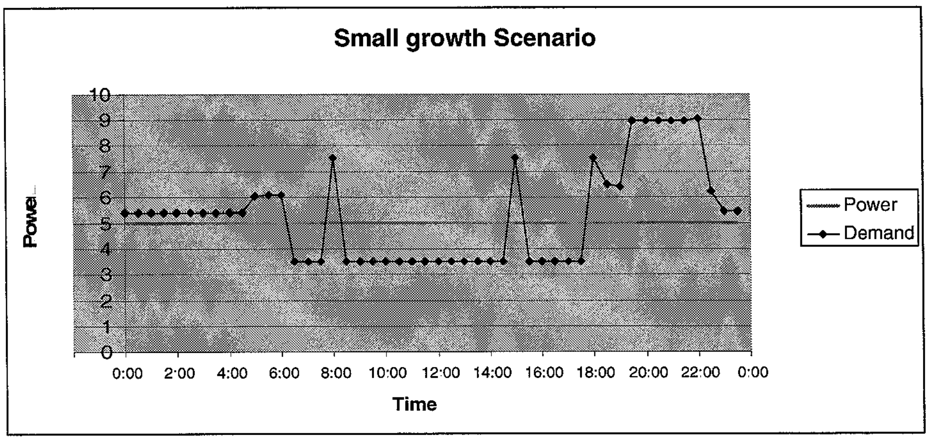
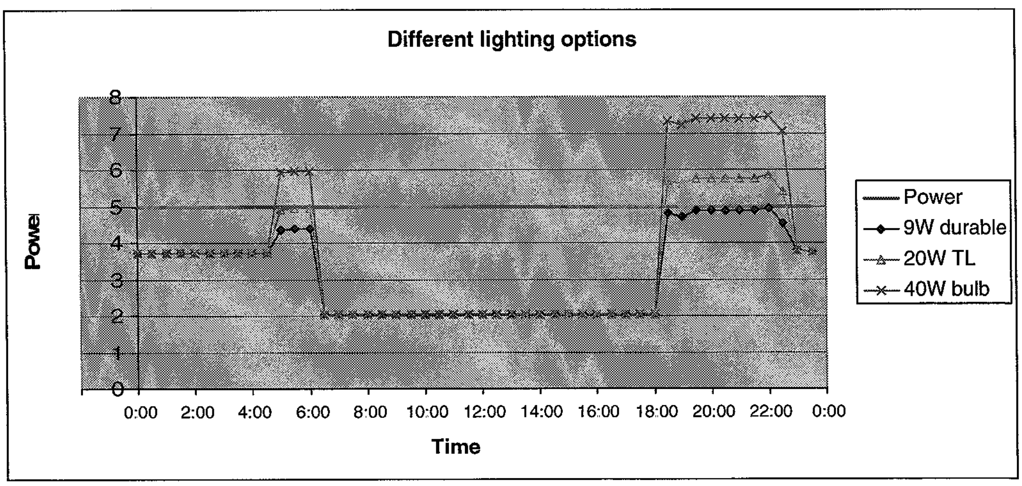


Figure 5.2c Power supply and estimated load graph with different lighting options



The estimated power output of the MHP station of 5 kW calculated by the project team could only be reached (theoretically) in optimum conditions, with both the flow being 0.5 m3/s and the head being 2 meter. The power potential would however be zero when either the head difference equals zero (height of rainy season) or the flow approaches zero (dry season).

Demand exceeds estimated power supply

The power supply to be produced by the MHP station is assessed by the project team to be 5kW. By translating the demand conditions from the social section[1] into a technical demand for electricity and comparing that to the proposed supply, it becomes evident that supplying the current need for electrical power would cause the power demand to peak at 6 kW, which would be more than offered by the system. This is demonstrated by the power-load graph in Figure 5.2a.

A feasible scenario for using the 5 kW is by using it for lighting and for the currently available refrigeration units of the METS and the village. Use of power tools exceeding 3kW would have to be prohibited, and power tools using less can only be used when lighting is not activated. However, several villagers have already bought a refrigeration unit in anticipation of the expected electricity, and it is to be expected that at least one refrigeration unit per family circle will be bought. Constructing a load diagram on the basis of a small growth scenario shows that the 5 kW would not suffice for supplying electricity for both refrigeration and lighting at the same time. [Figure 5.2b]

A final issue with the potential power supply is that it is highly sensitive to the type of lighting used. The villagers would have to make use of low energy lighting (9 W lamps). If they were using TL lighting or the standard used 40W bulbs, the demand for power would immediately peak above the 5 kW at nights. [Figure 5.2c]

Problems with experimental turbine

The proposed design is for a propeller turbine. This turbine is being constructed in Paramaribo by a local firm. At the moment of the field research, the turbine was still being tested and experiencing difficulties. The local firm did not have any previous experience with constructing turbines and for design advice they had to rely on the university project coordinator, who also has no previous experience with turbine design.

Besides the fact that the turbine did not, in fact, function, the choice of turbine will also pose a problem once used. The propeller type of turbine has the worst part flow efficiency curve of all turbines[2]. If the flow falls to more than 40% of the designed rate, the efficiency drops to zero. Combined with the extreme fluctuation in flow expected at the Panato creek the efficiency of the turbine depends greatly on what flow the turbine is designed for.

[1] In appendix D, social section 2.1.1 "Need for electricity"
[2] Paish, 2002

Transmission issues

The site at Panato creek is located at a distance of several kilometres from Palumeu. There are no exact measurements done on this distance. On report mentions the distance as being approximately 2 km, a later report estimates 5 km. Measured from an aerial map the direct distance from the site to the Palumeu village is approximately 4 km.

The preferred distance is less than 2 km, because otherwise the increased voltage drop will create the necessity for high voltage transmission lines. In this case the proposed use of a low voltage line would lead to a substantial loss of power due to voltage drop over the long transmission line. The amount of power lost would ranged from total power loss for the standard sized low voltage conductors to 31% power loss for the larger, more expensive conductors.[Table 5.7]

Table 5.7 Power loss in transmission line

Conductor size(AWG)	Power loss over 4 km (240 V/ 5kVA)[1]
Less than 4	Complete
4	98%
3	78%
2	62%
1	54%
1/0	49%
2/0	39%
3/0	31%

For this reason the design at Palumeu needed to be switched to a high voltage transmission line, an option which is currently being considered. This option however means a doubling of the investment costs.

In Table 5.8 a summary output of the application of the model on the technical aspects of the Palumeu project is presented.

Table 5.8 Summary output for technical factors

Critical Factors			
Factor	**Sub factor**	Indicator	Short text
Application	->	**Positive**	Although a low power usage factor is to be expected, the conditions for application of a MHP design are otherwise favourable
	Designated end use	Cautious	The end use of the MHP will be purely electrical and the load is expected to follow a predictable pattern. However, a low power usage factor is expected due to the difference between night time load and day time load.
	MHP design	Positive	The Palumeu MHP does not have to be integrated into any kind of existing design
Potential	->	**Negative**	All sub factors indicate a negative impact
	Water Potential	Negative	Insufficient investigation has been done into stream flow characteristics. Water level measurements, local knowledge and observations from orientation visit imply lack of potential for MHP generation
	Site evaluation	Negative	The proposed MHP site is set at to great a distance from the village
	Power estimate	Negative	Even if proposed potential is realistic, net power output would be less than proposed 5 kW due to efficiency losses and losses due to load power factor if other appliances than lighting are connected
Power demand	->	**Negative**	Indicators for variation and growth are negative, and peak demand will not be met at current load spread
	Volume	Cautious	On basis of current need and equipment present, MHP would not be able to supply peak demand. Average power usage would be less than 5 kW, so demand could be met if peak was better distributed
	Variation	Negative	Uneven load spread will lead to loss of capacity during the day

[1] Voltage drop calculated for aliminium wiring using E-Tools (copyright Elite Software). For formula, see appendix A.4.

	Growth	Negative	Expectation of growth in number of electricity appliances indicates proposed power will not be enough to support a small growth scenario
Civil Works	->	**Positive**	The minimal amount of construction on civil works are a positive aspect
	Storage and Intake	Cautious	MHP requires minimal construction on storage and intake. Problems with cement availability are expected to be resolved, but are at current hampering project.
	Waterways	Positive	The design of the MHP does not call for construction of waterways
Hydroelectric equipment	->	**Cautious**	Although the right choices for equipment are made given the information used by the project team, practical issues with the turbine and the control equipment still need to be resolved
	Turbine	Cautious	The choice of turbine is the only logical one in light of the minimal size of the available head. However, lack of local availability leads to use of an experimental design which is still untested in practice
	Generator	Positive	The generator is second hand with an unknown number of running hours, casting uncertainty on its remaining lifetime. The technical specifications are suitable for power requirements
	Control Equipment	Cautious	A preference is given for the use of electronic load controllers, which are not commercially available but could be locally constructed.
Transport and distribution of energy	->	**Negative**	This factor is set negative because of the unresolved transmission issues
	Transmission	Negative	The distance from site to village requires construction of a high voltage transmission line, which is unfeasible within the current budget
	Distribution	Cautious	No distribution design has been drawn up. Besides standard requirements the design will need to account for the current flexibility in housing situation, ensure against tampering and take extra safety precautions because of the current housing style.
Operational procedures	->	**Negative**	Within the project no preparations for the operational phase have been made
Major maintenance procedures	->	**Negative**	Within the project no preparations for major maintenance procedures have been made
Personnel requirements	->	**Negative**	The engineering personnel requirements for designing the MHP station are not fulfilled, and operation and maintenance has not been prepared for in the project design
	Engineers	Negative	The engineers available for the project do not cover all the expertise areas
	Operators	Cautious	No arrangements have been made for the operation of the plant. Personnel is potentially available.
	Maintenance personnel	Cautious	Personnel for major maintenance is available but will have to be flown in from Paramaribo
Material requirements	->	**Cautious**	Material requirements can be met, but are subject to the expensive transportation arrangements between Palumeu and Paramaribo
	Quality	n.a.	No information obtained on the quality of material required
	Availability	Cautious	All material necessary for construction ad maintenance is available in Paramaribo. Transportation costs to Palumeu will pose an economic restriction, but not a technical one

5.9.3 Organizational category

In the Palumeu case the main impacts in the organizational category on the project were caused by:

- Lack of experience in project team

- Absence of local manager/project leader
- Insufficient future planning
- Conflicting objectives and expectations
- Positive promotion
- Communication and trust issues

Lack of experience in project team

Insufficient experience in the area of micro hydro design is identified as one of the key problems in project preparation and execution. None of the project team members has any previous experience with designing and constructing micro hydro installations. Within the project no measures have been taken to remedy this situation by means of training courses or by making use of an experienced consultant. The lack of experience is reflected in mistakes made by the project design team that are covered in basic MHP design manuals:

- Lack of proper hydrological survey: The projects team decided to go ahead with the design of the system based on only two measurements done in the Panato. Basic MHP design requires at least one year's worth of data, either by measurement or model prediction, to get an overview of stream flow characteristics. This is especially important in the light of the turbine type chosen by the project team, which is highly susceptible to stream flow variations.
- Misconceptions about electricity transmission: The proposed design for a low voltage line bridging 4 km would lead to such an extreme voltage drop that this design was unfeasible. The necessity for a high voltage line has led to an unexpected budget deficit of about US$ 94,000, doubling the proposed budget. This is again due to the fact that the project team did not take into consideration the basic principle that a MHP project should not be constructed more than two kilometres from the target community due to voltage drop issues.
- No attention to operational cost coverage: The most important success indicator for a MHP installation to become a long-term sustainable source of power is that the MHP is connected to an income generating scheme that at least covers the operational costs of the MHP system. Three years into the project provisions have yet to be made for covering costs once operation starts.

Absence of local manager/project leader

A major shortcoming in the project management structure is the lack of presence of a qualified local manager for the MHP projects. Two local community members have been appointed as foremen, responsible for upkeep of the site and monitoring of progress in the absence of a University project team representative. These foremen indicate that due to their lack of knowledge on construction techniques they are often confronted with difficulties beyond their ability to solve. For this purpose a locally stationed, qualified project manager is indispensable.

At a kroetoe held during the observational visit, the Kapitein of Palumeu made a number of statements and complaints regarding this fact. He referred to a previously made request to station a project leader on the site, who is responsible for all operational activities. Up to the date of the orientation visit, no actions were taken to appoint such a manager.

The lack of a local manager also caused difficulties in the hierarchy in local leaderships and related responsibilities. Although the Kapitein stands above the appointed foremen in the village hierarchy, these two report back to the University coordinator. As village spokesman the kapitein carries responsibility for the success of any communal effort. However, the foremen seem to function parallel to the kapitein in some respects of this project, thereby making it unclear who is locally responsible for different project aspects.

An example of authority problems is the occurrence of several planting gardens at the Panato site, although earlier field reports mention the University coordinator specifically prohibiting this.

Insufficient future planning:

There have been no arrangements made for the operational phase of the MHP project. This includes financial as well as organizational arrangements:
- There has been no cost- benefit analysis to ascertain if there will be enough income to cover operational cost (see the section on the economic category)
-No estimation of what operating costs for the MHP will be
-No arrangements for how the MHP will be operated
-No query to ascertain whether or not there will be qualified personnel available for operation of the plant

This lack of planning creates a high degree of uncertainty on the ability of the MHP to function on a long term basis, as there are no means of predicting what the shortcomings will be in the operational period. Therefore there is no possibility for any design changes to prevent these shortcomings from interfering with the success chances of the plant.

Conflicting objectives and expectations

In interviews with the different stakeholders of the project, it has come to light that different stakeholders hold different views on what the primary targets of the project are.
-The local community expects electricity to satisfy their need for lighting, refrigeration but also other electrical appliances such as televisions, stereo's etc.
-The director of the METS holds the view that as the METS lodge at Palumeu is the primary source of income for the village, the main target should be to satisfy the electricity needs of the METS lodges at Palumeu.
-The University coordinator views the project as a prestige project that will prove the local ability to design and construct a MHP without outside support, the main target being the installation of a functional micro hydro station and turbine in the inlands, regardless of the end use.

These three views on what is the primary objective could lead to difficulties in distributing the electricity once the project comes online.

Positive promotion

One factor that has initially made a positive impact on the project has been the promotional activities within the community at the start of the project. Several meetings were held to inform the community of the benefits of a MHP station, and the University coordinator made use of visual aides such as a scale model to explain the workings of a MHP station to the local population. As a result the whole community of Palumeu put an effort into the collection of rocks, gravel, sand and other material locally available for the construction of the MHP. As the project stagnated and there was no certainty on completion, the momentum was lost and the positive effects of promotion wore off.

Communication and trust issues

Inadequate communication was a major issue for the local population. There was a lack of regular information dissemination and consultation with especially the villagers. Communication as a structural process to inform stakeholders and, in return, to receive their inputs and responses, was not very well developed. This could be illustrated by a number of statements from villagers and local administrators made during a kroetoe organised during the site observations.

- The villagers emphasise the lack of information from the Project Agency in Paramaribo. The reasons for stagnation of construction activities were not known and people have to guess whether there will be sufficient power available for everyone. Some of them feared that they could be excluded from supply and expressed their desire to be included in the power requirement assessment (their houses should not be skipped). The villagers were never given any indication that the generated power might suffice only for lighting and only a few other household appliances distributed over the village. A few households had anticipated to what they perceived and have already bought refrigerators and other apparatus.
- Visiting tourists, claiming expertise in the field op hydropower generation, stated their doubts about the technical feasibility of the project, hence further undermining villagers' faith in the project.
- The Dutch citizen, who is considered as the original initiator of the micro-hydro idea, has been out of the planning for medical reasons, but came back recently. He was so dissatisfied with the project planning that he expressed the intention to come back with his own crew and complete the electrification project his own way. These kinds of occurrences are again a factor of distrust and frustration for the local people.
- The local foremen indicate long lapses in communication with the University project team, creating uncertainty over when and how to prepare for further construction

The lack of proper communication seemed to have a major impact on the project. This factor was however not setup into the model design. An adaptation may be needed in the model to allow for this factor.

In Table 5.9 a summary output of the application of the model on the organizational aspects of the Palumeu project is presented.

Table 5.9 Summary output for organizational factors

Category	Critical Factors			
	Factor	Sub factor	Indicator	Short text
Organizational	*Objectives*	->	***Negative***	The only sub factor is negative
		Organizational objectives	*Negative*	Objectives did not include a profit-generating scheme nor was there a formal mission statement made on the MHP designated use once constructed.
	Project Management	->	***Negative***	Aside from autonomy all indicators are negative
		Leadership	*Negative*	The project leader did not meet the experience, commitment and autonomy requirements
		Structure and capacity	*Negative*	The project management team did not include all necessary engineering fields, nor was there a clear hierarchical structure
		Autonomy	*Positive*	The project committee could function without deciding influences from outside the committee
		Accountability	*Negative*	The project team is not subject to performance reviews
	Plant Management	->	***Negative***	No positive indicators and insufficient preparation for operational phase
		Ownership	*Cautious*	Although it is the stated purpose that the MHP system will belong to the community, no formal arrangements have been made yet
		Approach to plant management	*Negative*	There is no indication that management of the MHP will utilise a income orientated, business like approach
		Management Personnel	*n.a.*	No data available as no plans for operation have been drawn op

		Technical Personnel	*n.a.*	No data available as no plans for operation have been drawn op
		Administrative Personnel	*n.a.*	No data available as no plans for operation have been drawn op
	Promotion	->	***Negative***	Indicator for promotion is positive but the insufficient preparation in light of a pilot scheme outweighs this
		Promotion of project	*Positive*	There has been a positive promotional campaign, both within community and outside
		Promotion of pilot	*Negative*	Insufficient preparation in light of the fact that Palumeu functions as a pilot
	Learning process	->	***Negative***	All indicators on sub factors are negative
		Local Knowledge	*Negative*	Local knowledge is not utilised in the project design
		Former experience	*Negative*	Former experience on MHP projects is not being utilised in the project
		Evaluation	*Negative*	There have been no arrangements made for evaluation points

5.9.4 Social category

The negative outlook of the social category can mainly be assigned to the following causes:

- Lack of extension program for social and technical capability enhancement
- Inadequate investigation into demand factors
- Nature of community involvement

Lack of extension program for social development and technical capability enhancement
Experience in MHP (and other renewable energy technology) projects worldwide shows that installation of the MHP station, followed by provision of energy towards the target community, is not enough to bring about a sustained social development for this community. If the MHP is to fulfil this purpose for the village of Palumeu, there needs to be an extension program that will utilize the opportunity brought about by the provision of electricity to ignite this development. This goal can not be found reflected in the orientation of the project aims and execution towards social, economic and environmental development. The MHP by its nature ensures that the electricity provided would be brought in an environmentally sustainable way, reducing the use of fossil fuel. Viewing the project as bringing about economic development is questionable. There are no schemes for income generation or employment creation connected to the program. At best the project can be seen as a way of giving the METS a cost reduction incentive for staying in the area, thereby consolidating a source of income already present. The need for an active extension program orientated on technical capability enhancement or social development programs such as a focus on education is not recognised in any of the aims nor brought forward by any of the main parties involved as a point of focus.

Inadequate investigation into demand factors
The demand factors, consisting of the need for electricity, the willingness to pay and the ability to pay have not been properly investigated.

- There has been only a cursory investigation done by the project team into the volume of the need for electricity, consisting of an inventory of the electrical equipment present in the houses of prominent villagers and the METS. An inventory made during the orientation visit brought out that a lot more equipment was present and that the villagers, based on the assumption of a regular electricity supply, were already in the process of buying more appliances. In the technical category this resulted in a demand forecast exceeding the estimated power provision.

- A kroetoe held during the orientation visit brought to light that the village community is confused on what the arrangements will be for payment of electricity once the plant becomes operational. The Kapitein of Palumeu remarked that since the villagers contributed labour to the construction of the dam, they should be excluded from payment, at least for the first couple of years. The METS would then be solely responsible for cost coverage. The same option is also remarked by the chairman of the WMM representing the village in the project committee in Paramaribo. This situation indicates that the willingness to pay (or rather lack thereof) of the community can be expected to cause difficulties during the operational period.
- As there are no thorough income statistics obtained on the Palumeu community, there is no clear indication on what amount of contribution they will be able to make towards cost coverage. For the most part the village functions as a substance economy, not spending any money on survival, and monetary income is viewed as pure profit. As there are no statistics on how this income is distributed through the village, no certain verdict can be delivered on the community's ability to pay.

The inadequate investigation into these demand factors reflects negatively on the MHP project's chances of functioning without difficulties during the operational phase.

Nature of community involvement

The presence of an attitude of ownership and responsibility towards the MHP structure is considered in literature (see chapter 2.3) to be an important factor for ensuring that the MHP project will function well in the community in which it is being deployed. This attitude is stimulated by intensively involving the community in the project during the different phases, and doing so on several levels of organisation.

The nature of the involvement of the community at Palumeu does not adhere to this requirement. The conception of the project was done by a Dutch citizen from outside the community, and further developed into a design in Paramaribo. At the start of the program an active promotional campaign ensured the involvement of the entire community. The villagers were, however, only involved as labourers, not in any organizational capacity. At present the project is at a standstill, and the Kapitein indicates there is a lack of communication between the project team and the village. Besides the two foremen appointed for local upkeep the community is no longer an active participant in the project.

This lack of involvement prohibits the growth of an attitude of ownership and responsibility towards the MHP structure.

In Table 5.10 a summary output of the application of the model on the social aspects of the Palumeu project is presented.

Table 5.10 Summary output for social factors

Category	Critical Factors		Indicator	Short text
	Factor	Sub factor		
Social	***Demand***	->	***Cautious***	Although there is a need, there is doubt about the willingness and ability to pay
		Need for electricity	*Positive*	There is a need present for replacement of current energy source
		Willingness to pay	*Cautious*	No data collected by the project on the willingness and there was mention of free supply by a project committee member
		Ability to pay	*Cautious*	Ability to pay of community has not been investigated by the project. Current numbers estimated on basis of figures from orientation visit
	Technical Capability	->	***Negative***	Local skill should be adaptable to MHP technology, but no arrangements have been made to actually accomplish this

	Availability	Cautious	Local mechanical skill should be adaptable to MHP technology
	Enhancement	Negative	No provisions have been made for enhancing local skill
Community involvement	->	***Negative***	Both sub factors are set Negative
	Character	Negative	Local population did not have an active involvement in the conception and design, nor were they actively involved on an organizational level during construction
	Extent	Negative	At present only two foremen are actively involved with the project
Livelihood	->	***Positive***	Most livelihood indicators are set positive and the MHP is not expected to have any negative impacts on the poverty situation
	Poverty	Cautious	No plans have been drawn up yet that indicate the MHP project will alleviate poverty by means of employment opportunity or income generation
	Health care	Positive	There are health care facilities situated within the village that would benefit from the presence of the MHP
	Educational facilities	Positive	Access to a stable electricity supply would enhance the willingness of teachers to be stationed at Palumeu
	Gender aspects	Positive	Night time lighting would provide the opportunity to practice craftsmanship at night, benefiting especially the women who are regularly occupied during the day
	Housing	Positive	Current housing state is being improved from nomadic huts to solid houses and electrical lighting would reduce fire hazard for the leaf roofs
Orientation towards sustainable development	->	***Negative***	The project does not encompass any extension programs aimed at achieving further social development, and the MHP can at best be seen as a means of ensuring the current level of income through the METS

5.9.5 Economic category

The main factors worth mentioning in this category were

- No inclusion of profitable/job generation scheme into project
- Negative outcome of Cost Benefit Analysis
- Potential for future economy of scale

No inclusion of income generation scheme into the project
One factors considered by literature to be amongst the most important for making a MHP project sustainable in the long term is the presence of a productive, profit earning economic activity connected to the MHP. In the Palumeu case no such scheme was included in the project design. From the local data search one of the options for income generation in the inlands is from wood processing. In the Palumeu case, however, there are two reasons why wood processing would form a problem:

- Available power: with the excess power available only small domestic wood processing tools could be used. Installing a saw mill such as the one at Poketi (40kW) would not be possible.
- Absence of a market: Palumeu is situated more than 200 km from Paramaribo and is reachable either by airplane or by travelling across the river, which would take two weeks and is only feasible with canoes. This means that the marketing of products in Paramaribo would be very expensive due to transportation costs, and Palumeu would not be able to compete with wood from the Marron villages along the Upper Suriname. Since the local demand is very limited, marketing products will be a limiting factor for implementing a profitable productive venture.

This means that it is highly unlikely that the electricity from the Palumeu MHP will be put to a productive use.
By providing electricity to the METS, the village will be providing this organisation with an incentive for staying in the area. However, the purpose of the project is not to sell the electricity to the METS at a profit generating rate. Using the electricity as a replacement source of energy for lighting and refrigeration, the MHP project is supposed to help the METS cut back on current expenditure. No extra income will be generated for the village.
This means that the MHP project will not add to the economic development of the village and one of the primary conditions for the project being sustainable is not satisfied.

Negative outcome of Cost-Benefit Analysis
Another key factor missing in the project preparation is the presence of a study to determine the financial or economic feasibility of the MHP project. No calculations have been made to ascertain whether the local population and the METS will even be able to cover the costs of running the MHP when it becomes operational.
Since there is no form of income generating scheme connected to the MHP, the only revenues for the system would be from fees paid by the local community and the METS.
Currently the budget is unable to accommodate the costs of a high voltage transmission line. The project team is looking for new contributors to cover these costs: US$ 93,650,- , which is almost equal to the already spend budget.
In order to get an insight into the extent to which the costs for constructing and running the project could be covered, an estimated cost benefit analysis is made for a period of ten[1] years, based on the observations done during the orientation visits and costs estimates from the Poketi case file.
Based on the figures obtained on fuel expenditure for lighting and estimating the reinvestment costs for the solar systems used for refrigeration, the current expenditures of the METS and the village expenditures on lighting and refrigeration are estimated. Cost calculations for the Poketi case, an estimated salary expenditure of two employees at METS local salary rates and values for major maintenance and reinvestments on the turbine and generator based on the budgeted values are used for estimating the running costs of the MHP.
With these estimated numbers a couple a cost benefit analyses were performed for several scenarios[2]. Each scenario was performed with and without the inclusion of the UNDP grant, in order to get an insight into the true value of the project. In box 5.1 the cash flows for several scenarios are presented.
Four results of the cost benefit analysis are summarised in Tables 5.11a-d.

In Table 5.11a the NPV and cumulative cash flow after 10 years are given. Both are extremely negative, and based on this outcome alone the project can be classified as economically unsound.

In Table 5.11bthe results for three scenarios are presented. These scenarios were calculated for two different options.

- Option I: The costs for running the MHP station are divided by the amount of energy used. This means that the village carries about 3 quarters of the costs, the METS one. (61 kWh:20kWh per day)

[1] In a normal microhydro scheme a cost benefit analysis should cover a period of at least thirty years for a proper analysis. In light of the uncertainty of the costs and benefits involved, extending the analysis beyond ten years would however create a false image of certainty.
[2] Appendix D, economic section 4.1

- Option II: The village only contributes the replacement costs saved from its current expenditures and the METS carries the rest of the costs.

The three scenarios that are presented in this table are:

- Scenario one: The annual costs of the project if it were to reach a positive cumulative cash flow after 10 years.
- Scenario two: The same as scenario one, only this time the UNDP grant is subtracted from the investment costs.
- Scenario three: The costs of the project if it were to have a positive net value after ten years, with deduction of the UNDP grant.

In all three scenarios the project is shown to be financially unattractive. In order to reach a positive cash flow in the least costly case (scenario 2), each household would have to spend US$ 119,- more annually than they are currently spending. This is more than a monthly salary from the METS. The METS itself would have to spend about US$ 3,600,- more than it is currently spending, US$ 10,700,- if they carry all the extra costs alone. The unit price for electricity would then be SRD 4.55 per kWh for the METS, which is about 30 times higher than the EBS charges for a high voltage industrial connection in Paramaribo.

In Table 5.11.c the assumption is made that all investment costs will somehow be covered and only the daily running costs are considered. In the table the annual running costs are represented, as well as the annual current expenditures on lighting for the METS and the village. These figures hold true except for the 5th and the 10th year, where reinvestment for equipment would cause both savings and expenditures to rise. Still, form this perspective the balance would be positive in favour of the MHP project.

However, these figures are based on two critical assumptions:

- The MHP station delivers electricity to the village, 24 hours a day and all year round.
- The MHP delivers electricity at the estimated running costs.

If the costs for operation rise with more than 16% the expenditures for the METS rise above the current ones. For comparison: One extra annual salary at METS rates would constitute a cost increase of 26%. This means that even in this scenario the financial feasibility is highly sensitive to the height of the annual costs.

For the savings on current expenditures to exceed the costs of running the MHP, the MHP has to deliver a constant supply of electricity at the proposed power level for more than 50% of the year. If not, the annual savings will be less then the running costs. In light of the questionable status of the available water potential, it is doubtful whether meeting these daily running costs would be truly possible.

Another option run through the model is the revenues that would be needed for reaching a positive cumulative cash flow in ten years from an on-site, income-generating venture at the Panato creek location itself. This would eliminate the need for a transmission line and thereby reduces the investment costs for the MHP project.

In both cases (with and without the UNDP grant) the costs for running such a scheme would exceed an annual amount of US$ 10,000. In light of the absence of a proper market for produced goods (see under the previous heading "No inclusion of income generation scheme into the project") the possibilities for this scenario coming true are also doubtful.

Box 5.1 Cost-Benefit Analysis sheets

Cash flow after 10 years not including UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative (undisc)
0	-193.600	0	-193.600	1,000	-193.600	-193.600
1	-4.650	9.410	4.760	0,907	4.315	-188.841
2	-4.650	9.410	4.760	0,822	3.912	-184.081
3	-4.650	9.410	4.760	0,745	3.547	-179.322
4	-4.650	9.410	4.760	0,676	3.216	-174.562
5	-4.650	10.625	5.975	0,613	3.660	-168.588
6	-4.650	9.410	4.760	0,555	2.643	-163.828
7	-4.650	9.410	4.760	0,503	2.396	-159.069
8	-4.650	9.410	4.760	0,456	2.172	-154.309
9	-4.650	9.410	4.760	0,414	1.970	-149.550
10	-12.496	12.685	189	0,375	71	-149.361
				NPV =	-165.699	-149.361

Cash Flow and NPV after 10 years including UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative (undisc)
0	-193.600	48.950	-144.650	1,000	-144.650	-144.650
1	-4.650	9.410	4.760	0,907	4.315	-139.891
...	...	...	...	...	...	...
10	-12.496	12.685	189	0,375	71	-100.411
				NPV =	-116.749	-100.411

Scenario 1: Reaching a positive cumulative cash flow (IRR=0) after 10 years(without grant)

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative (undisc)
0	-193.600	0	-193.600	1,000	-193.600	-193.600
1	-4.650	24.795	20.145	0,907	18.264	-173.455
	...	...	...	...	...	...
10	-12.496	24.795	12.299	0,375	4.614	4
				NPV =	-74.341	4

Scenario 2: Reaching a positive cumulative cash flow (IRR=0) after 10 years (WITH grant)

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative
0	-193.600	48.950	-144.650	1,000	-144.650	-144.650
1	-4.650	19.900	15.250	0,907	13.826	-129.400
....	....	...	...	...	...	...
10	-12.496	19.900	7.404	0,375	2.778	4
				NPV =	-55.085	4

Scenario 3: Achieving a positive NPV (IRR=discount rate=10,3%) in 10 years(WITH grant)

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative
0	-193.600	48.950	-144.650	1,000	-144.650	-144.650
1	-4.650	28.990	24.340	0,907	22.067	-120.310
...	...	...	...	...	...	...
10	-12.496	28.990	16.494	0,375	6.188	90.904
				NPV =	57	90.904

Achieving a positive cumulative cash flow in ten years with on-site scheme (WITH grant)

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative
0	-99.950	48.950	-51.000	1,000	-51.000	-51.000
1	-4.650	10.535	5.885	0,907	5.335	-45.115
...	...	...	...	...	...	...
10	-12.496	10.535	-1.961	0,375	-736	4
				NPV =	-18.244	4

Table 5.11a NPV and cumulative cash flow after 10 years (US$)

	NPV	Cash flow
With UNDP grant	-116,749	-100,411
Without UNDP grant	-165,699	-149,361

Table 5.11b NPV and required cash inflows for several scenarios (US$)

	Scenario1: Required cash inflows for reaching a positive cumulative cash flow (IRR=0) after 10 years without UNDP grant		Scenario2: Required cash inflows for reaching a positive cumulative cash flow (IRR=0) after 10 years WITH UNDP grant		Scenario3: Required cash inflows for reaching a positive NPV (IRR=discount rate) after 10 years WITH UNDP grant	
NPV of scenario after 10 years	-74,341		-55,085		57	
Option I: Cost division between METS and village according to amount of power used						
Annual inflow needed[1]	**Total**	**Extra**	**Total**	**Extra**	**Total**	**Extra**
Total (METS+Village)	24,795	15,385	19,900	10,490	28,990	19,580
Village total(61 kWh/day)	18,673	10,854	14,986	7,168	21,832	14,014
Per Family unit	1,098	638	882	422	1,284	824
Per household	311	181	250	119	364	234
Mets (20 kWh/day)	6,122	4,782	4,914	3,574	7,158	5,818
Option II: METS covers all extra costs						
Annual costs for METS	**Total**	**Extra**	**Total**	**Extra**	**Total**	**Extra**
Total costs	16,977	15,637	12,082	10,742	21,172	19,832
Costs per kWh	2.33	2.14	1.66	1.47	2.90	2.72
Costs per kWh *in SRD*	***6.40***	***5.89***	***4.55***	***4.05***	***7.98***	***7.47***

Table 5.11c Annual running costs and savings ignoring investment costs

	Average annual running costs of MHP plant(US$)	Current annual expenditures of METS and village on lighting and refrigeration(US$)	Annual savings if METS and village only have to cover these costs(US$)
Total costs for Plant	4,650	9,410	4,760
Village(61 kWh/day)	3,502	7,818	4,316
Per Family unit	206	460	254
Per household	58	130	72
Mets (20 kWh/day)	1,148	1,340	192

Table 5.11d Annual revenues needed for positive cumulative cash flow in ten years with on-site scheme

	Annual Inflow needed	NPV after 10 years
With UNDP grant	10,535	-18,244
Without UNDP grant	15,430	-37,500

[1] The heading "Total" stands for the total annual cash inflow that the project will somehow have to generate in order to achieve the subject scenario.
The heading "Extra" stands for the extra annual cash flow that the project will draw from the METS or the village after the amount of cash is deducted that they will save by switching from current energy sources to the MHP plant.

In a final calculation the estimated current expenditures on lighting and refrigeration and the estimated costs for running the MHP scheme were used to calculate what the maximum investment would be that should be made on this project (including the transmission line) in order to reach a positive cash flow in ten years. This amount would be about US$ 44,200,- dollars, almost half of the estimated costs of the transmission line alone.

Potential for future economy of scale

There has been much attention paid to the Palumeu MHP project. This attention comes from the government as well as from other communities situated in the inlands.

- Government representatives were present at the initial kroetoe at Palumeu where the concept for executing a MHP project was presented to the village. The government is interested in experiences from the Palumeu case as they are planning to implement their own MHP project near the former Poketi site.
- The university coordinator for the Palumeu project (as well as other members of the Faculty for Technical Sciences) has been approached by communities along the Upper Suriname to assess the possibility of executing their own MHP project.

The prospect of several new MHP projects being deployed in Suriname means that there will be a greater market for MHP related technology and services. At present Palumeu is the only MHP case in the country and there are no firms specialised in providing MHP technology products, nor are there consultants specialised in providing consultancy on MHP projects. This has a negative impact on the project, reflected in the lack of an experienced consultant in the project team and the fact that the turbine is being designed and constructed by a firm unfamiliar with this technology. An increased market for these products and services would be an incentive for the presence of such firms and consultants. Although this does not effect the current situation of the Palumeu case, it would increase the chances of sustainability for future projects.

In Table 5.12 a summary output of the application of the model on the economic aspects of the Palumeu project is presented.

Table 5.12 Summary output for economic factors

Category	Critical Factors			
	Factor	Sub factor	Indicator	Short text
Economic	***Costs and benefits***	->	***Negative***	Using estimates for fuel expenditures, the village and the METS should be able to cover the running costs by saving on current expenditure. At current their budget cannot, however, cover the costs of a transmission line, and from an economic point of view the project is an unprofitable one.
	Income generation	->	*Negative*	Both sub factors are set negative
		Income generating schemes	*Negative*	The MHP project does not encompass any income generating schemes. Even if such a scheme was present, the market options are extremely limited due to the scarce local market and the transportation costs for accessing the Paramaribo market
		Incentives	*Negative*	There are no incentives applied for stimulating the presence of an income generating scheme
	Funding	->	***Negative***	Although there are some funds available, the ones acquired will not extend into the operational phase
		Availability	*Cautious*	There is funding available for covering intermediation and capital costs. No information was obtained on fund availability for access promotion or stimulating private entrepreneurship
		Extent	*Negative*	The funds acquired do not extend into the operational phase of the project
	Loan Financing	*Local availability*	*n.a*	Due to time constraints on the field research, the availability and conditions of loan financing for the community of Palumeu has not been researched. No
		Suitability for	*n.a*	

		long term MHP investment		indicator can therefore be set for this factor
		Training of local institutions	*n.a*	
	Economy of scale	**->**	***Negative***	Although there is indication the number of MHP schemes might increase, the present project cannot benefit from the presence of a large MHP orientated market
		Programme size	*Negative*	The Palumeu MHP itself is fairly small in size, although there are indications that other MHP projects might be implemented in the near future
		Available capacity	*Negative*	Currently there are no suppliers for MHP technology within Suriname
		Outside stimulation	*Negative*	There is at current no outside stimulation being applied that would encourage the start of a MHP industry
	Focus on poverty reduction	*Aptness of tariffs*	*n.a*	No arrangements have been made for the setting of tariffs. It can therefore not be assessed whether tariffs would have been fit for covering the MHP costs, would have promoted access connection or whether local inflation trend was accommodated for
		Access promotion	*n.a*	
		Inflation	*n.a*	

5.9.6 Institutional category

The main factors of notice in the institutional category are:

- Lack of broad development programme and locally active agencies
- Conditional consent from the Granman
- Positive government orientation towards MHP

Lack of broad development programme and locally active agencies
The lack of an extension programme for the MHP towards social development has already been remarked as one of the negatively influencing factors in the social category. Reviewed from the institutional level, it becomes clear that there are no development programmes being deployed at all. The US Peace Corps has a representative stationed at Palumeu, but is currently not deploying any development programmes. Although there are a number of development agencies situated in Paramaribo that can potentially deploy such programs, none are active in Palumeu. Until this potential is explored the chances of sustainable development occurring in Palumeu are unfavourable.

Conditional consensus from the Granman
The Granman of both the Trio and the Wayana were present at the kroetoe held to introduce the MHP project plans to the community at Palumeu. At the meeting the Granman of the Wayana expressed that although he was in favour of providing the village of Palumeu with a stable electricity source, he wanted to set a condition. The Granman resides at the village of Apetina, located several kilometres downstream of Palumeu. The village of Apetina is much larger and more important to the Wayana as a central meeting village for the communities. The Granman indicated that providing Apetina with a stable electricity source was, according to him, more beneficial for the Wayana as a tribe and therefore the more logical village to start with a MHP project. The condition set by the Granman was that after Palumeu, the village of Apetina should be the next village supplied with MHP. This condition, if not met, could lead to difficulties later on for the Palumeu MHP project. Lack of support from the Granman during the operational phase could cause lack of support from the Wayana majority of villagers at Palumeu.

Positive government orientation towards MHP

One positive aspect in the institutional category is that the government expresses a favourable attitude towards the use of MHP technology in the inlands. This is mainly due to the fact that the government wants to cut back on its expenditures on electricity for the inlands by switching to hydropower as a source of energy rather than fossil fuel which has to be transported to the inlands at high costs. The government has expressed a positive interest in the outcome of the Palumeu project. This reflects positively on the chances for success of the Palumeu MHP.

In Table 5.13 a summary output of the application of the model on the institutional aspects of the Palumeu project is presented.

Table 5.13 Summary output for institutional factors

Category	Critical Factors			
	Factor	**Sub factor**	Indicator	Short text
Institutional	***Development Programme***	->	***Negative***	There are no development programmes deployed in Palumeu
		Integration of development programmes	*Negative*	The Palumeu MHP project is not imbedded into a wider development programme and there are no other programs being deployed in the area
		Aims	*n.a.*	There are no development programmes being deployed in the area, no nature of aims can be assessed
		Clarity of aims towards community	*n.a.*	There are no development programmes being deployed in the area, clarity and communication of aims towards community cannot be assessed
	Political involvement	->	***Cautious***	The project is at present free from political interference, but the condition set by the Granman might lead to future difficulties
		Consent of the Granman	*Cautious*	The Granman has given his consensus on the basis that his resident village, Apetina, be next in line for deployment of a MHP project
		Other Political interference	*Positive*	The government expresses in interest in the outcome of the project, but exerts no influence. No political movements have expressed an interest in the project
	Government Policy/Legislation	->	***Cautious***	The presence of legislation issues and lack of active promotion create uncertainty as to the impact this factor will have on the success of the MHP project
		Legislation	*Cautious*	Land tenure issues and lack of subsidy for MHP do not reflect positive on the MHP project, but there legislation is not expected to have an outright negative effect on the project
		Promotion Renewable Energy Technology	*Negative*	The government has a favourable attitude towards RET but does not make active promotion for using these technologies
		Standardization	*Positive*	No prohibitive standards on construction and technology used will be imposed
		Grid supply	*Positive*	The extension of the grid to the inlands has been deemed economically unfeasible and will not compete with the MHP station
	Development agencies	->	***Cautious***	Although currently not active in Palumeu, there are several development agencies active in Paramaribo with the potential for executing development programmes in the community

5.9.7 Environmental category

None of the factors in the environmental category are considered to experience a negative impact from the project or to have a negative influence on the chances of successful execution and operation of the project. From an environmental standpoint the project is considered to have a positive outlook.

In Table 5.14 a summary output of the application of the model on the environmental aspects of the Palumeu project is presented.

Table 5.14 Summary output for environmental factors

Category	Critical Factors			
	Factor	Sub factor	Indicator	Short text
Environmental	***Impacts***	->	***Positive***	None of the sub factors is considered to experience a negative impact
		Resources	*Positive*	The project is not likely to damage the presence local resources
		Habitats	*Positive*	There are no habitats near the MHP site
		Ecosystems	*Positive*	Due to the small size of the MHP, any damage done will be negligible
		Air	*Positive*	The MHP will substitute the use of fossil fuel and thereby reduce CO2 emissions
		Water	*Positive*	No water pollution will be caused by the MHP
		Soil	*Positive*	The presence of the MHP increases the intensity of the slash and burn cycle in the area. Due to the size of Palumeu the priority of this impact is considered low
		Flora	*Cautious*	If a high voltage line is indeed constructed this will have a high impact on the local flora. This impact is considered to have a medium priority compared to the forest size
		Fauna	*Positive*	Both the level and priority of this impact are considered low
		Aesthetics	*Positive*	The remoteness of the site makes any aesthetic intrusion on the local setting low priority
		Natural and Cultural heritage	*Positive*	No natural or cultural artefacts known will be damaged by the system
	Reserved/Residual flow	->	***Positive***	There are no restrictions posed or applied as to the size of the residual flow
	Regulations	->	***Positive***	The government does not impose specific environmental regulations in the area

5.10 Summary conclusions on Palumeu case

From the application of the assessment model to the Palumeu case it becomes clear that there are quite a number of factors restricting the chances for the project of becoming long-term functional, let alone bringing about a process of sustainable development for the village of Palumeu.

With the particular choices made for this project, the absence of water potential for delivering the year round 5 kW promised by the project developers can be seen as a direct reason for the project to fail. However, reviewing beyond the technical category, it seems that the cause for most of the difficulties experienced by this project lies within the organizational category. The lack of engineers experienced in the development of micro hydro projects can be seen as one of the main causes for the difficulties experienced within the project. This inexperience led to the choices made on the technical aspects and the improper survey into the social aspects by not recognizing the need for such investigation. The enthusiastic decision to start construction of the project without properly investigating if operation of the system will be feasible, considering both the financial aspects as well as the requirements for a capable staff, can be seen as a form of optimism that also stems from inexperience.

The lack of proper communication towards the village is also a factor that severely limits the proper execution of the project. This is a factor that has not been accounted for in the model. An adaptation may be needed in the model to account for this factor. A proper approach would be to evaluate this model against several more cases to determine if this lack of communication is a factor that is generally applicable to the case of Suriname or just a one time occurrence for this particular case.

Assuming that it would be somehow possible to construct a functional MHP plant at the Panato creek and erect a transmission line for transferring this power to Palumeu, the project would still have to be considered as insufficiently orientated at reaching sustainable development. There is no recognition of the need for a social extension program and no income and employment generating schemes have been connected to the project. The only aspect of sustainable development that has been covered by the project is that, if functional, it should be able to reduce the use of fossil fuel in Palumeu, thereby delivering a positive contribution to the environment.

5.11 Evaluation of model use

From the application of the model to the Palumeu case, a number of important lessons are learned about the model itself:

- Necessity for a particular order in assessment of factors
- Need for distinguishing between internal and external factors
- Need for a dual mapping mode
- Shortcomings of tools
- Shortcomings in clarity of output
- Need for a weighting system
- Advantages of model for editing the critical factor map
- Disadvantages of model for editing of information into the model
- Drawback of the assessment study's size
- Problems with stationing of model

Necessity for a particular order in assessment of factors

In the Palumeu case the model is used in a static mode. Many parameters for the Palumeu case have already been set by the choices made by the project team. In this case the model can mostly function as a checklist, identifying the strengths and shortcomings of these choices made. The order in which the different categories, factors and sub factors are identified is left up to the user and is of no great consequence for the end result. However, if the model is to be usable as an ex-ante assessment model in the dynamic sense envisioned in the model design, the situation will be different. In the Palumeu case the project has a high probability of being technically unfeasible at the Panato creek. If this conclusion was drawn before the start of the project, this fact would basically negate the need for further assessment and the whole project would become a hypothetical case. This illustrates the need for the model to follow a certain order. In Figure 5.3 a flowchart is presented representing a proposed order in which the assessment could be carried out.

The flowchart starts with the presence of a social need for electrification. This initiates the foundation of an organizational structure to solve the need, and the start of an orientation study to assess the potential for micro hydropower (or other energy sources) as a solution. The model then follows a number of steps as illustrated until the final planning for the operational phase. In the flowchart the backward linkages between the different factors are also illustrated, representing the dynamic nature desired from the model.
In the current state the mode in which the model is constructed uses a subdivision by category instead of a set order such as illustrated in the flow chart. The linkages between factors have to be followed manually. This means that although the model is usable as an ex-ante model, this is requires the user to possess knowledge on the proper execution of an assessment study in order to follow the right order. This means that for the model to become generally usable, it needs to be changed to a form where the flowchart order is automatically imposed on the user.

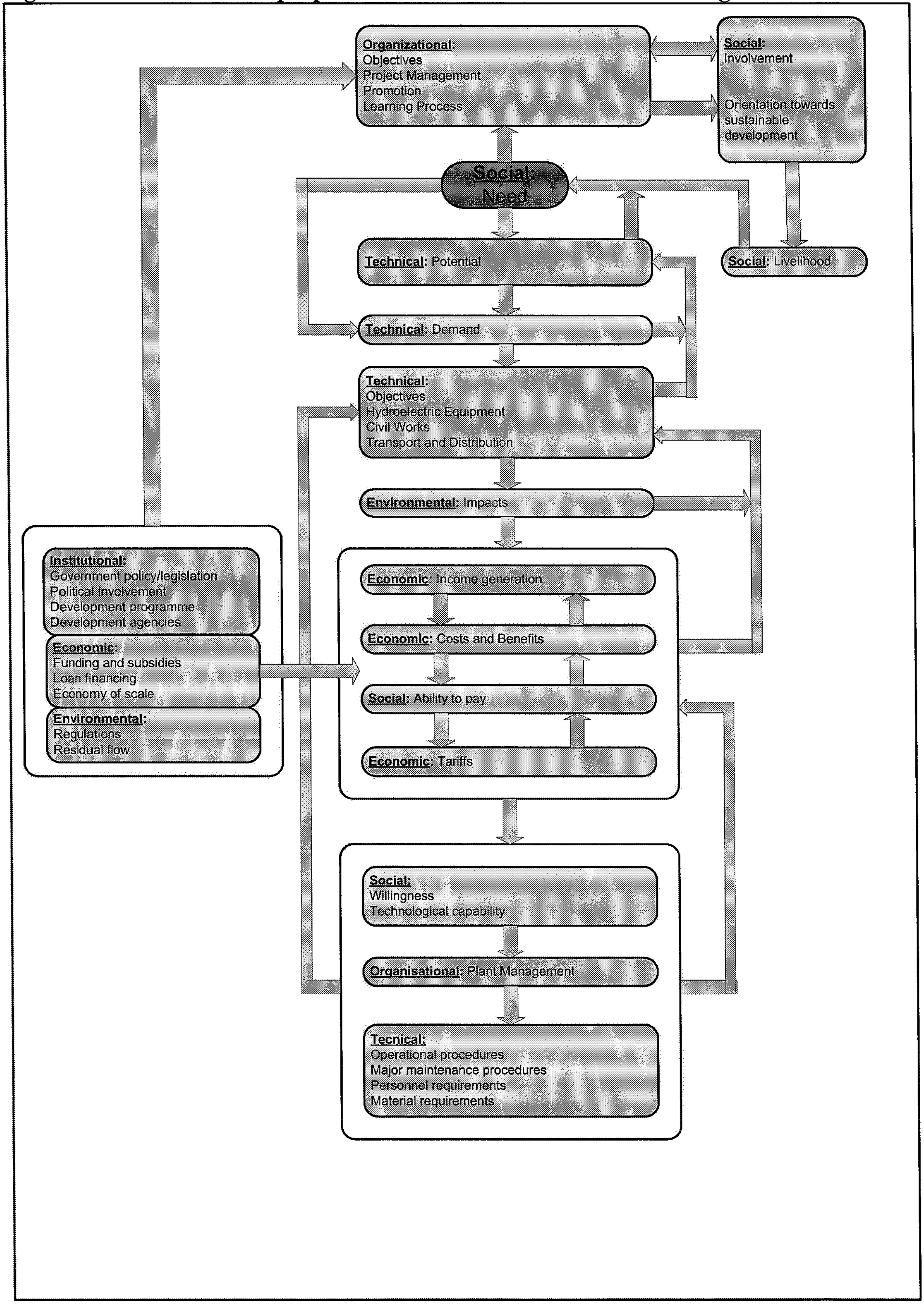
Need for distinguishing between internal and external factors
From the flowchart it becomes clear that the factors influencing the project at hand can basically be divided into two categories: the factors which are internal, influenced by the choices made by the organisation conducting the hydro project. The other factors are external, lie outside the influence of the organisation. They exert an influence on the project, but can not be adjusted by choices made within the project. These factors lie in the institutional and economic category and the regulatory aspects of the environmental category. This means that once proper data has been collected for these factors and this data is inserted into the model, these factors should remain relatively independent from the project at hand and would not have to be researched for every new project.

Need for a dual mapping mode
The current mode in which the model is built, per category instead of in the flowchart form as presented in Figure 5.3, is very useful to gaining a quick insight as to where the difficulties or constraints lie in a project, and what the positive aspects are. This feature is very useful. If the model is transformed into a model following flow chart mode, this overview would become less clear. The best option would be if a software base can be found that would allow the model to have a dual mode, allowing the user to switch from a form following the flowchart to the current overview mode.

Shortcomings of tools
In the current form the model makes use of linkages to calculative tools such as a voltage drop calculator, spreadsheets for calculating the load and creating power load graphs and spreadsheets to calculate financial feasibility. There is room for a lot of improvement with these tools. When conditions in one category are changed, the changes need to be manually transferred to the different calculators. This is easily done but time consuming if the user wants to quickly try out several scenarios.

Shortcomings in clarity of output
The output mode of the program has both its strengths and weaknesses. The graphical output gives an easy overview of what the positive and what the negative aspects of the project are. This does however not give any details on why these factors are set positive or negative. To get this information one needs to either manually open the factor of interest, or use the document output form. This form however creates a document which needs a substantial amount of editing to transform it into a proper assessment form.

Figure 5.3 Flowchart with proposed order for ex-ante assessment using critical factors



Need for a weighting system
In the current form the model gives a positive, negative or cautious result for each sub factor which is then used to ascertain the outcome of the main factors and subsequently, the subject category. In chapter 3 it is indicated that all factors are given equal weight as all the factors found are considered to be of critical importance to the outcome of the project. That being the case, there are two rule schemes that can be chosen for deciding the outcome of (sub-) factors and the subject category on the basis of the indicators set.
One is an absolute rule, where if one indicator is set negative, this should set all subsequent levels in the tree from indicator to category to negative. If there are no negative indicators the presence of a cautious indicator would set the whole tree cautious. Only if all indicators where positive the final outcome of a category could be positive.
The other option would be an ordinal rule where the outcome of a factor or category is decided by tallying the number of positive, negative and cautious indicators and assigning an outcome based on which indicator possesses majority.
In practice, neither of these rules suffices. Applying the model to the Palumeu case, it became clear that there needs to be some kind of weighting system. In the current model that weighting is left up to the user, who can argument choices based on best practice knowledge, local knowledge or experience. This has the positive effect of the model remaining flexible and not subject to a rigid set of weighting rules. The negative side to this is of course the introduction of subjectivity into the outcome, as the user's choices and argumentation influence the outcome of the assessment. Assigning a system of weights, however, would require extensive research and testing of the model where the effects of each indicator on the final outcome would have to be measured. In view of the subject matter, a long term MHP project aimed at sustainable development, such research can be considered unrealistic.

Advantages of model for editing the critical factor map
The modular structure of the model makes editing the critical factor map an easily manageable task. Attention has to be paid to the associated measurement tables and linkages, but inserting new factors and sub factors (such as the influence of the Granmans), rearranging them within a certain category or transferring them to another category where necessary does not pose significant difficulties.

Disadvantages of model for editing of information into the model
The editing of information into the model turned out to be a cumbersome task and will greatly hamper its practical application. In this experimental stage the information needed for the use of the model was inserted through unedited text copied into the model, links to digital documents are internet sites possessing information or data on best practice use and links to hard copy documentation obtained from the local data search. Use of the information in this form was manageable for users possessing intimate knowledge on the contents of the available material, but otherwise time-consuming and cumbersome. For a practical use of this model outside of this experimental research, all of this information would have to be manually edited into the model in an easily surveyable way. In addition, issues concerning copyright of library articles or data obtained from outside archives would have to be carefully examined.

Drawback of the assessment study's size
The objective of this research was to design an assessment model that would incorporate as much of the factors that are critical for designing a sustainable MHP system as possible. As a consequence, the model is very broad and requires a great deal of input in order to function.

During the field study an attempt was made at obtaining a broad spread of data, with the focus on the organizational category. Attempting to accurately fill in the model and to acquire information on all of the indicators would constitute quite a large assignment. The volume of research required would become less every time the model is used, as information acquired on relatively set factors (such as information on government policy and regulation) would eliminate the need for new research in that category. Until this information has been properly edited into the model, however, the numbers of indicators taken into account makes the assessment model a sizable instrument to use.

Problems with stationing of model

A final issue with the practical use of the model is where and how the model should be stationed. In order to gain the cumulative effect described in chapter 3, the model would have to be used consecutively on each new project, preferably with the information and results of the previous project edited back into the model. This means that the model would have to be stationed in a well-known and public location that would not only allow developers access to the model in it current state, but would be continuously updated as feedback on the model is received. This would require an investment in both facilities and personnel for storing and editing the model.

The Anton de Kom University, being a well-known knowledge institute in Suriname, is one potential location for such a model, possessing both the infrastructure as well as the know-how needed for the upkeep of such a model. The presence of budget, personnel and the desire to actually undertake this is a matter which would have to be further investigated.

Other sources for stationing the model have not been investigated.

5.12 Summary conclusions on model use

By applying the model to the Palumeu case a lot of valuable information was obtained on its ability to function in practice. The most important lesson is that although the current modular design is very practical for quick identification of the problem areas in a case, the model itself would not be very efficient when actually used as an ex-ante method. For this the model should preferably follow a step by step design such as represented in the flow chart in Figure 5.3. Another fundamental issue is the lack of a weighting system in the model, leaving the designation of importance of the various indicators op to the user and thus introducing a measure of subjectivity to the model. Solving the weighting problem would require a sizable amount of extra research.

Functionally the model would benefit from the improvement –or substitution- of the currently used tools and its ability to create a readable output. These issues are mostly related to the software used.

Besides the fundamental issues with the model, there are also practical issues with its upkeep and use, as the model would require time-consuming work for the editing of information and for the processing of evaluations and results of projects the model was used on.

All these lessons lead to the conclusion that the use of such a multilevel assessment tool, although advantageous for the identification of errors in a MHP project, would require a great amount of work before it could be used in more than the experimental capacity for which it was currently used.

6. Final Conclusions and Recommendations

The objective of this research was to explore the possibility for the design of an ex-ante assessment method that could help maximise the chances for a micro hydro project of being both able to function for a long time as well as providing a basis for achieving sustainable development.
This objective was translated into a number of research questions which this thesis tried to answer. Practically, the research was conducted both through theoretical and field research. The results of this research have been presented in the previous chapters.

The conclusions on the research can be divided into two categories:
- Conclusions and recommendations on the proposed assessment methodology.
- Conclusions on micro hydro power application in Suriname and recommendations for future projects.

6.1 Conclusions and recommendations on the proposed assessment methodology

The conclusions on the assessment methodology designed can be subdivided into three main themes:
- The comprehensiveness of the model designed for performing the assessments.
- The functionality of the model.
- The possibilities for practical application.

Comprehensiveness
From the literature review it became clear that in order for a project to be sustainable in the sense that it was able to function for a long time as well as provide a starting point for sustainable development, a myriad of factors needed to be considered during project design and execution. These factors are spread across a number of categories, namely organisational, social, technical, economic, institutional and environmental.
Obtaining these categories and structuring into a theoretical map provided the basis for constructing a comprehensive assessment methodology.
Initially, the factors incorporated into the theoretical map were obtained from general literature research and case studies. In order to optimise the assessment methodology for the application in Suriname, a review was made of two past rural electrification cases in the inlands to investigate whether there were factors of importance relating to the specific case of MHP projects in these inlands. The conclusion from these reviews was that an extra sub factor needed to be added to the model, namely the influence of the Granman (chief of chiefs) of the tribe concerned. Other factors of importance to the two past cases conformed to the factors already obtained from the general literature study.
During the application to the Palumeu case the communication between the project team and the community at Palumeu turned out to have a serious impact on the execution of the project. Whether this factor merits separate inclusion into the model would be subject to the outcome of further investigation, to decide if this is a structural issue when conducting projects in the inlands of Suriname, or simply a one time occurrence related to the organizational setting of this specific case.

The conclusion of the literature research, evaluation and application of the assessment model is that the factors included form a sufficiently comprehensive basis for conducting the desired assessment.

Methodology

From the literature on process design two important requirements for ideal project design were given: The inclusion of backward linkages within and between the diverse project phases and the need for incorporation of elements from both process and blueprint approaches. On this basis an outline was given of an ideal design for a decision support system of which the assessment methodology would be an integral part. The system would have to be active during the whole of the project, including the operational phase. However, the design of such a system lies outside of the scope of this research. A functional design was chosen that would simulate the backward linkages by storing information from previous projects.

Application of the model showed that, even in its experimental form, it can greatly help with the conduction of assessments. The comprehensiveness of the model ensures that attention is paid to all the important factors and the graphical output is a great aid in pointing out the problem areas. Further research on the model, in order for it to develop into a fully functional ex-ante assessment tool, would have to focus on improving several methodological and functional aspects of the model.

- There are two fundamental aspects of the model that should be improved. One shortcoming of the model lies in its current modular design, which makes it inefficient for use as a true ex-ante assessment model. For the model to be able to function in such a capacity, the model needs to follow a more step by step approach. The second aspect that requires attention is the (lack of) weighting system of the model. At current the weighting is left up to the user, introducing a measure of subjectivity to the assessment methodology. Assigning objective weights to the different factors would however require a sizeable amount of research and be at the cost of flexibility of the model.
- The model has several limitations when it comes to processing input and displaying the results. These shortcomings are mostly a result of the software and tools used and could be solved by either finding existing software packages better suited for this purpose or designing a custom software package.

Practical use

A practical issue with using the model currently lies with the extent of the research needed to completely fill in the model. This should, however, pose a diminishing difficulty as there are a number of factors (mainly institutional and economic that should remain reasonably independent of the project at hand. Once the data on these factors has been filled in they should remain valid, diminishing the amount of work that needs to be done the next time the model is used.

The practical use of the model in such a way that it meets the desired objective of incorporating feedback being accessible for local developers would require facilities and personnel for the upkeep of the model. The processing of feedback and the editing of information into the system is a time consuming endeavour. Editing the critical factor map would require editors with know-how of the subject at hand. The possibilities for basing such a model in Suriname are unclear. The Anton de Kom University possesses the infrastructure and know-how for such an endeavour, but the presence of budget, available personnel and the desire for such an undertaking would have to be investigated.

Overall it can be said that the proposed model possesses a great deal of potential. Through further research and application, it can be developed from its present experimental form into a working, useable aid for the conduction of ex-ante assessments.

Recommendations for further research:
Further research on the design of the assessment methodology should focus on:
- Solving the fundamental issues with the structure of the model (the need for inclusion of a step by step option).
- Solving the fundamental issues with the weighting system. An investigation is needed to decide how a weighting system can best be introduced into the model without losing its flexibility.
- Investigation into the possibilities for basing and maintaining the model. This should include a survey of local organisations capable of maintaining such a model or possibly even non-local organisations that focus on this area of research.
- Refinement of the different categories: This research was an explorative one with a broad focus on all categories. Future research should narrow its focus separately on each category in order to get a more in depth perspective on the issues relating to that category.
- The importance of the informal aspect. During this research a wealth of knowledge was obtained from informal sources. The lack of extensive statistical data to base the model is a common occurrence in (most) developing countries. The knowledge required through informal means is of great importance for the (further) development of the model and special attention will have to be paid to the verification of this knowledge.

6.2 Conclusions on micro hydro power application in Suriname and recommendations for future projects

From the local research conducted, the review of the past projects and the application of the model to the Palumeu case, conclusions can be drawn on the Palumeu case specifically and the possibilities for micro hydro application in Suriname in general.

Palumeu
The conclusion that can be drawn from the assessment conducted is that there are too many aspects wrong with the Palumeu project. The chances of it being able to function, for an extended period of time, as a source of electricity to the village of Palumeu are slim and the present approach to the project does not bear well for the possibility of it serving as a stimulant for sustainable development within the community. The technical feasibility of the project providing the community of Palumeu and the resident eco tourism organisation with a useable source of energy is doubtful. In the unlikely case of succeeding with the technical implementation, the lack of social and Economic extension programs restrict the project from having a lasting positive effect towards sustainable development.
The main cause for this situation can be seen as stemming from a lack of experience and know-how within the executing project team.

Recommendations
With the Palumeu case a course has been set and the options for change are limited. Recommendations for the current project would be to use the hiatus period in construction for obtaining further data on the available water potential. As the dam is only partially constructed, it might be considered to find a new, more suitable location and abandon the current one. A costly decision, but perhaps not as costly as further construction and

installation of a MHP system in an unsuitable location. This would remain dependent, of course, on the availability of a better location. In light of the strong seasonal variations in the water level and flow of rivers the developers should consider building a bigger reservoir or -in the case of a run of the river scheme- investing in a longer bypass for utilising a larger head difference.

If the project is finished at the Panato creek, another option would be to abandon the concept of supplying electricity to the village of Palumeu and investigate the prospect of installing an income generating application at the Panato itself, thereby circumventing the need for a transmission line and limiting the loss of potential power.

Suriname

For the general case of Suriname, a conclusion that can be drawn from the local data search and the past and present cases is that there are several factors that will have a negative impact on the ability to design and execute a MHP project in the inlands. These factors include:

- The lack of experienced consultants in the field of micro hydrology
- The lack of hydrometric data for assessing potential MHP sites
- Expected difficulties relating to willingness to pay
- High transportation prices to the inlands, impacting on the costs of civil works

When deciding to commence with a MHP in the inlands, extra attention will have to be paid to these factors in order for a project to succeed.

On the positive side, the willingness of the government to find a replacement for diesel as a source of energy for the inlands and the rise of ecotourism as a source of income for the inlands have a positive impact on the chances of such a program succeeding.

Recommendations for future projects

When executing a new micro hydro project in Suriname, it would be of vital importance to include an experienced micro hydro engineer into the project. Although the efforts of the Palumeu project team to design and construct a system with only local know-how are commendable, the fact is that the lack of experience led and will lead to costly mistakes. It would be less costly to invest in retaining an experienced engineer for at least the first project in line after the Palumeu project. Possibly, this project could then be assigned a learning project, offering local engineers the opportunity to gain experience before independently undertaking any future projects.

The vital necessity to attach an income generating scheme to a MHP project should be impressed on every project developer executing such a project. In that light, an investigation into the possible revenues of eco tourism for the inlands should be undertaken to assess whether this industry has a true potential of fulfilling that role of income generating scheme.

Another aspect that will require more attention than has been given in past and current projects is the need for a social development programme. If such an extension program is not attached to future projects, the projects might succeed technically but would not bring along the desired development for the inhabitants of the inlands.

Epilogue

During the finalisation of this research two very sad events occurred.

The first one was the break down of the Palumeu project due to extreme flooding in the inlands of Suriname.
Several months after the conclusion of the field research part of this study, construction of the micro-hydro structure at Panato creek was finished. This was done with the help of private funding of a Dutch citizen affiliated with the village. A transmission line was not constructed. Four months after the completion of this construction, uncommonly heavy rainfall caused flooding all over the inlands, including at the Panato creek. The water level exceeded the design expectation, and the flooding caused damage to dam, the generator housing and the generator. Although my research pointed out the weakness in design due to lack of hydrometric measurement, such an outcome of the project was not what I anticipated or hoped for. I sincerely hope that another solution will be found to provide the people of Palumeu with the electricity they require.

Another, infinitely more sad event, was the passing away of Stef Niekoop, former head of the BWKW and teacher at the ADEKUS. He was a great help to me during my research and a great believer in the capacity of the Surinamese citizens to improve their capabilities and find a way to solve the energy problems in the inlands. May he rest in peace.

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Reference table for interviewees

Reference code	Name of Interviewee	Function
[DelPrado]	Ing A.R. Del Prado	Designer/Main engineer Poketi project
[NgATham]	Ir. K.S.A. Ng A Tham	Former Ministry of Interior/BWKW representative
[Naipal]	Dr S. Naipal	Project leader of the Palumeu Project/Anton de Kom University representative
[Bhagwandas]	A. Bhagwandas	Director METS; Ecotourism organisation
[Artist]	Drs J. Artist	Chairman of VIDS, Organisation of Inheemse chiefs
[Akrum]	Drs E. Akrum	Director of IMWO (Institute for social research at the ADEK)
[Ramses]	Ramses K.	Kapitein (chief) of Inheemse village Langamankondre
[Remak]	B. Remak-Zaalman	Chairman of Hiawata, foundation for Inheemse women of Marijkedorp
[Lytle]	R. Lytle	Missionary of the World Team Mission, a religious organisation active in Inheemse territories
[Seedo]	N. R. Seedo	Chairman of StiBop, foundation for the Marron village Botopasi
[Strijk]	R. Strijk	District Commissioner to Sipaliwini
[WongLoiSing]	R. Wong Loi Sing	Representative of Community Development Fund Suriname
[Abidie] [Banai]	J. Abidie, F. Banai	Two representatives of Ministry for Regional Development
[Hewit]	T. Hewit	Head Education of the Jan Starke Institute; Training centre for Interior inhabitants
[Akker]	S. van den Akker	Director of REMACON, engineering company for the Palumeu project
[Niekoop]	Ing S. Niekoop	Former head of Bureau Waterkrachtwerken (BWKW)
[DosRamos]	Ing O.A. dos Ramos	Designer/Executing engineer of Kwamalasamutu project
[Jantz]	Th .L. Jantz	Chairman of Word Music Ministry, foundation representing Palumeu village
[Janomo]	E. Janomo	METS Resort Manager Palumeu
[Keijyer]	Mr. Keijyer	Basja of Palumeu

Internet Locations used

[http://www.microhydropower.net/]
Internet portal on (micro) hydropower

[http://www.itdg.org/]
Homepage of the ITDG - Intermediate Technology Development Group

[http://www.undp.org/energyandenvironment/]
UNDP page on Energy and Environment

[http://www.cbvs.sr/]
Homepage of the Central Bank of Suriname

[http://www.suriname.nu/]
Informational page on Suriname

[http://www.uvs.edu/]
Homepage of the Anton de Kom University of Suriname

[http://www.surinamevacations.com/]
Homepage of the METS Travels and Tours

[http://www.medischezending.sr]
Homepage of the missionary society for health care in the inlands of Suriname

[http://web.worldbank.org/]
World Bank internet page for development indicators

[http://www.devdir.org/]
Directory of development organizations

APPENDICES

A. General

1. Definitions used

Sustainable development:
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland definition)

Sustainable micro hydro project
Project that is able to meet people's electricity needs during a long period, as well as providing a basis for social and economical development without compromising the ability of future generations to meet their own needs.

Categorisation of factors
Organizational category
Category that comprises all factors relating to the management approach and structure of the project.

Social category
Category that comprises the factors pertaining to social status and development of the community involved.

Technical category
Category that comprises the factors pertaining to the technical feasibility of designing, constructing and operating the micro hydro project

Economic category
Category that comprises the factors pertaining to the financial costs and benefits and the economic environment in which the project is being deployed.

Institutional category
Category that comprises the factors pertaining to the outside institutions which fall outside of the influence of local developers and community, such as government and development agencies.

Environmental category
Category that comprises the factors pertaining to the ecological impacts of the projects and the surrounding regulations.

Surinamese concepts
Inheemsen
Indigenous (Native American Indian) population of Suriname.

Marrons
Tribal inhabitants of the inlands of Suriname, descendants of rebel African slaves from the colonial period.

Kapitein
Chief of an Inheemse or Marron community.

Basja
Assistant to the Kapitein of an Inheemse or Marron village.

Granman
Chief of chiefs for the whole of a certain Marron or Inheemse tribe.

Kroetoe
A meeting to discuss issues of importance to an Inheemse or Marron village. The use of the term kroetoe implies that at least on person of importance will be at the meeting (e.g. the kapitein or a government official).

2. Hydropower

Some specifications on hydropower and turbine design

Table A.2.1 Classification of hydropower stations

Classification of hydropower stations	Subdivision	Power
Large(>15 MW)	Large	>100 MW
	Medium	15-100 MW
Small(<15MW)	Small	1-15 MW
	Mini	100 kW- 1MW
	Micro	5 kW -100 kW
	Pico	<5kW

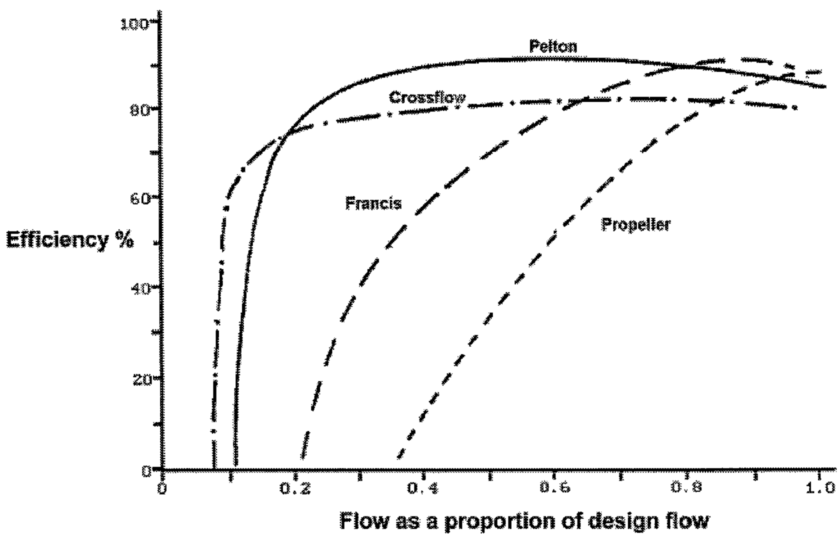
From: ITDG.org

Table A.2.2 Turbines sorted by type and head applicability

Turbine type	Head classification		
	High (>50 m)	Medium (10–50 m)	Low (<10 m)
Impulse	Pelton Turgo Multi-jet Pelton	Crossflow Turgo Multi-jet Pelton	Crossflow
Reaction		Francis (spiral case)	Francis (open-flume) Propeller Kaplan

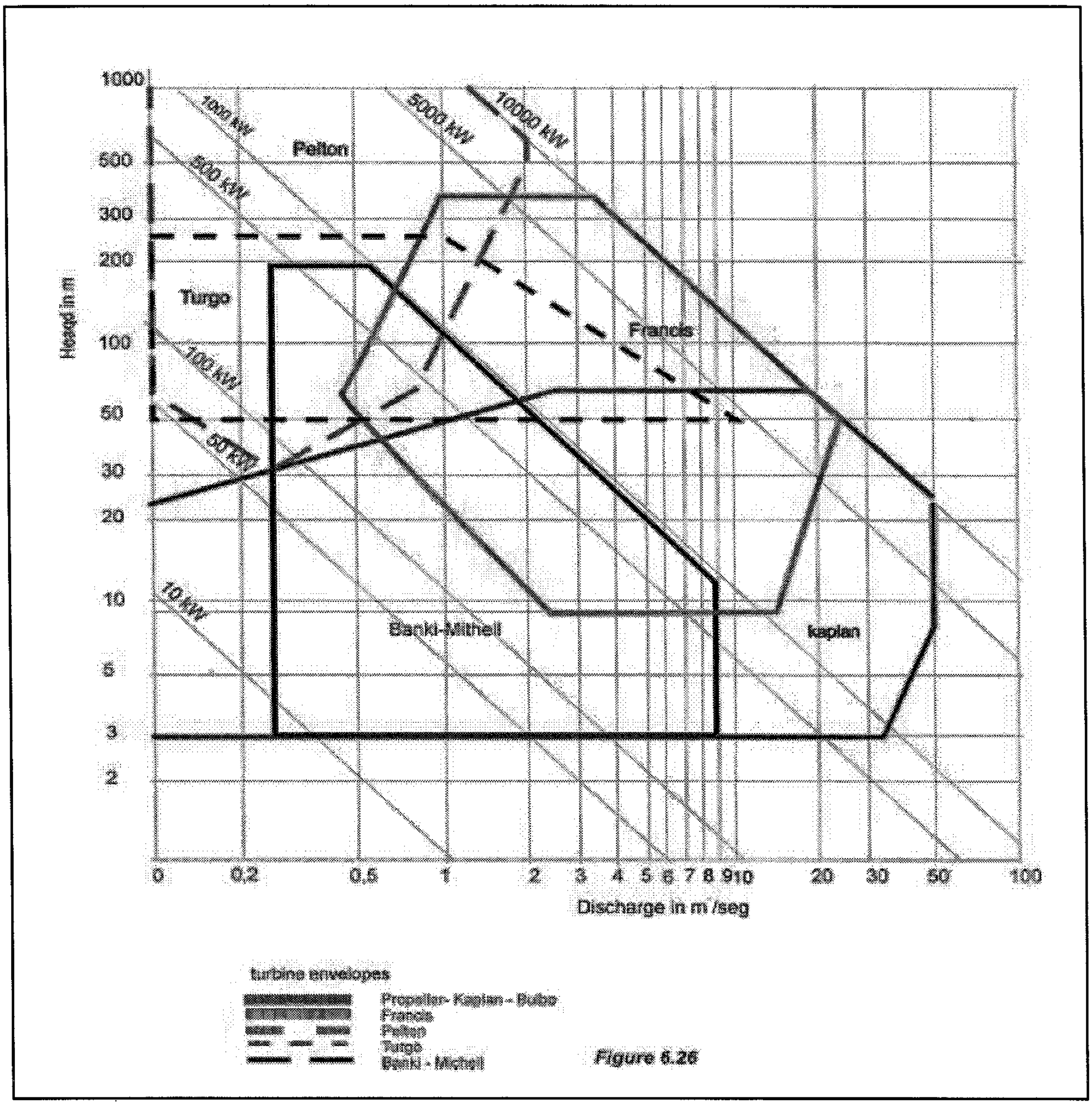
Source: [Paish2002]

Figure A.2.1 Part-flow efficiencies of turbines (Q_{actual}/Q_{design})



Source: [Fraenkel1991]

Figure A.2.2 Functional range of turbines



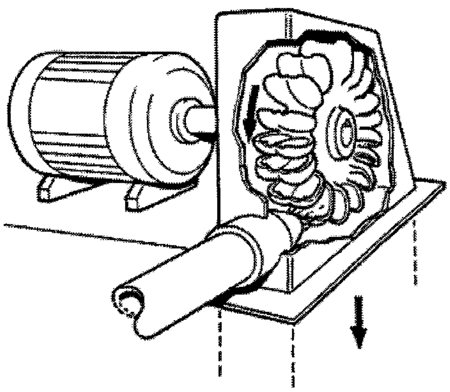
Source: [Penche1997]

Figure A.2.3 Minimal Technical Flow for turbines

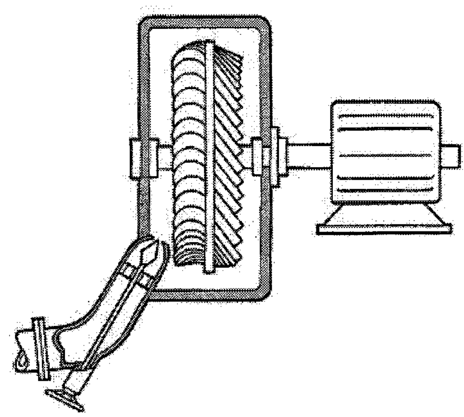
Turbine type	Q_{min}
Francis spiral	30
Francis open flume	30
Semi Kaplan	15
Kaplan	15
Cross flow	15
Pelton	10
Turgo	10
Propeller	65

Source: [Penche1997]

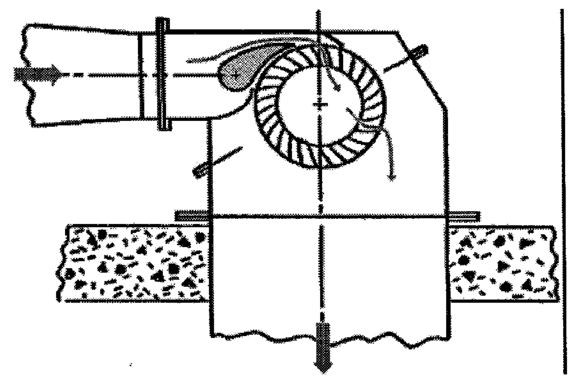
Figure A.2.4 Turbine Schematics



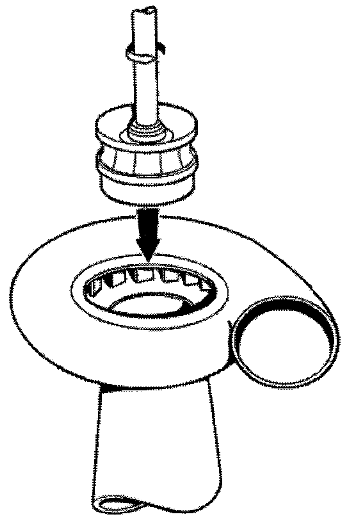
A) Pelton turbine



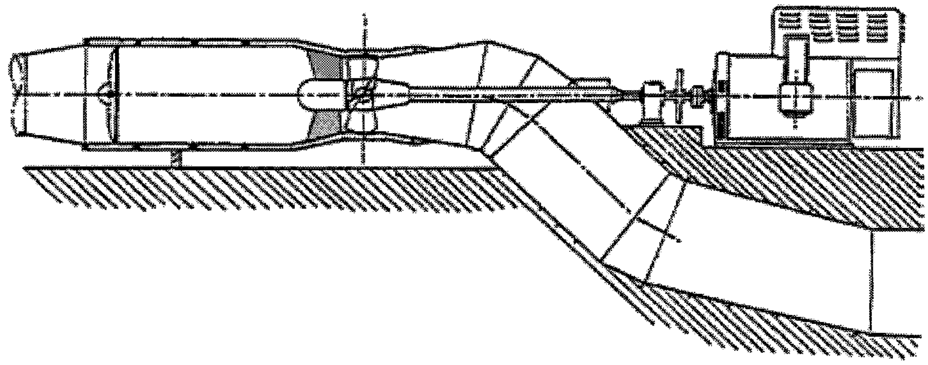
B) Turgo turbine



C) Crossflow turbine



D) Francis turbine



E) Propeller turbine

Source: [Paish2002]

3. Lifecycle Modelling

Project vs. Asset lifecycle
When modelling the life cycle of a micro hydro project two points of reference can be used. One is the project surrounding the construction of the micro hydro system, resulting in a model of a project life cycle. The other way of defining the life cycle would be by using the constructed system itself as a point of reference. The resulting model is called an asset life cycle.

There are several ways of defining phases within a project life cycle. A life cycle model will always start with the conception of the project. Generally, the following phases can be distinguished next[78]:

- Pre feasibility: The options of realising the concept or idea are inventoried
- Feasibility: The options are narrowed down and a optimal path is chosen
- Development: A project detailed project design is created
- Execution: The project design is executed or constructed
- Launch: The project is finished and can begin operation
- Evaluation: The project is evaluated and lessons learned are used for future reference.

The life cycle of the micro hydro system (the asset in this case) can be divided into four phases. They are:

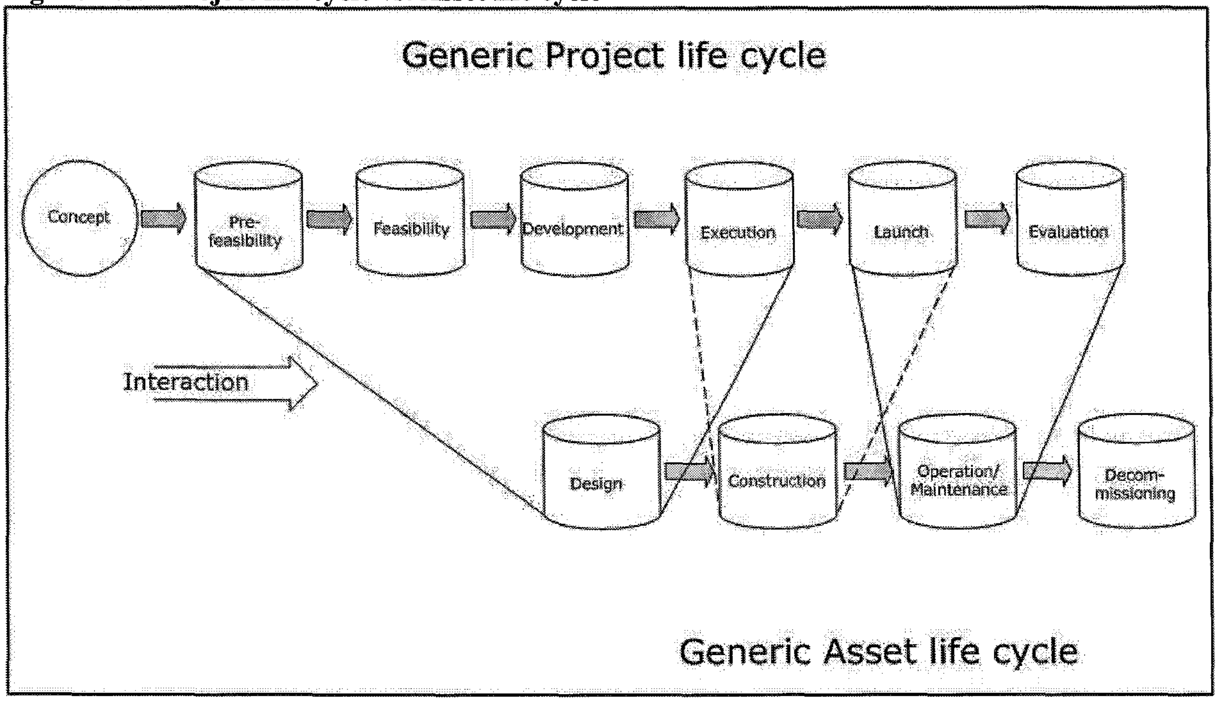
- Design: The design for the asset is conceived and engineered
- Construction: The asset is constructed or produced
- Operation/Maintenance: The asset becomes functional and has to be maintained
- Decommissioning: After it has reached the end of its lifetime or usefulness, the asset is decommissioned.

These are the general phases comprising project and asset life cycles. In other models the phases might be named differently, some phases might be merged or others subdivided into more phases, all depended on the project at hand and the level of detail in which one wishes to describe the life cycles.
Although the two life cycles are separate, there is interaction between them. The micro hydro system is a product of the micro hydro project. As such, the project life cycle phases can be coupled to the product life cycle phase. Pre feasibility, feasibility, development and execution are linked to the design phase of the product. Execution and launch are linked to the construction phase, while the operational phase can be linked to launch and evaluation.
Figure A.3.1 gives an example of generic project and product life cycles and how they interconnect.
The purpose of the DSS proposed in chapter 3 is to provide support and guidelines for project design. These guidelines have to be aimed at long term, sustainable development. This means that the model must be able to look beyond merely the lifetime of the micro hydropower system or end with the finalisation of the construction project. The model is therefore designed on the basis of a merger between the concept of a product and a project life cycle. The project and asset life cycle are merged into four stages:

[78] Definition on project and asset life cycle adapted from [Labuschagne 2005]

- Concept and Feasibility: The conception, pre feasibility and feasibility study of the project life cycle are combined into this phase. In the asset life cycle, the first stage of the design phase is represented by this phase.
- Design and Construction: This phase combines the project phases Development and Execution, resulting in the design and construction of the asset.
- Operation and Maintenance: The operation/maintenance phase in the asset life cycle is entered during the launch phase in the project life cycle. Evaluation follows after the system has been running for a certain amount of time
- Decommissioning: The system is decommissioned once it reaches the end of its lifetime or usability

Figure A.3.1 Project life cycle vs. Asset life cycle



4. Formulas

Formula for power generation

$P = \eta \rho g H_n Q$

P = Total power generated by the plant [W]
Q = Flow; volume of water routed through the turbine per second [m3/s]
H_n = Net head; The height difference between the intake and the turbine, adjusted for head loss due to friction in the diverse structures [m]
g = Gravity constant [m/s^2]
ρ = Water density [kg/m^3]
η = Turbine efficiency

Formula for calculating voltage drop:

Single-phase: VD = $2\ C\ I\ L_C/A_C$.
Three-phase: VD = $1.7\ C\ I\ L_C/A_C$.

VD = Voltage drop [V]
C = Direct-current constant. [Ω.m]
I = Current [A]
L_C = Conductor length [m]
A_C. = Conductor cross section [m^2]

Formula for calculating Net Present Value:

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_0$$

NPV= Net Present Value
t = Year of cash flow
n = Total project time (years)
r = Discount rate
C_t = Net cash flow in year t.
C_O = Cash flow in the investment year (t=0)

Formula for calculating discount rate:

$$r = \frac{(1+i)}{(1+p)} - 1$$

r = real discount rate
i = nominal interest rate
p = inflation rate

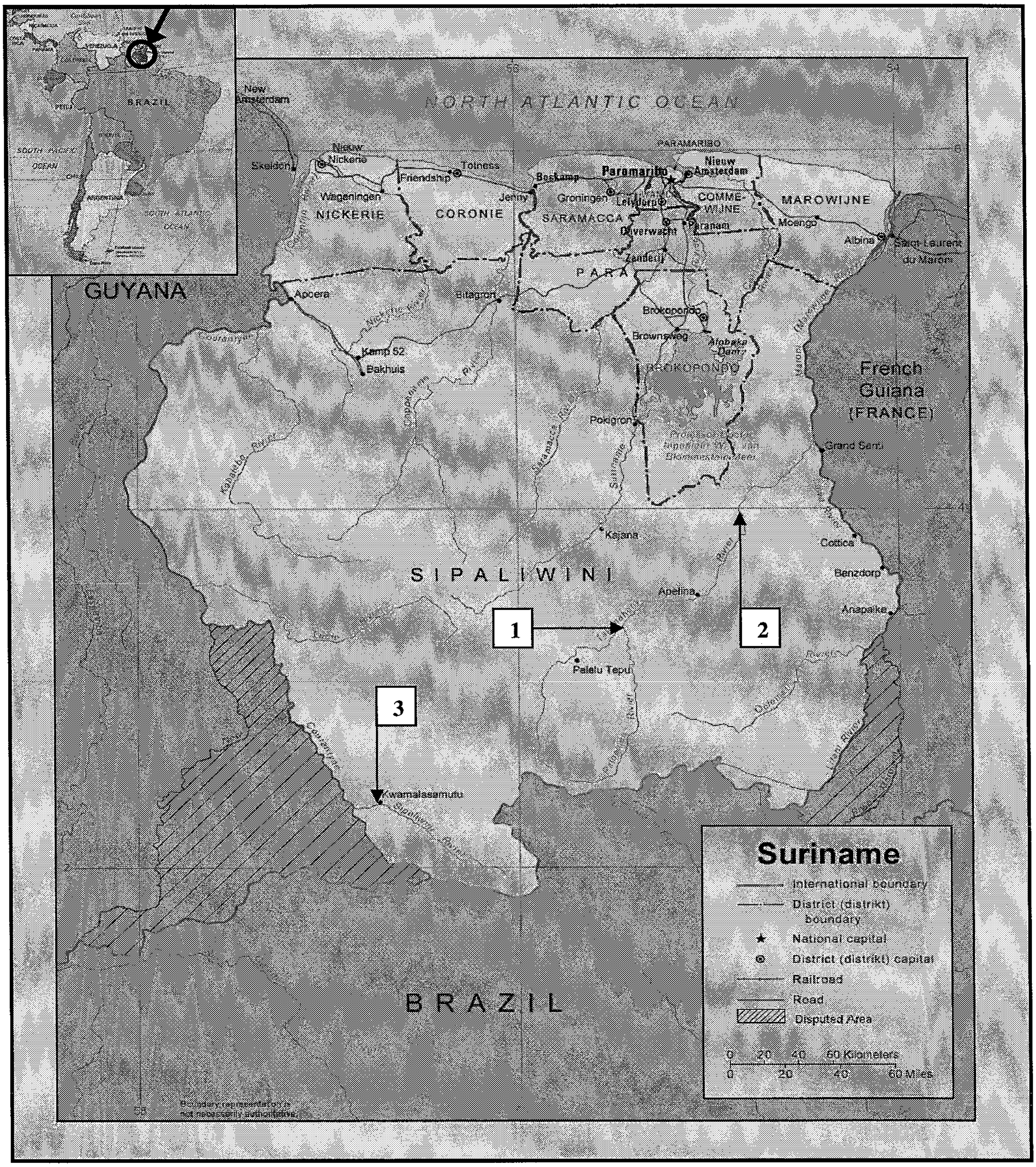
5. World Development Indicators for Suriname

World Development Indicators for Suriname	2001	2002	2003	2004	2005
Agriculture, value added (% of GDP)	11	12	9	-	-
Aid per capita (current US$)	53	26	25	54	-
Air transport, registered carrier departures worldwide	1900	1700	4402	4768	-
Annual deforestation (% of change)	-	-	-	-	
Births attended by skilled health staff (% of total)	-	-	-	-	-
Cash surplus/deficit (% of GDP)	-	-	-	-	-
CO2 emissions (metric tons per capita)	5	5	-	-	-
Electric power consumption (kWh per capita)	-	-	-	-	-
Energy use (kg of oil equivalent per capita)	-	-	-	-	-
Exports of goods and services (% of GDP)	24	21	28	-	-
Fertility rate, total (births per woman)	-	3	3	3	-
Fixed line and mobile phone subscribers (per 1,000 people)	376	424	560	659	-
Foreign direct investment, net inflows (BoP, current US$)	-	-	-	-	-
Forest area (sq. km)	-	-	-	-	147760
GDP (current US$)	763465536	950808128	1020536960	1108983424	-
GDP growth (annual %)	5	3	5	5	-
GNI per capita, Atlas method (current US$)	1770	1900	2060	2230	-
GNI, Atlas method (current US$)	772219008	838082432	912425600	996704512	-
Gross capital formation (% of GDP)	30	25	34	-	-
High-technology exports (% of manufactured exports)	0	-	-	-	-
Immunization, measles (% of children ages 12-23 months)	82	73	71	86	-
Imports of goods and services (% of GDP)	54	44	64	-	-
Improved sanitation facilities, urban (% of urban population with access)	-	99	-	-	-
Improved water source (% of population with access)	-	92	-	-	-
Industry, value added (% of GDP)	22	20	22	-	-
Inflation, GDP deflator (annual %)	35	30	13	9	-
Internal freshwater resources per capita (cubic meters)	-	199696	-	197106	-
Internet users (per 1,000 people)	33	45	52	67	-
Life expectancy at birth, total (years)	-	69	69	69	-
Literacy rate, adult female (% of females ages 15 and above)	-	-	-	87	-
Literacy rate, adult male (% of males ages 15 and above)	-	-	-	92	-
Malnutrition prevalence, weight for age (% of children under 5)	-	-	-	-	-
Merchandise trade (% of GDP)	113	101	131	147	-
Mortality rate, infant (per 1,000 live births)	-	-	-	30	-
Mortality rate, under-5 (per 1,000)	-	-	-	39	-
Net barter terms of trade (2000 = 100)	-	-	-	-	-
Personal computers (per 1,000 people)	46	-	-	-	-
Population growth (annual %)	1	1	1	1	-
Population, total	437486	440670	443628	446460	-
Poverty headcount ratio at national poverty line (% of population)	-	-	-	-	-
Present value of debt (current US$)	-	-	-	-	-
Prevalence of HIV, total (% of population ages 15-49)	1	-	2	-	-
Primary completion rate, female (% of relevant age group)	103	-	-	-	-
Primary completion rate, total (% of relevant age group)	98	-	-	-	-
Revenue, excluding grants (% of GDP)	-	-	-	-	-
Roads, paved (% of total roads)	26	26	-	-	-
School enrolment, primary (% net)	93	92	92	-	-
School enrolment, secondary (% net)	64	63	63	-	-
Services, etc., value added (% of GDP)	66	69	69	-	-
Short-term debt outstanding (DOD, current US$)	-	-	-	-	-
Surface area (sq. km)	163270	163270	163270	163270	-
Total debt service (% of exports of goods, services and income)	-	-	-	-	-

Source: www.worldbank.org

B. Local Data and Maps

1. Political Map of Suriname with locations of Case Studies

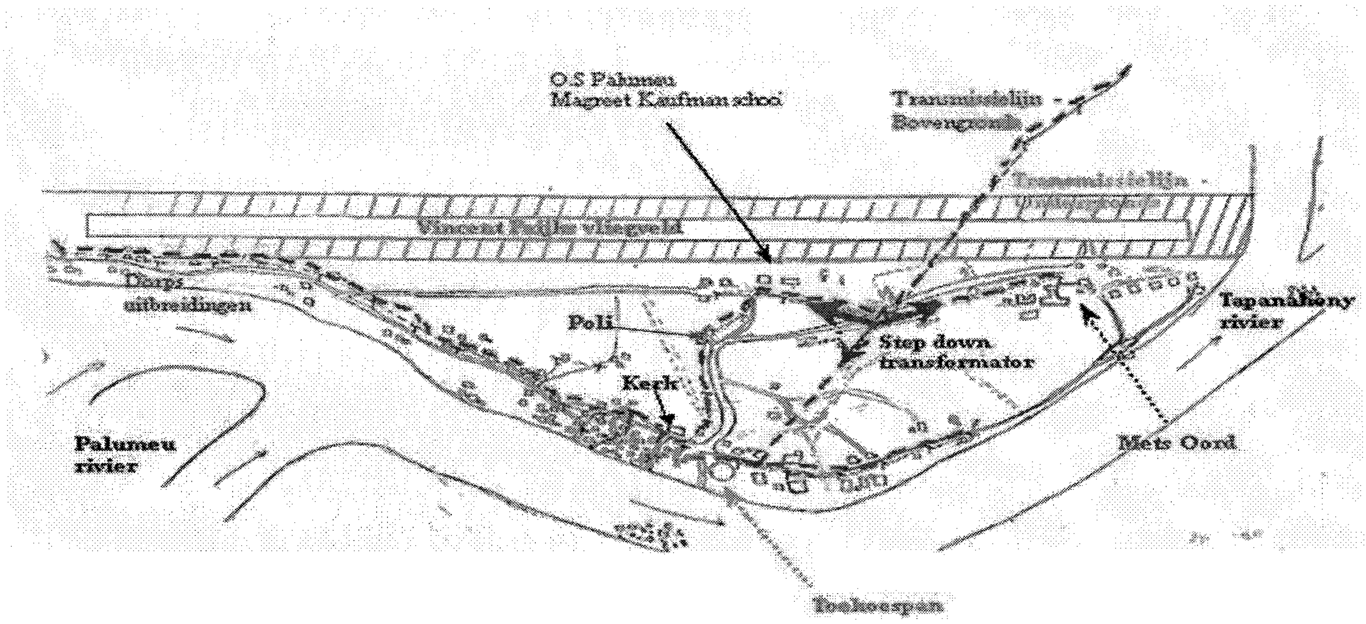


Source: Adapted from http://www.lib.utexas.edu/

1 Palumeu
2 Poketi
3 Kwamalasamutu

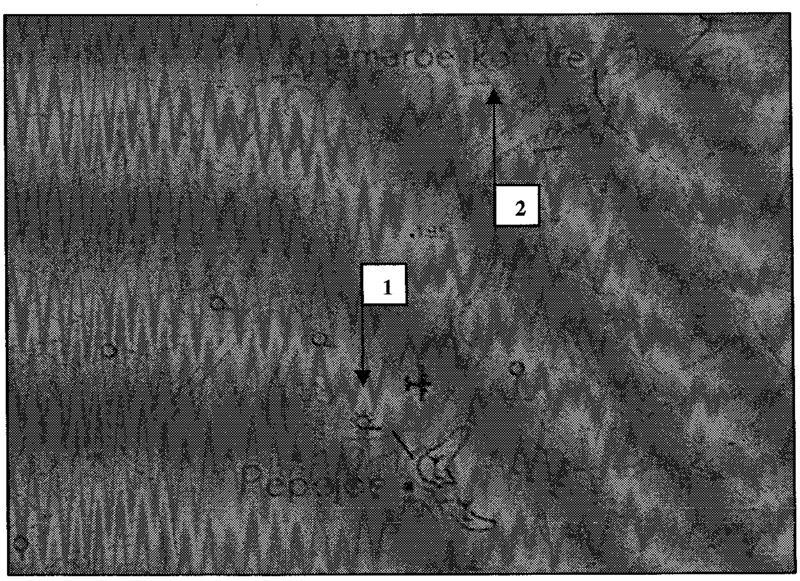
2. Layout of Palumeu Village:

2.1 Sketch of the layout of Palumeu village



Source: ADEKUS Palumeu case files, field report 09-2002

2.2 Location of Panato creek site

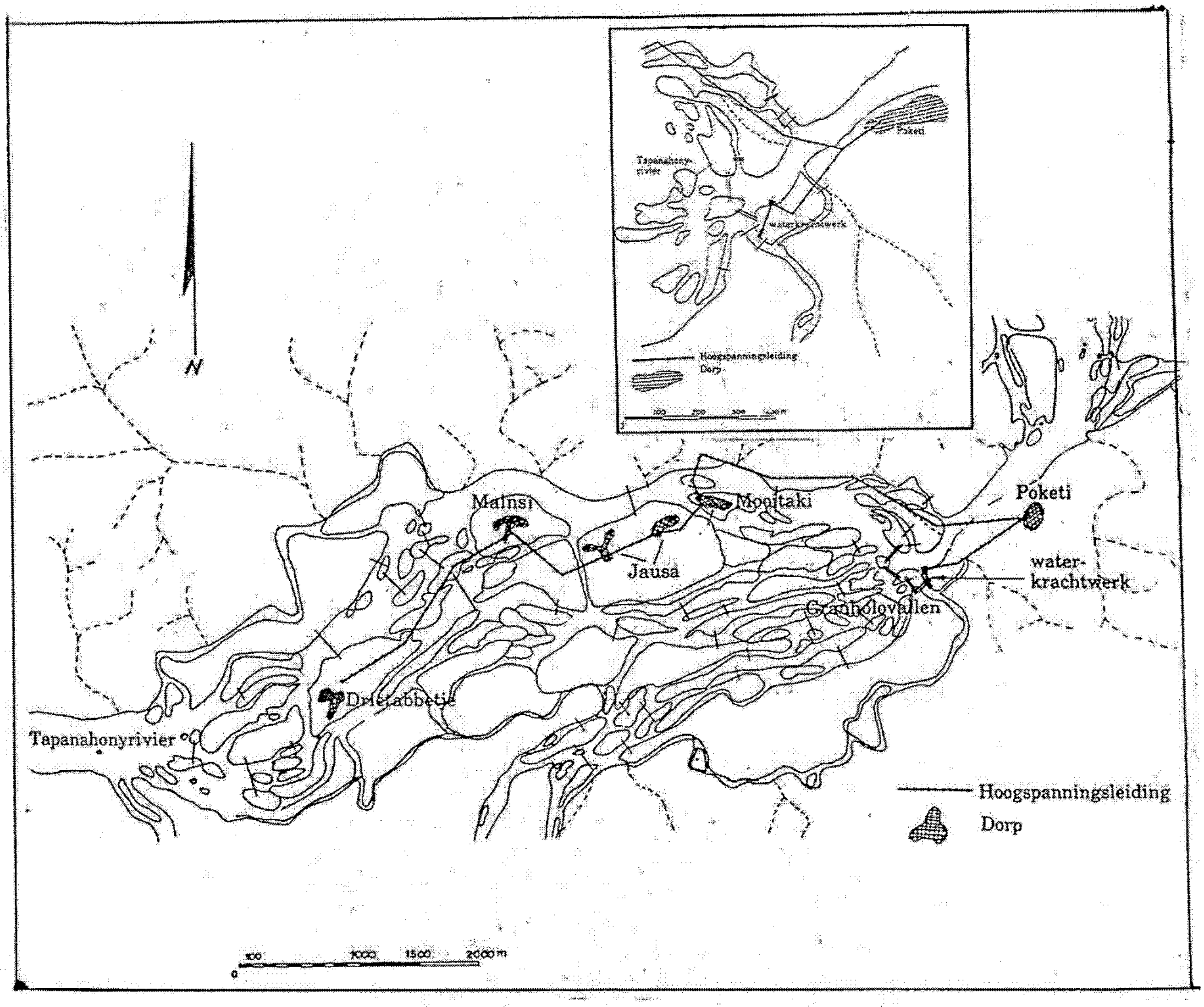


1 Palumeu Village
2 Site at Panato creek

Source: Central Bureau for Arial Cartography

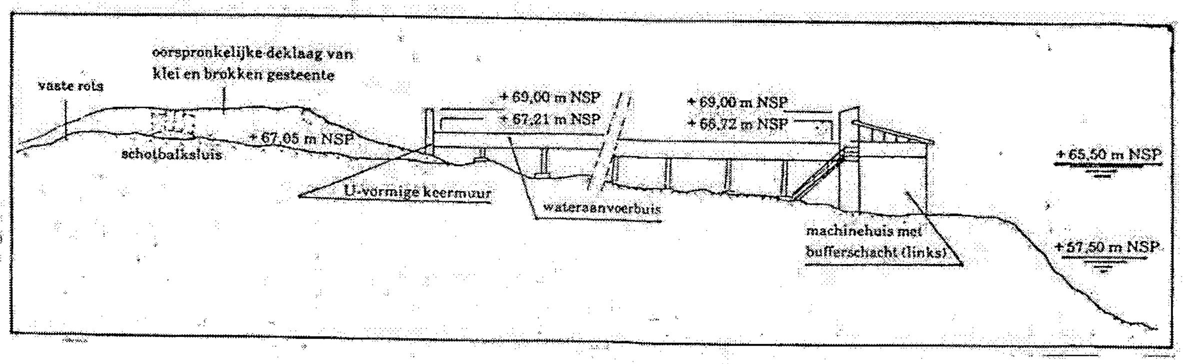
3. Poketi Hydro Power Station

3.1 Situational Sketch of Poketi Micro Hydro Plant and connected villages



Source: [DelPrado, 1981]

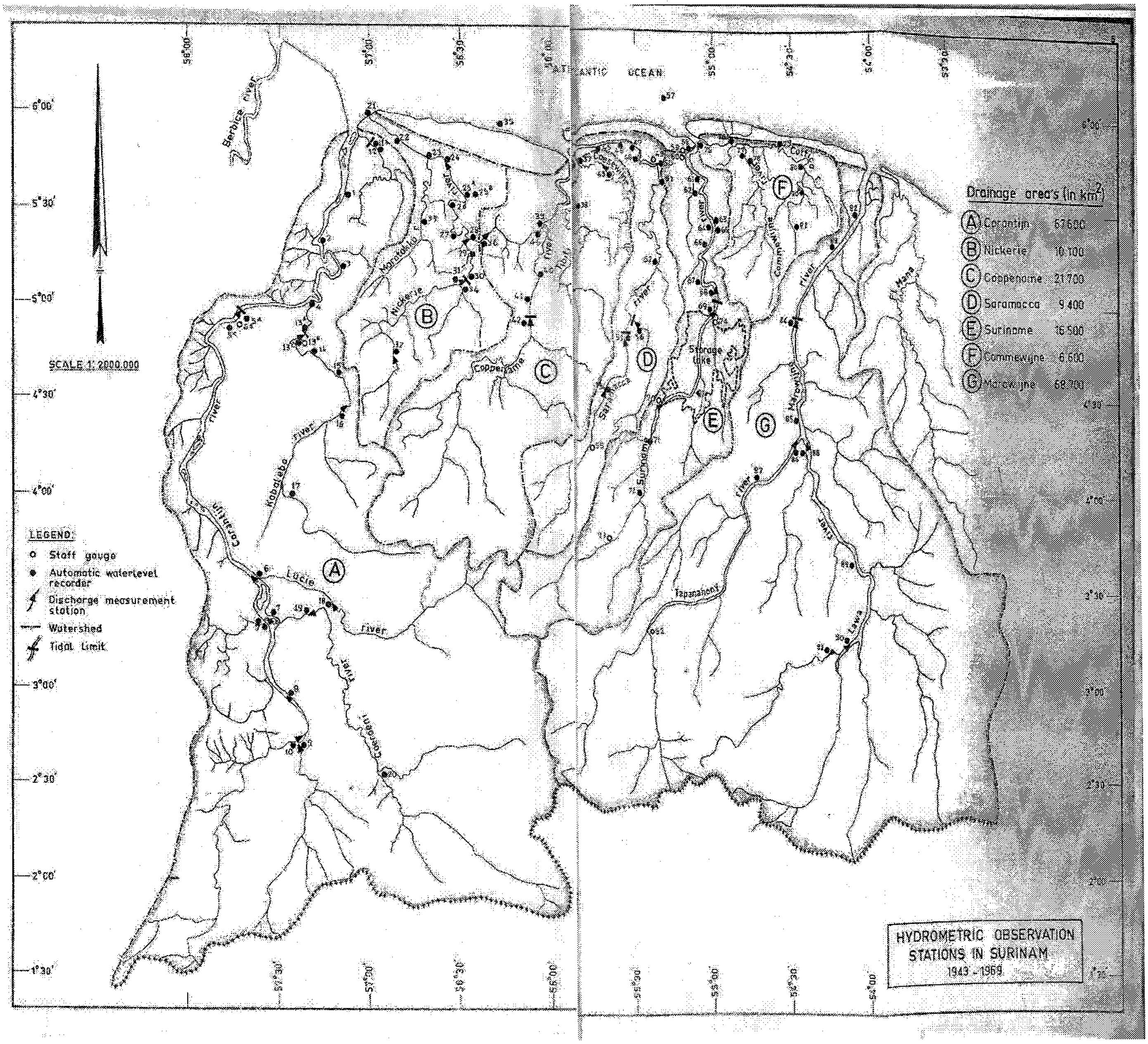
3.2 Cross Section of the Poketi Hydro Power Station



Source: [DelPrado, 1981]

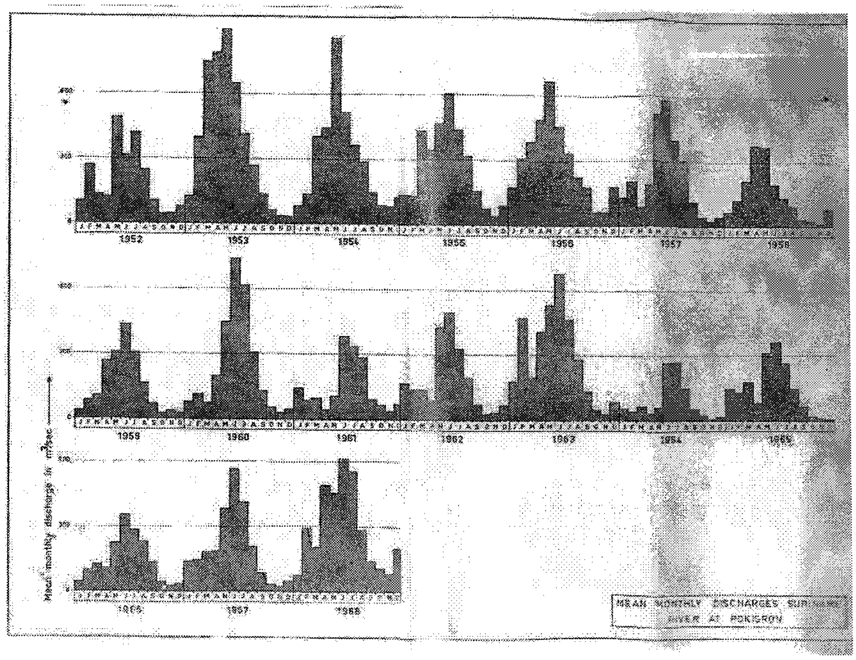
4. Hydrometric Measurements

4.1 Map of hydrometric measurement stations in Suriname



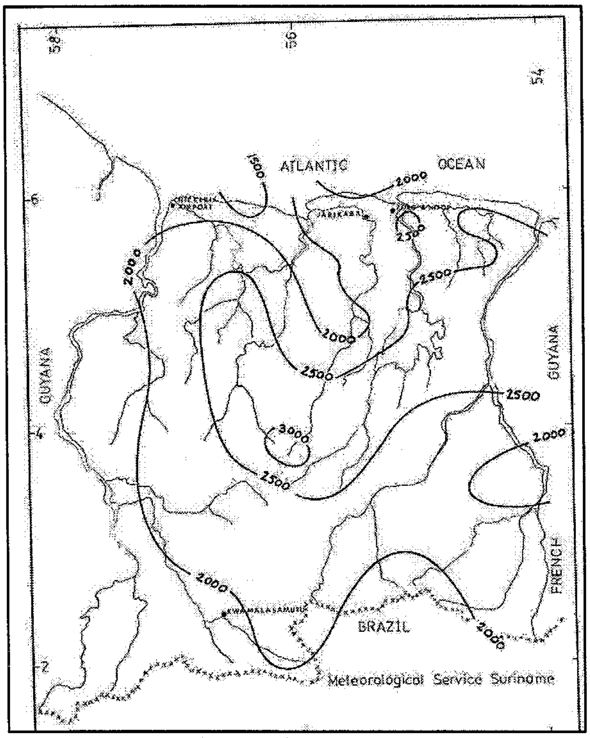
Source: The Hydraulic Research Division, Suriname

4.2 Mean Monthly discharges at Pokigron Station, Upper Suriname



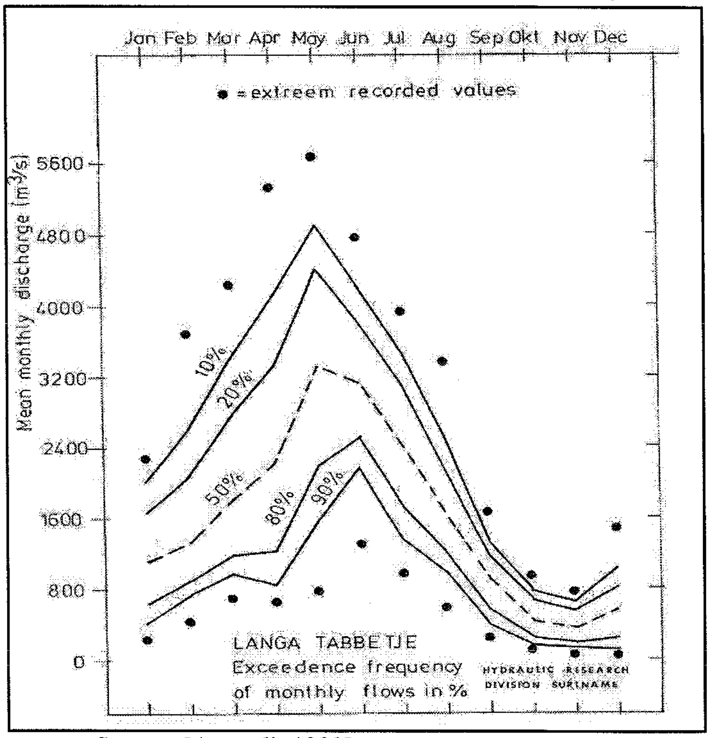
Source: [WLA, 1969]

4.3 Precipitation in Suriname



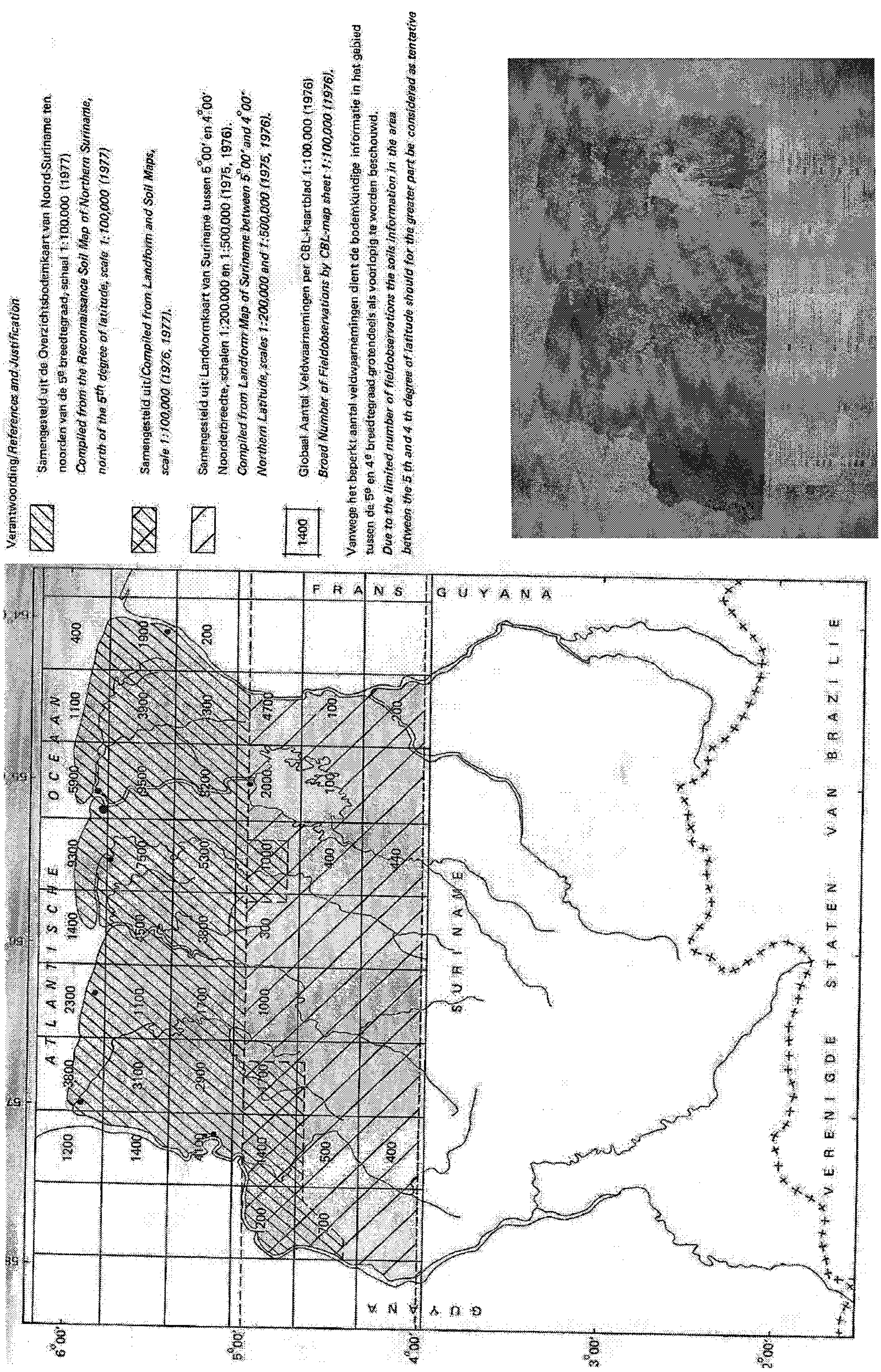
Source: [Nurmohammed, 1998]

4.4FDC of the Tapanahony at LangaTabbetje



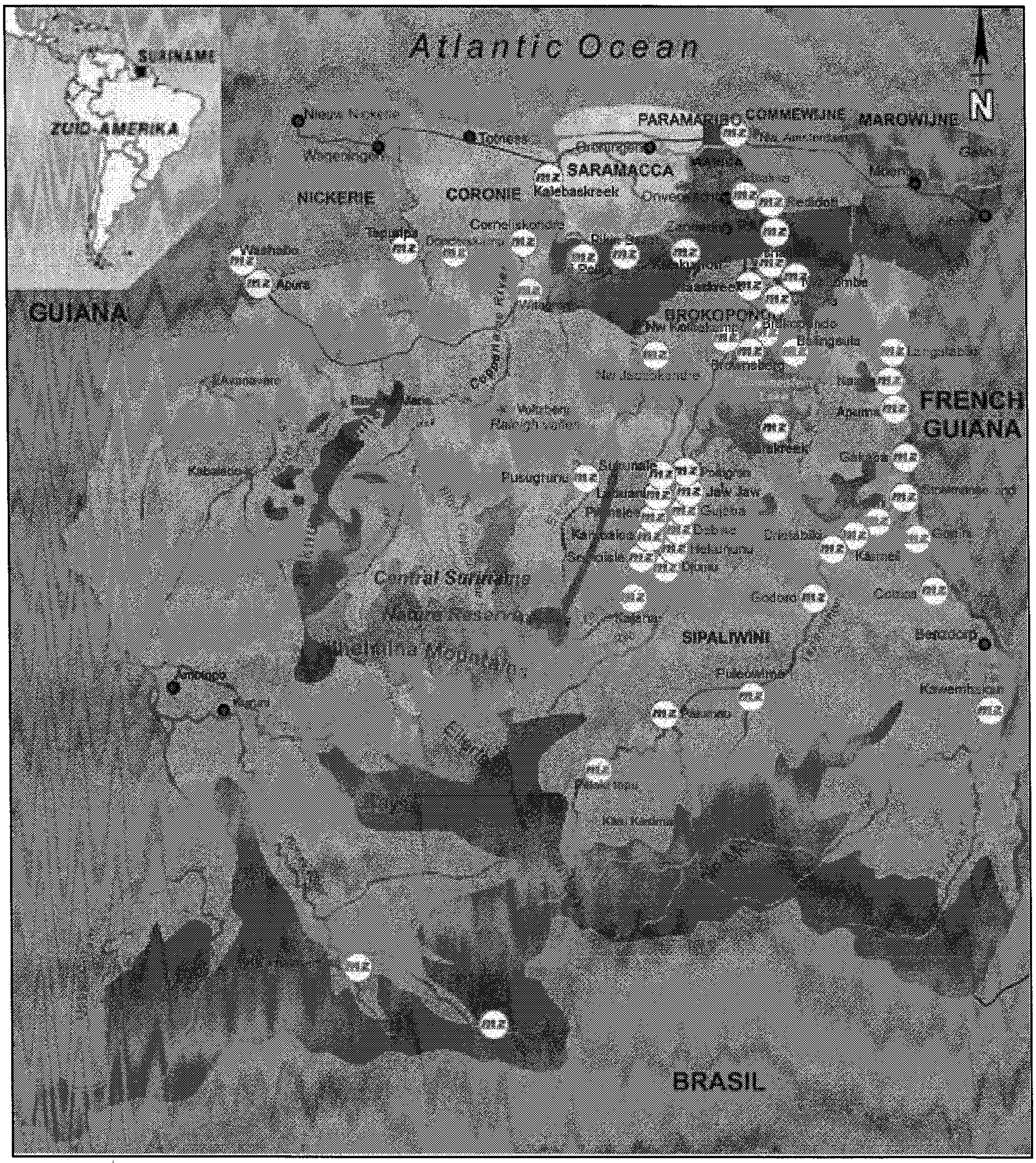
Source: [Amatali, 1993]

5. Availability of Geological Data in Suriname



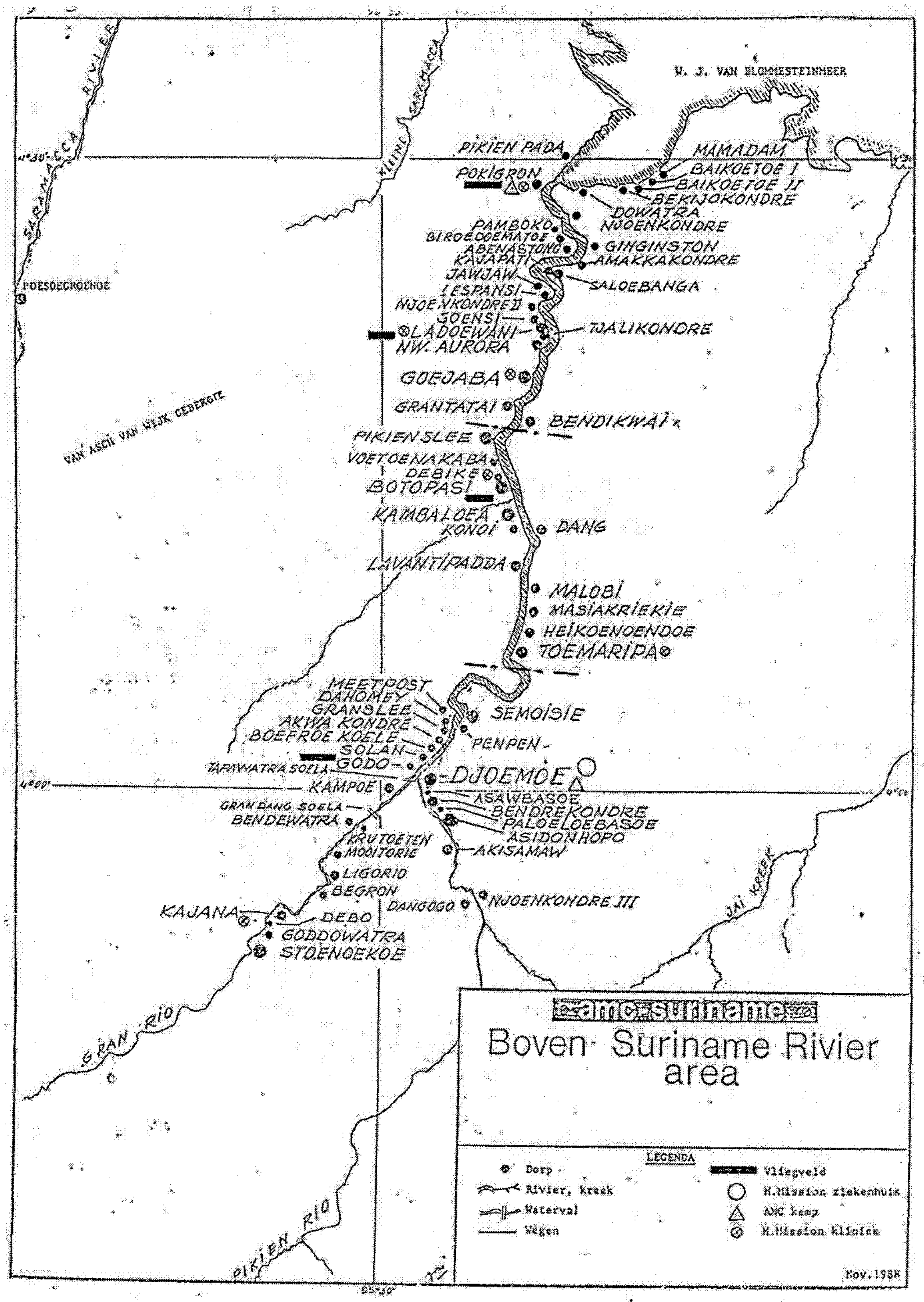
Source: Geological Survey Department

6. Location of Medical Outposts in the Inlands of Suriname



Source: http://www.medischezending.sr/

7. Location of Marron Villages along the Upper Suriname



Source: [Nurmohammed, 1998]

8. Government Expenditure on Electricity for Villages along the Upper Suriname

Village(+additional number of villages connected to generator)	Installed capacity(kW)	Monthly allowance (barrels diesel oil/month)	Average Transportation fuel (barrels gasoline/month)	Average Oil (cartons/month)
Stonuku	34	8	4	2.18
Cayenne(+3)	125	15	4	2.18
Legorio(+1)	40	10	4	2.18
Jaujau	12	5	4	2.18
Dangogo	40	10	2	1.09
Asidonhopo(+3)	150	17	2	1.09
Bendekondre	40	10	2	1.09
Godo	40	8	2	1.09
Semoise	90	12	2	1.09
Manlobi	40	8	2.33	1.27
Dangogo	60	10	2.33	1.27
BotoPasi	150	17	2.33	1.27
Foetoenakeba	60	10	2.33	1.27
Piekienslee	60	10	2.33	1.27
Guyaba	140	17	2.33	1.27
Nw Aurora	60	10	0.75	0.33
Jaujau	30	8	0.75	0.33
Abenaston	60	10	0.75	0.33
Danboko	60	10	0.75	0.33
Pokigron	125	12	0.33	0.33
Duwatra	60	10	0.33	0.27
Difutu	40	8	0.33	0.27
Total 22(+7)	**1,516**	**235**	**44**	**24**

Total installed capacity	1516 kW
Approximate households	2100
Average installed capacity per person	0.72 kW
Average running hours	18:00 - 22:00
Yearly usage per household	1 MWh

Government expenditure per year	**SRD**	**US$**
Diesel	1,635,600	594,764
Gasoline	327,360	119,040
Oil	57,600	20,945
Total	**2,020,560**	**734,749**
Total per household	962	350

Source: [Banai]

9. Flight Transportation Costs to the Inlands

Commercial transportation costs for the flights to the inlands in Suriname in 2005

	C-206	BN2B	C-404	C-208	N24A	DHC-6
	400 KG	700 KG		1000 KG	1000 KG	1400 KG
ALALAPADU	$ 835	$ 1,500		$ 1,850	$ 1,975	$ -
AFOBAKKA	$ 260	$ 495		$ 590	$ 640	$ 925.00
ALBINA	$ 325	$ 560		$ 700	$ 750	$ 1,020.00
ANTINO	$ 580 + 35	$ 1035 + 50		$ 1350 + 75	$ 1400 + 75	$ 1,955.00
AMOTOPO	$ 750	$ 1,350	$ 1,350	$ 1,610	$ 1,650	$ 2,400.00
AVANAVERO	$ 625	$ 1,125	$ 1,125	$ 1,265	$ 1,350	$ 2,125.00
APETINA	$ 625	$ 1,185			$ 1,750	$ 2,200.00
BOTOPASIE	$ 420	$ 750		$ 960	$ 1,010	$ 1,420.00
BAKHUYS	$ 535	$ 1,045	$ 1,045	$ 1,205	$ 1,350	$ 1,800.00
CABANA **	$ 275	$ 500		$ 610	$ 700	$ 900.00
COEROENIE	$ 760	$ 1,385		$ 1,750	$ 1,800	$ 2,550.00
COTTICA	$ 520	$ 950		$ 1,180	$ 1,300	$ 1,700.00
DJOEMOE	$ 470	$ 855		$ 1,030	$ 1,150	$ 1,530.00
DONDERSKAMP	$ 315	$ 570		$ 740	$ 850	$ 1,100.00
DRIETABBETJE/GODO	$ 440	$ 800		$ 1,000	$ 1,100	$ 1,525.00
HOLO						
GROSS ROSEBELL	$ 250	$ 450	$ 500	$ 590	$ 605	$ 850.00
KAYSER	$ 700	$ 1,215	$ 1,215	$ 1,475	$ 1,550	$ 2,250.00
KABALEBO	$ 625	$ 1,125		$ 1,265	$ 1,350	$ 2,125.00
KWAMALASAMOETOE	$ 920	$ 1,650		$ 2,065	$ 2,300	$ 3,185.00
KAJANA	$ 495	$ 885		$ 1,095	$ 1,150	$ 1,700.00
LADUANI	$ 375	$ 675		$ 870	$ 1,000	$ 1,275.00
LANGATABBETJE	$ 290	$ 525		$ 675	$ 750	$ 980.00
LAWA	$ 690	$ 1,250		$ 1,430	$ 1,625	$ 2,200.00
MOENGO	$ 255	$ 455	$ 500	$ 610	$ 650	$ 900.00
NICKERIE	$ 460	$ 835	$ 850	$ 1,090	$ 1,150	$ 1,575.00
NW. JACOB KONDRE	$ 250	$ 450		$ 590	$ 620	$ 850.00
OELEMARIE	$ 750	$ 1,350			$ 1,815	$ 2,550.00
PALOEMEU	$ 625	$ 1,125	$ 1,200	$ 1,325	$ 1,400	$ 2,040.00
POESOEGROENOE	$ 375	$ 675		$ 850	$ 900	$ 1,275.00
RALEIGHVALLEN	$ 390	$ 705		$ 895	$ 950	$ 1,300.00
SARAKREEK	$ 375	$ 685		$ 850	$ 900	$ 1,250.00
SIPALIWINI	$ 920	$ 1,650		$ 2,065	$ 2,300	$ 3,185.00
STOELMANSEILAND	$ 425	$ 780		$ 975	$ 1,050	$ 1,500.00
TAFELBERG	$ 510	$ 925		$ 1,190	$ 1,250	$ 1,750.00
TABIKI	$ 580	$ 1,050		$ 1,350	$ 1,400	$ 1,955.00
TEPOE	$ 660	$ 1,150		$ 1,450	$ 1,525	$ 2,125.00
WASHABO	$ 535	$ 1,045		$ 1,250	$ 1,350	$ 1,800.00
WAGENINGEN	$ 400	$ 710		$ 770	$ 875	$ 1,275.00
ZANDERIJ	$ 220.00	$ 385.00	$ 440.00	$ 550.00	$ 600.00	$ 825.00

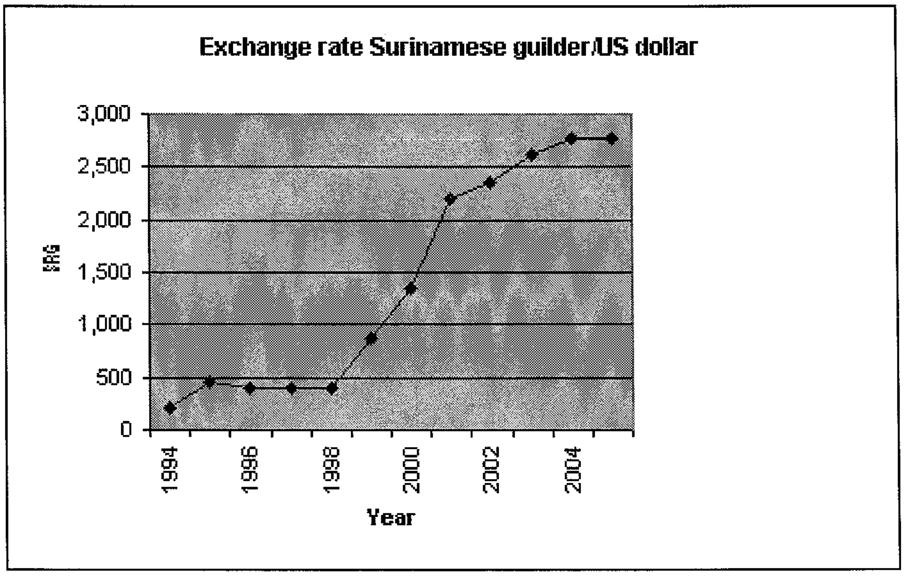
Source: Gum Air, Suriname

10. Exchange rates

Exchange rates of the Central Bank of Suriname for the Surinamese Guilder versus the US$.

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004*	2005*
January	94	426	408	406	406	733	995	2,200	2,200	2,550	2,770	2,750
February	100	424	407	406	406	750	1,009	2,200	2,200	2,550	2,770	2,750
March	136	430	406	406	406	764	1,015	2,200	2,200	2,590	2,770	2,750
April	154	450	406	406	406	769	1,015	2,200	2,200	2,650	2,770	2,750
May	161	501	406	406	406	809	1,015	2,200	2,200	2,650	2,770	2,754
June	198	499	406	406	406	830	1,015	2,200	2,200	2,650	2,770	2,780
July	187	482	406	406	406	872	1,060	2,200	2,293	2,650	2,770	2,780
August	192	471	406	406	406	916	1,173	2,200	2,540	2,650	2,770	2,780
September	193	458	406	406	406	974	1,173	2,200	2,540	2,650	2,770	2,780
October	240	435	406	406	406	995	2,200	2,200	2,540	2,650	2,770	2,780
November	376	420	406	406	406	995	2,200	2,200	2,541	2,650	2,770	2,780
December	434	412	406	406	406	995	2,200	2,200	2,546	2,650	2,753	2,780
Average:	**205**	**451**	**406**	**406**	**406**	**867**	**1,339**	**2,200**	**2,350**	**2,628**	**2,769**	**2,768**

* Per January 1st, 2004 the government of Suriname switched to using the SRD instead of the SRG.
The exchange rate was 1,000 SRG = 1 SRD.
In this table the exchange rates for the US$ are represented against the old SRG value.



Source: www.CBvS.sr

11. Electricity tariffs

Electricity tariffs of the Energy company of Suriname (December 2005)

Tariefgroep I: Vermogen minder dan 25 kVa, laagspanningsnet.		
Huishoudelijke afnemers **(Tarief 11)**		
VERBRUIK (in kWh)	**VAST RECHT p/mnd (SRD)**	**p/kWh (in SRD)**
0 t/m 58	7,50	0,054
59 t/m 150	10,00	
151 t/m 300	12,50	
301 t/m 400	15,00	0,082
401 t/m 500	15,00	
501 t/m 650	50,00	0,109
651 t/m 800	75,00	
801 en meer	100,00	0,152
Niet-Huishoudelijke afnemers **(Tarief 21, 23, 25, 31)**		
VERBRUIK (in kWh)	**VAST RECHT p/mnd (SRD)**	**p/kWh (in SRD)**
Tarief 21 en 31		
1 fase	30,00	0,152
2 fase	120,00	
3 fase	140,00	
Tarief 23 en 25	15,00	0,152
Tariefgroep II: **(Tarief 22 ,26, 32)** Aansluiting groter dan 25 KVA)		
VAST RECHT :	140,00	
Per kWh (HT) :	0,1354	
Per kWh (LT) :	0,1268	
Per KVA :	17,56	
Toeslag arbeidsfactor :	0,0383	
Tariefgroep III: **(Tarief 39)** Hoogspanningsaansluiting		
VAST RECHT :	140, 00	
Per kWh (HT) :	0,1583	
Per kWh (LT) :	0,1382	
Per KVA (HT) :	10,50	
Per KVA (LT) :	3,64	
Toeslag arbeidsfactor :	0,0383	

Connection costs for home users:

Component in Surinamese currency:	SRD 74,-
Component in US dollars:	USD 290,-
Safety deposit:	SRD 30,-

Source: N.V. Energiebedrijven Suriname

12. Development organisations active in Suriname

Development organisations active in Suriname

CIS - Conservation International Suriname
Educons - Stichting Education and Communication Network
Forum NGOs- Forum for Non Governmental Organisation
GEF - Global Environment Facility (Suriname). SGP - Small Grants Programme
HfH - Habitat for Humanity (Suriname
laDB - Interamerican Development Bank
MCA - Inter-American Institute for Cooperation on Agriculture
IVVO - Instituut Voor Vrouwelijike Ondernemers
NGB - National Gender Bureau
NIKOS - NGO Instituut voor Kaderontwikkeling en Onderzoek in
OAS - Organization of American States
PAHO / WHO - Pan American Health Organization
SCF - Suriname Conservation Foundation (Suriname)
SRC - Suriname Red Cross
Stichting Lobi – Organisation for prevention of AIDS and other gender diseases
Stichting Projekta - Organization for Women and Development
Stichting Projekten PCOS - Stichting Projekten Protestants Christelijk Onderwijs Suriname
Stinasu - Stichting Natuurbehoud
SZV - Surinaamse Zendings Vliegdienst / MAF - Mission Aviation Fellowship (Suriname)
UNDP - United Nations Development Programme
UNESCO - United Nations Educational. Scientific and Cultural Organization
UNICEF - United Nations Children's and Education Funds
US Peace Corps
WRC - Women's Rights Centre
WWF - World Wildlife Fund

Foreign representatives active in Development in Suriname
Embassy of France
Embassy of Japan
Embassy of the Netherlands
Delegation of the European Commission

Source: [WongLoiSing from www.devdir.org]

13. Potential hydropower sites in Suriname

An outline of the large scale hydropower potential in Suriname

Location / Project	River	Capacity (MW)
Afobakka (Benut)	Suriname	189
Devisvallen (KI)	Kabalebo/Corantijn	500
Kabalebo vliegveld (KII)	Kabalebo	300
Matapi	Corantijn	150
Maopityanvallen	Coeroeni	250
Tapatosso (Tap II)	Tapanahoni (Drietabbetje)	319
Apetina (Tap III)	Tapanahoni	-
Jai Creek(Tap I)	Jai Creek	11
Palumeu river (Tap IV)	Palumeu river	70
Soekratiepoort	Marowijne (grensrivier)	500
Phedra (Sur I)	Suriname	21
Saramacca I(Sar I)	Saramacca	16
Saramacca II (Sar II)	Kleine Saramacca	-
Saramacca III (Sar III) (Dramhoso)	Saramacca	48
Saramacca IV (Sar IV) (Pakka Pakka)	Saramacca	45
(Stondansi)	Nickerie river	-
Total		2419

Possible micro-hydropower stations in the interior of Suriname.

Place	River	Capacity (kW)
Djoemoe (Tapawatra)	Suriname	40- 1200
Marchallkreek	Suriname	40
Njoen Jakobkondre	Saramacca	40
Poketie (installed in 1981)	Tapanahoni	40
Stoelmanseiland	Marowijne	60-120
Poesoegroenoe	Saramacca	40
Ladoeani	Suriname	40
Kwamalasemoetoe	Sipaliwinie	(40)
Kamalasoela	Lawa	(40)
Langa tabbetje	Marowijne	(40)
Botopasi	Suriname	(40)
Nabij Raleighvallen	Coppename	(40)
Total		500– 1720

Source: [Tractabel, 2000]

14. Databases in Suriname

Listing and description of potential databases and databases used for acquiring local data for input into the model.

Social category:

Two main databases for the social statistics are:
- The Faculty for Social sciences of the ADEK University
- The general bureau for Statistics (ABS)

The Faculty for Social sciences of the ADEK University:
Advantages:
- The faculty has a research institute especially for conducting social studies (IMWO).
- The IMWO has a modest library containing social research reports about Suriname

Drawbacks:
- Limited funds. At current, the IMWO is unable to initiate a research by themselves.
- Little to no data is available relating to the inhabitants of Trio and Wayana territories (where both the Palumeu and the Kwamalasamutu projects were conducted) in the inlands of Suriname.

The General Bureau for Statistics (ABS):
Advantages:
-This bureau has statistical data available on issues relevant to the social category, such as population density, population growth figures and income statistics
- In 2004 a general census was executed by the census bureau connected to the ABS. Results from this nationwide inventory could be very useful for filling in social statistics.
Drawbacks:
- Due to the turmoil in the inlands created by the inland rebellions of the eighties and the large number of relocations by the inland population towards the city during and after that period, older statistics are considered invalid for the current situation.
-One disadvantage with the (old and current) statistics lies in the regional division used by the census bureau. Statistics are grouped by district, where for accurate assessments the numbers would be needed per village.
-Another problem with the census figure lies with the nomadic behaviour of the Inheemsen. The Inheemsen of the south tend to travel over large distances, some crossing the border into Brazil or French Guyana. This means that social measurements conducted during one period could very well be rendered invalid because a large number of inhabitants moved to another area.
-At the time of the field study not all of the results of the census had been processed yet. Only Part one of the national results was available. Once the rest of the results become available they should be incorporated into the design.

Technical category:

Main database sources are:
The Bureau for hydropower works (BWKW)
The Hydraulic research division (WLA)
Meteorological Services Suriname (METEO)
Sescon Library (private)

Geological Survey Department
Central Bureau for Arial Survey (CBL)
The Faculty for technological sciences of the ADEK University
Ground registration and Land Information System (GLIS) (under development)

<u>The Bureau for hydropower works (BWKW)</u>
This Bureau was responsible for all research pertaining to hydropower in Suriname.
Advantages:
-The BWKW was responsible for measurement of hydrological data in the upstream portion of the Surinamese rivers. This data (such as stream flow characteristics and run off data) is of vital importance for assessing potential hydropower sites.
- In the past the BWKW conducted several studies on potential large and small scale hydropower sites. The data from these files would be useful for incorporation into the assessment model.
Drawbacks:
-After the eighties the government decided to discontinue the BWKW. The bureau itself still exists but only one employee remains as keeper of the archive.
-After the dismantlement of the bureau, many of the files have disappeared. A large portion was taken away by former employees. As a result the whole of the archive has been reduced to a single case file. According to the keeper the archive will be completely dismantled once his employee service ends.
-Because the bureau was dismantled after the eighties, what data is available is mostly outdated.

<u>The Hydraulic research division (WLA)</u>
This research division is responsible for the collection of hydrological data in the coastal areas of Suriname's waterways.
Advantages:
-The WLA possesses hydrological data on the coastal areas of the Surinamese rivers. Because of the loss of data from the BWKW, this is now the only reliable source for this kind of data
Drawbacks:
-The data only relates to the downstream portions of the rivers. Most potential hydropower site is located upstream. Although the data can be useful to get an idea of the seasonal behaviour of the Surinamese waterways, they cannot form a reliable source for a true assessment of a site's potential.

<u>Meteorological Services Suriname (METEO)</u>
This is the bureau responsible for collection of meteorological data in Suriname
Advantages
- This bureau has measurement stations throughout the inlands especially at the diverse airstrips.
-The bureau has rainfall measurement data dating back to the 1950's for both coastal and inland regions.
Drawbacks:
-During the inland rebellion many measurement stations have come in disarray, either through loss of equipment or loss of local personnel
-There are large gaps in the data of the past two decades, because of the rebellion and subsequent shortage of funds for reinitialising the stations.

<u>Sescon Library</u>

This is a private library belonging to former employees of an advisory bureau (Sescon bureau).
Advantages:
-The Sescon library contains a huge amount of old reports and studies pertaining to development projects within Suriname. This includes various energy projects and constructive projects. The data and experiences from these projects can be useful for incorporation into the model.
Drawbacks:
-The actual library has not yet been build. At the moment the library is actually a huge archive which has yet to be catalogued. Finding relevant data is therefore a difficult task.
-The library is in private possession and not yet publicly accessible. One has to gain access by contacting one of the owners.

<u>Geological Survey Department (Dienst Bodemkartering)</u>
This is the government department responsible for conducting geological surveys
Advantages:
-Contains data from geological surveys in the inlands
Drawbacks:
-Not all data is publicly accessible
-Most surveys do not extend all the way to the southern border of Suriname

<u>Central Bureau for Arial Survey (CBL)</u>
This is the government department responsible for conducting geological surveys
Advantages:
-Contains detailed maps and aerial photographs for most parts of Suriname. These can be useful for identifying potential locations near a village

<u>Ground registration and Land Information System (GLIS) (under development)</u>
This is a new land information system in which various databases such as that of the cadastre, the CBL and the geological survey department will be combined and digitalized.
Advantages:
-This database will combine various databases useful for the assessment model
-The data will be digitally available, making it easier to attach data and photographs to the model
Drawbacks:
-The GLIS project is still underway; project completion is planned in 2008.

<u>The Faculty for Technological sciences of the ADEK University</u>
The faculty for technology of the ADEKUS incorporates several departments with specialities useful to MHP projects.
Advantages:
-The several departments within the faculty are actively involved with the Palumeu MHP and with potential future projects
Drawbacks
-Communication between the several departments within the faculty is often troublesome. Information obtained by one department might be kept from other departments by neglecting to notify them of the presence of that information or by deliberately refusing to share this information.

Economic category:

The main databases available for this category were:
-The Central Bank of Suriname (CBvS)
-The Foundation for Tourism in Surinam (STS)

The Central Bank of Suriname (CBvS)
Advantages:
-The CBvS publishes the exchange rates of the Surinamese Dollar back to 1994 as well as price indexes for standard household goods, making it possible to get an idea of the stability of prices in Suriname
Drawbacks:
-The price indexes do not include technological equipment
-The currently available indexes end with 2004.

The Foundation for Tourism in Surinam (STS)
This foundation registers statistics relating to Tourism in Suriname
Advantages:
-As ecotourism seems to be a major upcoming source of income in Suriname, the statistics obtained by this organisation could be very useful for calculating potential revenues of endeavours in the inlands

Environmental category:

Potential databases for this category are:
-The Faculty for Technological sciences of the ADEK University, department of Environmental technology
-Conservation International Suriname: An environmental organisation in Suriname that is responsible for the management of the largest nature reserve in Suriname (South America???)

C. Operationalisation

1. Factors from Literature Cross Referenced against Critical Factor Map

From Literature Source

Factor from Literature	Source	OR	SO	TE	EC	IN	EN
Clear objectives.	Khennas 2000	X					
Financial sustainability through profitable end uses	Khennas 2000	X			x		
Dynamic leadership	Barnes& Foley 2004	X	x				
Strong coordinating organization	Smith 1994	X					
Capable micro - hydro project developers	Khennas 2000	X					
Formal qualification vs. specific practical experience	Khennas 2000	X					
Availability of local micro-hydro capacities substantially reduce costs	Khennas 2000	X		x	x		
High degree of autonomy	Barnes& Foley 2004	X					
Technical assistance services should be separated from credit functions	Khennas 2000	X					
Responsibility	Barnes& Foley 2004	X					
Local community involvement	Barnes& Foley 2004	X	x				
No provision for repair and maintenance	Grierson 1992	X		x			
Effective business-like style of management.	Khennas 2000	X					
Productive end-uses/enterprise-like approach	Khennas 2000	X					
Business like management structure,	Khennas 2000	X					
Well trained local operator and manager	Smith 1994	X					
Lack of trained personnel	Grierson 1992	X	x				
Local capacities to manage, operate and maintain micro hydro plants	Khennas 2000	X		x			
Successful promotion (goal orientated)	Khennas 2000	X					
Importance of a successful pilot project	Smith 1994	X					
Local knowledge	Mog 2004	X	x				
Build programmes on a thorough understanding of what has already been tried before in the country and elsewhere.	Khennas 2000	X				x	

Organized Model

Category	Factor	Sub factor
Organizational	Organisational objectives	Objectives
	Project Management	Leadership
		Structure and capacity
		Autonomy
		Accountability
	Plant Management	Ownership
		Approach to plant management
		Management Personnel
		Technical Personnel
		Administrative Personnel
	Promotion	Promotion of project
		Promotion of pilot
	Learning process	Local Knowledge
		Former experience

Process approach	Mog 2004	X					
Demand	Barnes& Foley 2004		X		x		
Failure to identify the local energy market	Grierson 1992	x	X				
Community Involvement (emphasis on financial)	Smith 1994		X		x		
Agricultural inputs	Barnes& Foley 2004		X		x		
Ability to pay	Khennas 2000		X		x		
Lack of familiarity with technology	Paish 2002		X	x			
Developing crucial local capacities is unavoidably long and costly	Khennas 2000	x	X			x	
Continued learning and adaptation	Mog 2004	x	X				
Technical catalysts close proximity to villagers at relatively low cost.	Khennas 2000		X	x			
Technology transfer, support and training	Paish 2002	x	X	x		x	
Character of participation	Mog 2004	x	X				
Community Involvement (emphasis on financial)	Smith 1994		X		x		
Broad based community support (as lead actors)	Mog 2004	x	X				
End-use effect on poverty and gender impacts	Khennas 2000		X				
Access to health and educational services	Barnes& Foley 2004		X				
End-use effect on poverty and gender impacts	Khennas 2000		X				
Adequate dwellings	Barnes& Foley 2004		X				
Concentration on economic development of villages	Smith 1994		X		x		
Enhancing critical local technological capacities	Grierson 1992		X			x	
Irrigation	Smith 1994		x	X			
Expansion limitations	Paish 2002		x	X			
Cost effectiveness (head)	Paish 2002			X			
Seasonal restrictions	Paish 2002			X			
Geotechnical studies	Penche 1997			X			
Electrical power generation	Penche 1997			X			
Detailed survey of hydro power demand	Smith 1994		x	X			
Mismatch between plant capacity and energy demand	Grierson 1992		x	X			

		Evaluation
Social	Demand	Need for MHP generated electricity
		Willingness to pay
		Ability to pay
	Technological Capability	Availability
		Enhancement
	Community involvement	Character
		Extent
	Livelihood	Poverty
		Health care
		Education facilities
		Gender aspect
		Housing
	Orientation towards sustainable development	Orientation towards sustainable development
Technical	Application	Designated end use
		MHP design
	Potential	Water Potential
		Site evaluation
		Power estimate
	Power demand	Volume
		Variation

Plant factor	Paish 2002			X						Growth
Appropriate technology and size	Khennas 2000			X						
Construction of civil works	Penche 1997			X					Civil Works	Storage and Intake Waterways
Fabrication of turbines	Paish 2002			X					Hydroelectric equipment	Turbines
Choice of generators	Fraenkel1991			X						Generators
Choice of control equipment	Penche 1997			X						Control Equipment
Length and voltage of transmission line	Fraenkel1991			X					Transport and distribution of energy	Transmission
Limiting and metering of electricity to users	Penche 1997			X						Distribution
Presence of proper operational procedures	Fraenkel1991			X					Operational procedures	Operational procedures
No provision for repair and maintenance	Grierson 1992	X		X					Maintenance procedures	Maintenance procedures
Well trained local micro hydro engineer(south south transfer)	Smith 1994		X	X	X				Personnel Requirements	Engineers
Local capacities to manage, operate and maintain micro hydro plants	Khennas 2000	X		X						Operators Maintenance personnel
Low cost, reliable, locally manufactured equipment	Smith 1994		X	X					Material requirements	Quality
Inappropriate equipment	Grierson 1992			X						Availability
Cost recovery	Barnes& Foley 2004	X			X			Economical	Cost and benefits	Cost Benefit Analysis
Financial sustainability through profitable end uses	Khennas 2000	X			X				Income generation	Income generating schemes
Enabling private involvement	Smith 1994	X			X					Incentives
Limited private sector involvement.	Grierson 1992	X	X		X	X				
Stimulation of profitable load through funding associated end-use investments	Khennas 2000	X			X					
Cover intermediation with grant funding	Khennas 2000				X	X			Funding	Availability
Grants for capital investments	Barnes& Foley 2004				X	X				
Ensure funds are available for micro hydro and associated end-uses(pro-poor	Khennas 2000				X	X				Extent
Cover all aspects of the project including end-use investments	Khennas 2000				X	X				
Financing (loans)	Paish 2002				X				Loan Financing	Local availability

Both 'soft funds' and funds at commercial rates will be needed	Khennas 2000				X		
Dependable, local finance	Smith 1994				X		
Proper loan conditions	Khennas 2000				X		
Training of financial institutions the special needs and risks of micro hydro	Khennas 2000				X		
Economies of scale	Khennas 2000	X			X	X	
Stimulate demand for hydro and support activities	Khennas 2000				X		
Setting tariffs	Barnes& Foley 2004	X			X	X	
Life line tariffs	Khennas 2000	X			X		
Connection fees	Barnes& Foley 2004	X			X		
Provide strong cost minimisation incentives	Khennas 2000				X	X	
Increasing access by lowering the initial costs	Khennas 2000				X	X	
Subsidies to improve the access of poor people to electricity.	Khennas 2000	X			X	X	
Tariffs in line with local inflation	Khennas 2000	X			X		
Integration with other development projects	Smith 1994	X				X	
Be transparent to and try to harmonise activities with other donors, partners, equipment suppliers, contractors, and government programmes	Khennas 2000	X				X	
Political interference	Barnes& Foley 2004					X	
Protect against abuse by officials	Khennas 2000					X	
Land ownership	Smith 1994		X			X	
Land tenure	Barnes& Foley 2004					X	
water rights	Smith 1994		X			X	
Governments need to assign clear responsibilities for micro hydro development and the development of the necessary 'enabling environment'.	Khennas 2000					X	
Governments need to treat all energy supply options	Khennas 2000					X	

		Suitability of loans for long term MHP investment
		Training of local institutions
	Economy of scale	Programme size
		Available capacity
		Outside stimulation
	Focus on poverty reduction	Aptness of tariffs
		Access promotion
		Inflation
Institutional	Development Programme	Integration of development programmes
		Aims
		Clarity of aims towards community
	Political involvement	Political involvement
	Government Policy/Legislation	Legislation

Governments need to ensure fair competition between competing supply options and provide equal access to aid and other concessional funds, subsidies, tax breaks and support.	Khennas 2000					X				
Lobby for changes in the enabling environment(governmental, financial institutions and donors)	Khennas 2000					X				Promotion RET
Give micro hydro the same chances for funding as other decentralised energy	Khennas 2000					X				
Quality and safety standards	Khennas 2000					X				Standardization
Cooperation with grid supply	Smith 1994			x		X				Grid supply
Grid vs. decentralised power sources	Barnes& Foley 2004	x		x		X				
Involvement of local institutions	Mog 2004					X			Development agencies	Development agencies
Effective institutional structures	Barnes& Foley 2004					X				
Diverse aspects of environmental impact study	Penche 1997						X	Environmental	Impacts	Resources Habitats Ecosystems Air Water Soil Flora Fauna Aesthetics Natural and Cultural heritage
Conflicting interest (energy vs. fishery, irrigation)	Paish 2002		x	x		x	X		Reserved/Residual flow	Provisions for necessary residual flow
Reliable water supply	Barnes& Foley 2004		x			x	X			
Government imposed environmental regulations	Penche 1997					x	X		Regulation	Environmental regulation

2. Operationalisation of Critical Factors and Model

Operationalisation of critical factors and model input/output generation. The table numbers refer to the tables listed in Appendix C.3: Measurement and Output Tables for Model.

Operationalisation of critical factors				Model output generation		
	Critical factors					
Category	Factor	Sub factor	Operational Indicator	Input	Criterion	Output schematic
Organizational	Objectives	Organisational objectives	Purpose of MHP	table 1.1	Does the objective of the MHP include an income generating scheme in its primary targets?	0.1
			Formality	table 1.1	Have the project targets been stated in an officially binding agreement between owners and executioners?	0.1
	Project Management	Leadership	Experience	table 1.2	Does the lead project member have any experience in the conductance of MHP or comparable projects	0.1
			Capacity to motivate	table 1.9	What indication does project experience with project leader indicate?	0.1
			Commitment	table 1.2	*Does the commitment of the project leader extent into the operational period*	0.1
			Autonomy	table 1.3/ 1.4	Does the project leader (and the project team) have autonomy in the design and construction of the project	0.1
		Structure and capacity	Personnel Qualification	table 1.2	Does the expertise of the project members cover the following fields: Hydrology, Civil engineering, Electronics, Mechanical engineering, Social studies.	0.1
			Clarity	table 1.4	Is there a clear, unambiguous hierarchy in the structure of the project team?	0.1
		Autonomy	Autonomy	table 1.3/ 1.4	Can the project team function in an autonomous capacity?	0.1
		Accountability	Accountability	Open	Is the project team subject to a form of performance review?	0.1
				Open	Is there a form of contractual liability for the project team to meet stated targets?	0.1
	Plant Management	Ownership	Ownership	Open	Will the local community be the official owner of the MHP station and associated equipment?	0.1
			Form	Open	Does the ownership structure allow the community to cast a deciding vote on decision regarding the MHP station?	0.1
		Approach to plant management	Approach	table 1.6	Are all indicators for assessing if the plant management will utilize a business like approach positive?	0.1
		Management Personnel	Qualification	table 1.5	Does the proposed management personnel have the qualifications to perform the required tasks?	0.1

			Coverage	table 1.5	Is there enough qualified personnel to cover all necessary management functions?	0.1
		Technical Personnel	Qualification	table 1.5	Does the proposed technical personnel have the qualifications to perform the required tasks?	0.1
			Coverage	table 1.5	Is there enough qualified personnel to cover all necessary technical functions?	0.1
		Administrative Personnel	Qualification	table 1.5	Does the proposed management personnel have the qualifications to perform the required tasks?	0.1
			Coverage	table 1.5	Is there enough qualified personnel to cover all necessary administrative functions?	0.1
	Promotion	Promotion of project	Promotion towards community	table 1.7	Is there an active promotional campaign for the execution of the MHP project towards the local community?	0.1
			Outside promotion	table 1.7	Is there an active promotional campaign for the use and advantages of MHP generation outside the local community?	0.1
		Promotion of pilot	Investment	Open	Does the project make use of conservative, proven design?	0.1
				Open	Has the project design been submitted for confirmation to an experienced MHP design agent or agency?	0.1
			Promotion	table 1.7	Is there an active promotional campaign to create an enabling environment for MHP projects?	0.1
	Learning process	Local Knowledge	Availability	table 1.8	Does the local community possess useful knowledge on the MHP site?	0.1
			Use	Open	Has this knowledge been incorporated into the project design where relevant?	0.1
		Former experience	Availability	Open	Is there any data available on other MHP projects deployed within the area?	0.1
			Use	Open	Has this data been incorporated into the project design where relevant?	0.1
		Evaluation	Project evaluation	Open	Are there scheduled evaluation points to monitor and evaluate project progress?	0.1
			Feedback	Open	Is there a procedure in place to make feedback from these evaluation points available for use with current/future projects?	0.1
Social	Demand	Need for MHP generated electricity	Presence	table 2.2	Is there a need for the instalment of an MHP energy source	0.1
			Quantity	table 2.1/ 2.3/ 2.4	Is the volume of the need enough to justify instalment of the MHP? Does the volume of the need match the volume of the potentially available power?	0.1
		Willingness to pay	Priority	table 2.2	Does the need for electricity have a high priority?	0.1
			Alternatives	table 2.2/Open	Are there alternative sources of energy available?	**0.2**
			Current Expenditure	table 2.1-3	Do current expenditures on energy pose a significant tax on available budgets?	0.1
			~~Commitment~~	table 2.1	Does the target population indicate a willingness to pay for MHP	0.1

					electricity?	
		Ability to pay	Current Income	table 2.1	Is the current level of net income sufficient to support the MHP structure?	0.1
			Future Income	table 2.4/ 2.6	Will estimated revenues from MHP connected schemes supply sufficient net income to support the MHP?	0.1
			Expenditures	table 2.3	Will cost saving on current expenditures after MHP instalment suffice to support the MHP?	0.1
	Technological *Capability*	Availability	Education Levels	2.9	Is the average educational level sufficient for the operational MHP tasks?	0.1
			Educational facilities	Open	Are there educational facilities available for the community that provide administrative, mechanical or accountancy training?	0.1
			Mechanical skill	2.9	Is the level of available mechanical skill sufficient for operation and maintenance of the MHP?	0.1
			Administrative skills	2.9	Is the level of available administrative and accountancy skill sufficient for operation and maintenance of the MHP?	0.1
		Enhancement	Need	2.9/3.10	Based on the available level of skill, is there a need to provide further training?	**0.2**
			Availability	Open	*Does the project include training courses or other methods of increasing* current technological capability?	0.1
	Community involvement	Character	Character of involvement	table 2.8	Is the community involved in all phases of the MHP project?	0.1
			Level of involvement	table 2.8	Is the community involved on an organisational level?	0.1
		Extent	*Percentage of community* involved as user	table 2.8	Is a majority of the community involved as a user?	0.1
			Amount of population involved as supplier/employee	table 2.8	Are there any community members who are or will be involved as suppliers for the MHP plant? Are there any community members who are or will be involved as suppliers for the MHP plant?	0.1
	Livelihood	Poverty	Local poverty	table 2.1	Does the local community suffer from poverty effects?	**0.2**
			Alleviation	table 1.1	Does the project offer poverty *alleviation by creating employment* opportunity and income generation?	0.1
		Health care	Proximity	Open	Are there any health care facilities situated near the community?	0.1
			Health benefits	table 2.7	Does the MHP offer any benefits to the local health care situation?	0.1
		Educational facilities	*Presence*	*Open*	*Are there any educational facilities situated near the community?*	0.1
			Benefits towards education	table 2.7	Does the MHP offer any benefits to the local educational situation?	0.1
		Gender aspect	Occurrence of gender bias	Open	Is there a strong occurrence of gender bias in social status within the community?	**0.2**
			Current employment division	table 2.1	Is there a strong occurrence of gender bias employment and income within the community?	**0.2**
			Equal opportunity possibilities of MHP project	table 2.6	Does the MHP project offer any opportunities towards the alleviation in gender bias?	0.1

		Housing	State of housing	Open	Does the local population possess adequate living conditions?	0.1
			Benefits of MHP towards housing	Open	Will current housing conditions benefit from the presence of the MHP?	0.1
	Orientation towards sustainable development	Orientation towards sustainable development	Orientation towards social *development*	table 1.1/ 2.6	Is there an extension program planned that will utilise the MHP for social development?	0.1
			Orientation towards economic development	table 1.1/ 2.6	Are there any profitable schemes planned that will utilise the MHP for *economic development?*	0.1
			Orientation towards *environmental sustainability*	table 1.1/ 2.6	Will the MHP stimulate development in an environmentally sustainable way?	0.1
Technical	Application	Designated end use	Usage type of turbine power	Open	Will the power output of the turbine be used for multiple types of energy provision?	**0.2**
			Load type	Open	Is the load subject to irregular peaks?	**0.2**
			Running hours	Open/3.7	Is the load evenly distributed throughout running hours of the MHP?	0.1
		MHP design	MHP design type	Open	Does the MHP design need to compensate for the presence of existing structures or water usage schemes?	**0.2**
	Potential	Water Potential	Head	table 3.1/3.2	Is there sufficient head for MHP power generation?	0.1
			Flow	table 3.1/3.2	Is there sufficient flow for MHP power generation?	0.1
			Size of residual flow	table 3.1/3.2	Does the acquired size of the residual flow impose unwanted restrictions on the MHP design?	**0.2**
		Site evaluation	Soil composition	Open	Does the soil composition indicate a stable underground for MHP structures?	0.1
			Structural layout	Open	Does the structural layout of the site offer the opportunity for construction of the MHP structure?	0.1
			Distance to potential site	Open	Is the MHP in close proximity to the target community?	0.1
		Power estimate	Efficiency	table 3.5	Does the power loss due to efficiency of the structure and connected components stay within acceptable limits?	0.1
			Net output	table 3.5	Does the net output match the need requirements	0.1
	Power demand	Volume	Peak power required	table 3.6/3.7		
			Average power required	table 3.6/3.7		
			Minimum power required	table 3.6/3.7	Does the demand volume and spread match the power available?	0.1
		Variation	Equipment running hours	table 3.6/3.7	Does the spread of equipment running hours ensure a sufficient load factor?	0.1
		Growth	Population growth	table 2.1		
			Increase of energy-applications	table 2.1/2.3	Will the growth in energy demand in the near future cause the demand to rise above the amount of power supplied?	**0.2**
	Civil Works	Storage and Intake	Size	Open	Does the size of the storage and intake require intensive construction?	**0.2**
			Availability of materials	table 3.11	Are the materials necessary for construction locally available?	0.1

		Waterways	Size	Open	Does the size and length of the waterways necessary require intensive construction?	**0.2**
			Availability of materials	table 3.11	Are the materials necessary for construction locally available?	0.1
	Hydroelectric equipment	Turbines	Type	Open	Does the turbine type conform to the best practice choice for head and flow?	0.1
			Efficiency	table 3.3	Do the turbine efficiency parameters conform to best practice choice for stream flow variation?	0.1
			Technology level	table 3.3/3.10	Does the turbine technology level match local technical capability	0.1
			Local availability	Open	Is the required turbine type locally available?	0.1
			Level of maintenance	table 3.3/3.10	Can the level of maintenance for the turbine be categorized as low, medium or high?	table 3.12
			Average lifetime	table 3.3	Is the estimated average lifetime of the turbine comparable to MHP standards?	0.1
		Generators	Type	table 3.4	Does the generator type conform to the best practice choice for continuous MHP running standards?	0.1
			Size	table 3.4/3.7	Does the generator power output capability compensate for MHP recommended sizing	0.1
			Technology level	table 3.4/3.10	Does the generator technology level match local technical capability	0.1
			Local availability	Open	Is the required generator type locally available?	0.1
			Level of maintenance	table 3.3/3.10	Can the level of maintenance for the generator be categorized as low, medium or high?	table 3.12
			Average lifetime	table 3.4	Is the estimated average lifetime of the generator comparable to MHP standards?	0.1
		Control Equipment	Types	Open	Does the choice for control equipment meet best practice choices for MHP?	0.1
			Technology level	2.9	Does the technology level of the control equipment match local technical capability	0.1
			Local availability	Open	Is the required control equipment locally available?	0.1
			Level of maintenance	table 3.3/3.4/3.10	Can the level of maintenance for the control equipment be categorized as low, medium or high?	table 3.12
			Average lifetime	table 3.3/3.4	Is the estimated average lifetime of the control equipment comparable to MHP standards?	0.1
	Transport and distribution of energy	Transmission	Distance	table 3.8	Is the distance between site and community within MHP standards?	0.1
			Transmission type	table 3.8	Is the voltage drop in the transmission line within acceptable limits?	0.1
			Construction type	table 3.8	Does the construction type match monetary limitations? Does the construction type match maintenance capabilities?	0.1
			Material requirement	table 3.8/3.11	Can material requirements be met locally?	0.1

		Distribution	Number of connections	table 3.9/2.1	Does the design take into account the current number of connections required? Does the design accommodate for expected increases?	
			Type of distribution limitation	table 3.9	Does the type of distribution limitation conform to monetary and safety requirements?	0.1
			Safety measurements	Open	Have sufficient safety measurements been included into the design?	0.1
	Operational procedures	Operational procedures	Presence	Open	Have operational procedures for the MHP station been drawn up?	0.1
			Contents	Procedures	Do the contents of the procedures cover all necessary areas for the local operators	0.1
			Material requirements	Equipment manual	Do the operational procedures cover the fulfilment of material requirements for daily operation?	0.1
	Major maintenance procedures	Major maintenance procedures	Presence	Open	Have procedures for major maintenance on the MHP station been drawn up?	0.1
			Frequency	Equipment manual	Does the frequency of planned maintenance match the equipment specifications?	0.1
			Material Requirements	Procedures, Equipment manual	Do the procedures cover the fulfilment of material requirements for major maintenance?	0.1
	Personnel Requirements	Engineers	Availability	Open	Are there engineers available locally to cover all engineering fields?	0.1
			Presence	1.2	Are there engineers present in the project team that cover all engineering fields?	0.1
		Operators	Availability	2.9	Are there potential operators available locally to run the plant?	0.1
			Presence	table 3.10/1.5	Have the personnel requirements for daily operational tasks been fulfilled?	0.1
		Maintenance personnel	Availability	Open	Is there maintenance personnel available locally to execute major maintenance operations?	0.1
	Material requirements	Quality	Quality requirements	Open	Does the material and equipment used meet quality requirements?	0.1
		Availability	Local availability	Open	Are the materials and equipment for operation and maintenance of the MHP available locally?	0.1
Economic	Costs and benefits	Cost benefit analysis	Capital cost coverage	table 4.1/4.2	Are the acquired funds and loans enough to match the capital costs	0.1
			Operational cost coverage	table 4.1/4.4	Are the revenues from the project enough to at least cover the daily running costs	0.1
			Reinvestment	table 4.1/Open	Are there sufficient provisions made for covering reinvestment?	0.1
			Net Present Value	table 4.3	Does the project yield a positive NPV?	0.1
	Income generation	Income generating schemes	Presence of productive schemes	2.6	Is the MHP connected to a profitable, income generating scheme?	0.1
			Market for output	Open	Is there a suitable market for the deployment of an income generating scheme?	0.1
		Incentives	Available financial incentives	table	Are there any incentives available for using the MHP for profitable	0.1

				4.6/5.3	schemes	
			Applied incentives	Open	Have any of the available incentives been applied?	0.1
	Funding	Availability	Funds for covering intermediation	table 4.5	Are there any funds available that can be used for covering intermediation costs for MHP projects?	0.1
			Funds for covering capital costs	table 4.5	Are there any funds available that can be used for covering capital costs of MHP projects?	0.1
			Funds for access promotion	table 4.5	Are there any funds available that the local community can apply to for access promotion?	0.1
			Funds for promoting industry/entrepreneurship	table 4.5	Are there any funds available that focus on the stimulation of private entrepreneurship?	0.1
		Extent	Amount	table 4.5	Is the amount of funding available enough for covering investment and operational costs?	0.1
			Duration	table 4.5	Is funding available throughout all phases of the project?	0.1
	Loan Financing	Local availability	Presence of loan financers	table 4.5	Does the community have access to loan financing institutions?	0.1
			Financers interested in MHP	Open	Do any of the financers indicate interest in special loan arrangements for MHP projects?	0.1
			Small loan Financers	Open/table 4.5	Do any of the loan financers supply small loans comparable with required connection fees?	0.1
		Suitability of loans for long term MHP investment	Term	table 4.5	Are there long term loans available, matching hydroelectric lifetimes?	0.1
			Interest	table 4.5	Are loans offered at low interest rates, comparable to savings rate?	0.1
		Training of local institutions	Presence of program	Open	Is there a program aimed at training local institutions in the particulars of MHP funding?	0.1
	Economy of scale	Programme size	Number of MHP projects within area	Open	Are there enough MHP projects in the area to provide a steady market for MHP related enterprises?	0.1
			Amount of job opportunity created by program	table 2.6	Do the MHP programs provide a steady job opportunity?	0.1
		Available capacity	Presence of local suppliers	Open	Are there suppliers available locally for MHP related equipment?	0.1
			Presence of local labour force	Open	Is the available labour force present enough to satisfy the demand from the present MHP projects?	0.1
		Outside stimulation	Application of outside stimulation	Open	Are there any outside incentives being applied to stimulate the growth of MHP related industry and services?	0.1
	Focus on poverty reduction	Aptness of tariffs	Cost coverage	table 4.6/3.7	Are the tariffs enough to cover at least the running costs?	0.1
			Conformation to local payment capability	table 2.1/ 2.6	Do the tariffs set conform to the local ability to pay?	0.1
			Use of cross subsidy	Open	Is there a cross subsidy system in place where richer people pay for	0.1

					poorer?	
		Access promotion	Connection fee	table 2.1/ 2.6	Does the height of the connection fee conform to the ability to pay of the majority of the community?	0.1
			Loan system	Open	Is there a loan system in place for spreading out payment on the connection fee?	0.1
		Inflation	Tariffs in line with inflation	Open	Do the tariffs set compensate for the inflation rate?	0.1
Institutional	Development Programme	Integration of development programmes	Inclusion in wider development programme	table 5.1	Is the MHP project part of a broader development project aimed at economic and/or social development?	0.1
			Presence of other development programs	table 5.1	Are there any other development programs being implemented that are aimed at the local community?	0.1
			Coordination with other development programmes	table 5.1	Do the targets set by the MHP project conflict with any of the development programs being implemented?	**0.2**
		Aims	Promotion of technology transfer/capability building	table 5.1	Do any of the aims of the developing projects being deployed include the promotion of technology transfer/capability building?	0.1
			Stimulation of market	table 5.1	Do any of the aims of the developing projects being deployed include the stimulation of the local economy?	0.1
			Stimulation of private entrepreneurship	table 5.1	Do any of the aims of the developing projects being deployed include the specific stimulation of private entrepreneurship on the local market?	0.1
		Clarity of aims towards community	Formulation of aims	table 5.1	Is there a formal record publicly available on the aims of the development projects being deployed?	0.1
			Communication of aims	table 5.1	Has sufficient promotional activity been exercised to make the local community aware of the aims of the development programs being deployed?	0.1
				Open	Has sufficient promotional activity been exercised to make other active agencies aware of the aims of the development programs being deployed	0.1
	Political involvement	Political involvement	Presence of political involvement	table 5.2	Are there any political factions exerting influence on the design, construction or operation project	**0.2**
	Government Policy/Legislation	Legislation	Legislation on subsidies	table 5.3	Does legislation on subsidies enable the MHP project to benefit from government subsidy?	0.1
			Legislation on tariffs	table 5.3	Are there government imposed energy tariffs that will restrict the MHP management in the setting of tariffs?	**0.2**
			Legislation on and tenure	table 5.3	Is there legislation on land tenure that interferes with the presence of a community owned MHP station?	**0.2**
			Legislation on water rights	table 5.3	Is there legislation on water rights that prohibits the use of hydropower for community purposes?	**0.2**
		Promotion RET	Government orientation towards RET	table 5.4	Is government policy towards RET positive for the execution of MHP projects?	0.1
			Presence of active promotion	table 5.4	Is there an actively implemented promotion towards the use of RET?	0.1

		Standardization	Prohibitive standards	table 5.5	Does the government impose any standards that conflict with the choices made for construction?	**0.2**
		Grid supply	Presence of a competing grid supply	table 5.6	Does the MHP project have to compete with grid supply?	**0.2**
	Development agencies	Development agencies	Presence	table 5.7	Are there any development agencies active locally?	0.1
				table 5.7	Are there any development agencies active nationally that can potentially become active locally?	0.1
			Coordination of Aims	table 5.7	Do the aims of the development agencies active in the area cover all three major areas of sustainable development: Social, Economical and Environmental?	0.1
Environmental	Impacts	Resources	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	table 6.2
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Habitats	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Ecosystems	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Air	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Water	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Soil	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Flora	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	

		Fauna	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Aesthetics	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
		Natural and Cultural heritage	Level of impact	table 6.1	What is the level of impact of the MHP project during construction and operation on this category?	
			Priority of impact	table 6.1	What is the priority of the impact of the MHP project during construction and operation on this category?	
	Reserved/Residual flow	Provisions for necessary residual flow	Government regulations	table 6.3	Does government regulation impose a reserve flow that limits the MHP *flow to less then the design flow?*	**0.2**
			Local regulations	table 6.3	Do local requirements impose a reserve flow that limits the MHP flow to less then the design flow?	**0.2**
	Regulation	Environmental regulation	Applicable environmental regulations	Open	Aside from flow regulations, are there any environmental regulations in place that will impose a restriction on the construction of the MHP?	**0.2**

3. Measurement and Output Tables for Model

0. General Output cross tables:

0.1 Output cross table Positive

Criterion	Indicator
Yes	Positive
No	Negative
Other	Cautious
Factor not applicable	n.a.

0.2 Output cross table Negative

Criterion	Indicator
No	Positive
Yes	Negative
Other	Cautious
Factor not applicable	n.a.

1 Organizational

1.1 MHP Objectives

		MHP targets	Form of target statement(official document, contract or publicly witnessed oral agreement)
Primary	1		
	2		
	...		
Secondary	1		
	2		
	...		

1.2 Project Staff

	Project Staff Member	Function	Expertise	Duration of commitment	Previous MHP experience
1					
2					
3					
4					
..					

1.3 Stakeholder

	Organisations involved	Role	Nature of involvement
1			
2			
3			

...			

1.4 Organisation flowchart

Draw organisational flowchart(example)

Owner(s)

Contributors

Project leader

Staff member	Staff member	Staff member

Construction crew

1.5 Plant management

	Plant personnel	Function	Category	Qualifications(Educational/ Experience)
1			Management/Administrative/ Technical/Other	
2			Management/Administrative/ Technical/Other	
3			Management/Administrative/ Technical/Other	
..			Management/Administrative/ Technical/Other	

Category: Administrative, Management or Technical
Function : Management, secretary, accounting, technical operator, collector etc

1.6 Indicators for businesslike approach

	Plant management requisite	Inclusion in management design
Tariff structure based on	Cost coverage	Yes/No
	Profit generation	Yes/No
	Replacement budgeting	Yes/No
Management mandate to	Disconnect debtors	Yes/No
	Adjust tariffs to costs	Yes/No

1.7 Promotional activities

	Promotional activity	Aim	Target group
1			
2			
3			
...			

1.8 Local knowledge

		Locally acquired knowledge
Hydrological	Head	
	Flow	
	...	
Geological	Soil composition	
	Structural layout	
	...	
Materials	Local materials	
...	...	

1.9 Capacity to motivate

1.	Positive experience with project leadership	
2.	Negative experience with project leadership	
3.	Reviewing experience with project leadership (or lack thereof) what option best describes capacity to motivate?	Positive/Cautious/Negative

2 Social

2.1 Population and commercial statistics

	Number	Average growth(%)	Average income level(SRD/year)	Average expenditure energy(SRD/year)	Intention to pay(%)		
					Yes	No	Cautious
Inhabitants							
Men							
Women							
Children							
Households					X	X	X
Commercial users							

2.2 Current energy sources

		Current energy sources	Average expenditure per household (SRD/y)	Priority of need for electricity provision
1	Cooking			low/medium/high
2	Lighting			low/medium/high
3	Entertainment			low/medium/high
4	Refrigeration			low/medium/high
5	(Other household application)			low/medium/high
..	(Other household application)			low/medium/high
..	(Commercial application)			low/medium/high
..	(Commercial application)			low/medium/high

2.3 Estimated electricity usage

	Current(nr)	Future estimate (nr)	Average Power(W)	Estimated daily usage (h)	Current expenditure (SRD/y)
Domestic lights					
Refrigeration					
Washing machines					
Radio's					
Television/video/DVD					
Water cookers					
Rice cookers					
Cooking plates					
Computers					
Power tools					
...					
...					

Total Power (kW)	
Total Usage (kWh)	

2.4 Commercial usage

	Trade	Estimated power (W)	Estimated usage (kWh)	Estimated revenue(SRD)
1	Rice stumper			
2	Cassava mill			
3	Saw mill			
..	...			

2.5 Current means of income

	Number of inhabitants
Fishing	
Agriculture	
Local art	
Lumber jacking	
Gold mining	
..	
..	

2.6 Potential income generating schemes

	Description of scheme	Estimated revenue(SRD/year)	Employment generation					
			Men		Women		Total	
			Number	Income	Number	Income	Number	Income
1								
2								
3								
...								

2.7 Potential benefit listing

	Potential benefits	Development category	Included in scheme/extension programme
1		Social/Economical/ Environmental	Yes/No
2		Social/Economical/ Environmental	Yes/No
3		Social/Economical/ Environmental	Yes/No
..		Social/Economical/ Environmental	Yes/No

2.8 Involvement

Nr of villagers involved	Percentage of total(%)	Nature of involvement	Duration	Phase

2.9 Technical capability

		Description
1	Average educational level	
2	Available mechanical skills	
3	Available administrative skills	
4	Available accountancy skills	

3 Technical

3.1 Waterpotential(1)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Head	Average													
	Minimum													
	Maximum													
Flow	Average													
	Maximum													
	Minimum													
Waterlevel Upstream	Average													
	Maximum													
	Minimum													
Waterlevel Downstream	Average													
	Maximum													
	Minimum													

Residual Flow limitation:

3.2 Waterpotential (2)

Monthly Potential		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
	Average													
	Minimum													
	Maximum													

3.3 Turbine statistics

.a) Turbine Statistics

Type	Specific speed	

.b) Hydroelectric equipment statistics

	Costs(SRD)	Lifespan (yr)	Local expertise	Maintenance
Turbine				
Drive system				
Governor				
Housing				

.c)Part Flow efficiency

Q/Qmax (%)	10	20	30	40	50	60	70	80	90	100
Efficiency										

.d)Drive system efficiency

Type	Efficiency

3.4 a) Generator Statistics

Type		
Specific speed		
Output potential	Power	
	Voltage	
	Current	
I/O efficiency	Relative speed	
	Efficiency	

3.4 b) Electrical equipment

	Costs(SRD)	Lifespan(yr)	Local Expertise	Maintenance
Generator				
Alternator				
Condensers				
ELC				

3.5 Total Output

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Total Potential														
Total System efficiency														
Real Monthly Output														

3.6 Usage statistics per subload

	Appliance	Number	Average power(W)	Average load (%)	Total(kW)	Running hours
1						
2						
3						
...						

3.7 Total Power-Load

From	Till	Sub load 1(kW)	Subload 2(kW)	..	Power demand(kW)	Total use(kWh)
0:00	0:30					
0:30	1:00					
1:00	1:30					
...	...					
23:30	0:00					

Total Daily use	

3.8 Transmission

	Value
Distance(km)	
Transmission voltage(V)	
Estimated voltage drop(V)	
Capital costs(SRD)	
Maintenance costs(SRD)	

3.9 Distribution

	Value
Number of connections	
Limitation type	Metering/Fixed fuse/None
Capital costs(SRD)	
Maintenance costs(SRD)	

3.10 Operational requirements

Maintenance	Civil Works	Turbine	Generator	Transmission	Distribution
Personnel					
Training level					
Equipment					
Costs(SRD)					
Replacement costs(SRD)					

3.11 Locally available Material

	Material	Needed for	Availability (location)
1	Timbre		
2	Sand		
3	Gravel		
..	...		

3.12 Output generation for maintenance level

	Maintenance Level	Indicator
1	High	Negative
2	Medium	Cautious
3	Low	Positive

4 Economic

4.1 Costs and Revenues

Cost-Revenue Sheets

Initial Costs

Cost Item	Costs(SRD)
Feasibility study	
Development	
Engineering	
Energy equipment	
Civil works	
Miscellaneous	
Initial Costs - Total	

Incentives/Grants	

Major Maintenance Costs

Cost Item	Costs(SRD)	Schedule(yr)
Turbine overhaul		
Generator overhaul		
Civil works		
..		

Annual Costs

Cost Item	Costs(SRD)
O&M	
Transport	

Debt payments	
...	
Annual Costs - Total	

Annual Revenues

Cost Item	Costs(SRD)
Energy savings/income	
Capacity savings/income	
...	
Annual Revenues - Total	

4.2 Financial Cash flows

Yearly Cash Flows		
Year	Annual	Cumulative
Nr	SRD	SRD
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
...		

4.3 Economic Feasibility
Net Present Value

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows
Nr	SRD	SRD	SRD		SRD
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
....					
....					
....					
....					
....					
				NPV =	0

IRR =	%

4.4 Income from users

Village input	Number	Average payments(SRD/yr)
Domestic users		
Commercial users		
Other		
Total		

4.5 Available funding

	Organisation	Fund/Loan	Available fund/loan size(SRD)	Criteria	Loan lifetime(yr)	Loan rates(%)
1						
2						
3						
..						

4.6 Tariffs and Connection fees

	Power usage range (kWh)	Tariffs (SRD/kWh)
1		
2		
3		
...		

	Powerlevel (kW)	Connection fees(SRD)
1		
2		
3		
...		

5 Institutional

Table 5.1 Development programs

	Agency	Active programs effecting community	Aim of programs	Conflict/Match with MHP aim	Conflict/Match with other development program aims	Promotional activity towards community
1		1 2. 3. ...				

2		1 2. 3. ...				
3		1 2. 3. ...				

Table 5.2 Political interference

	Political activity:	Description
1a	Are there any political factions funding the MHP?	
1b	What are the conditions for this funding?	
1c	Do these conditions constitute a future dependency on the political faction?	
2	Are there any political factions that have a deciding vote in the design and execution of the project?	
3a	Are there any political factions that have taken a (public) interest in this program?	
3b	What is the nature of this interest?	

Table 5.3 Legislation

	Description of legislative rules affecting MHP	Description of impact on MHP
Subsidies	1. 2. 3. ...	
Legislation on Tariffs	1. 2. 3. ...	
Land tenure	1. 2. 3. ...	
Water rights	1. 2. 3. ...	

Table 5.4 Government orientation towards RET

	Government RET orientation and activity	Answer
1.a	What are the official government policies toward the use of RET	
1.b	Do these policy statements offer equal opportunity for all renewable energy Technologies?	
1.c	Does the MHP project conform to government RET policy?	
2.a	Is the government policy towards RET actively promoted?	
2.b	Does the promotion include stimulation of private entrepreneurship in the field of RET?	

Table 5.5 Standards

	Government standards conform to best practice choice	Equipment/construction conform to government standards
Control Equipment	Yes/No	Yes/No
Distribution	Yes/No	Yes/No
Generators	Yes/No	Yes/No
Storage and Intake	Yes/No	Yes/No
Transmission	Yes/No	Yes/No
Turbines	Yes/No	Yes/No
Waterways	Yes/No	Yes/No

Table 5.6 Grid electricity

	Presence of competing grid	Answer
1	Is there an electricity grid present in competition with the MHP?	
2	Can the MHP function as an addition to a local grid?	
3	Is it financially feasible to extend the grid towards the target area?	
4	Are there any plans to extend the grid within the near future?	

Table 5.7 Development agencies

	Development agencies	Active locally	Main aims of agency
1			
2			
3			
...			

6 Environmental

Table 6.1 Measurement of impact levels and priority

			Construction phase		Operational phase			
Cause	Impacted subjects	Category	Impact description	Level of impact	Impact description	Level of impact	Significance to community	Priority of impact

		(Choose from below)	(noise, destruction etc)		(noise, destruction etc)			
Access road				Low/Medium/High		Low/Medium/High		Low/Medium/High
Cleaning				Low/Medium/High		Low/Medium/High		Low/Medium/High
Earth excavation				Low/Medium/High		Low/Medium/High		Low/Medium/High
Rock excavation				Low/Medium/High		Low/Medium/High		Low/Medium/High
Dam/weir				Low/Medium/High		Low/Medium/High		Low/Medium/High
Dewatering				Low/Medium/High		Low/Medium/High		Low/Medium/High
Spillway				Low/Medium/High		Low/Medium/High		Low/Medium/High
Canal				Low/Medium/High		Low/Medium/High		Low/Medium/High
Intake				Low/Medium/High		Low/Medium/High		Low/Medium/High
Tunnel				Low/Medium/High		Low/Medium/High		Low/Medium/High
Pipeline/penstock				Low/Medium/High		Low/Medium/High		Low/Medium/High
Powerhouse civil				Low/Medium/High		Low/Medium/High		Low/Medium/High
Fishway				Low/Medium/High		Low/Medium/High		Low/Medium/High
Transmission line				Low/Medium/High		Low/Medium/High		Low/Medium/High
Substation				Low/Medium/High		Low/Medium/High		Low/Medium/High
Transportation				Low/Medium/High		Low/Medium/High		Low/Medium/High

Categories of impacted subjects:
Resources, Habitats, Ecosystems, Air, water, Soil, Flora, Fauna, Aesthetics, Natural and Cultural Heritage

Table 6.2 Indicator output crosstable for Level and priority of impact.

Indicator output	**Priority of impact**		
Level of impact(down)	**Low**	**Medium**	**High**
Low	Positive	Positive	Cautious
Medium	Positive	Cautious	Negative
High	Cautious	Negative	Negative

Table 6.3 Regulations concerning residual flow

	Reserved flow		Flow potential for MHP
	Portion(%)	Absolute value(m3/s)	Value(m3/s)
Government regulation			
Local requirements			

4. Interview forms

4.1 Template Interview form for local data acquisition

Personal Data
Name: Function: Relation to Inlands/Electrification projects:

For Researcher:	Main category of information: Organisational/Social/Technical/Economic/Institutional/Environmental

1) Following the critical factor map, please specify the knowledge available on the factors and sub factors in this map, pertaining to the national and/or local setting.

Overview	Category of information

For researcher:
Focus on key areas: hydropower, electrification in the inlands, Inheemse and Marron territories

2) What databases do you know of that might have data pertaining to the factors in the critical factor map?

Database	Category of information

3) From the discussion of the information given in 1), what additional information can you give that might be of interest for the assessment and/or execution of a micro hydropower project in the inlands?

Additional information	Category of information

4.2 Template Interview form for Evaluation of past electrification projects

Personal Data
Name: Current function: Name of past electrification project: Function during past electrification project

1) Project overview and history:

2) From discussion of overview: Which factors had a significant impact on the design, construction and operation of the project?

Factor	Impact	Category

3) From discussion of overview: On which factors did the construction and operation of the project have a significant impact?

Factor	Impact	Category

4) Following the critical factor map, discuss which factors (not already discussed under 2) impacted on the project.

Factor	Impact	Category

5) Comparing the critical factor map to the factors discussed under 1 and 2, are there any factors outside of the map impacting on the project?

Factor	Impact	Category

6) What additional information can you give that might be of interest for the assessment and/or execution of a micro hydropower project in the inlands?

Additional information	Category

5. Schedule of Observational visit to Palumeu

Day 1	Arrival First meet with the Kapitein of Palumeu, explanation of visit purpose Initial visit to construction site Kroetoe (group discussion) with Kapitein, foremen, local Mets manager and several villagers
Day 2	Exploration of construction site, available material and part of transmission route with the foremen Visit to village, inventory of village social parameters (need for electricity, income, housing, facilities) Social conversations with community members on project history and execution Observations on running hours
Day 3	Inventory of village equipment and energy usage together with the village basja and short interview with the basja Inventory of METS equipment and energy usage Observations on running hours
Day 4	Observations on running hours Interview with METS local manager Discussion of inventoried equipment and energy usage with foremen Departure

D. Output of model application to the Palumeu project

1. Summary

In this section the output of applying the model to the Palumeu case is presented.

The structure and operationalisation of the model are explained in chapter 3, the chapter on model design. The critical factors used, the operationalisation of these factors and output generation schematic of the model, and the model's measurement tables are presented in appendix C.

The data and information needed for assessing each indicator for the Palumeu case was obtained through the methods explained in chapter 4: an observational visit to the village, interviews with the people listed in table 4.3c and field reports from visits of the project team to the construction site and the village.
For a map on the location and layout of the village please refer to appendix B.2

In this appendix first the graphical output of the model is provided, followed by a printout of the text-output, which has been edited to make the text more readable.

Graphical output
From left to right in the graphical output, the topics in the chart represent: categories, factors, sub factors and indicators. In front of each of these, a flag is placed.
This flag indicates if the subject topic has a positive (green) or negative (red) influence on the sustainability of the project, or if the nature of the influence is uncertain (cautious).

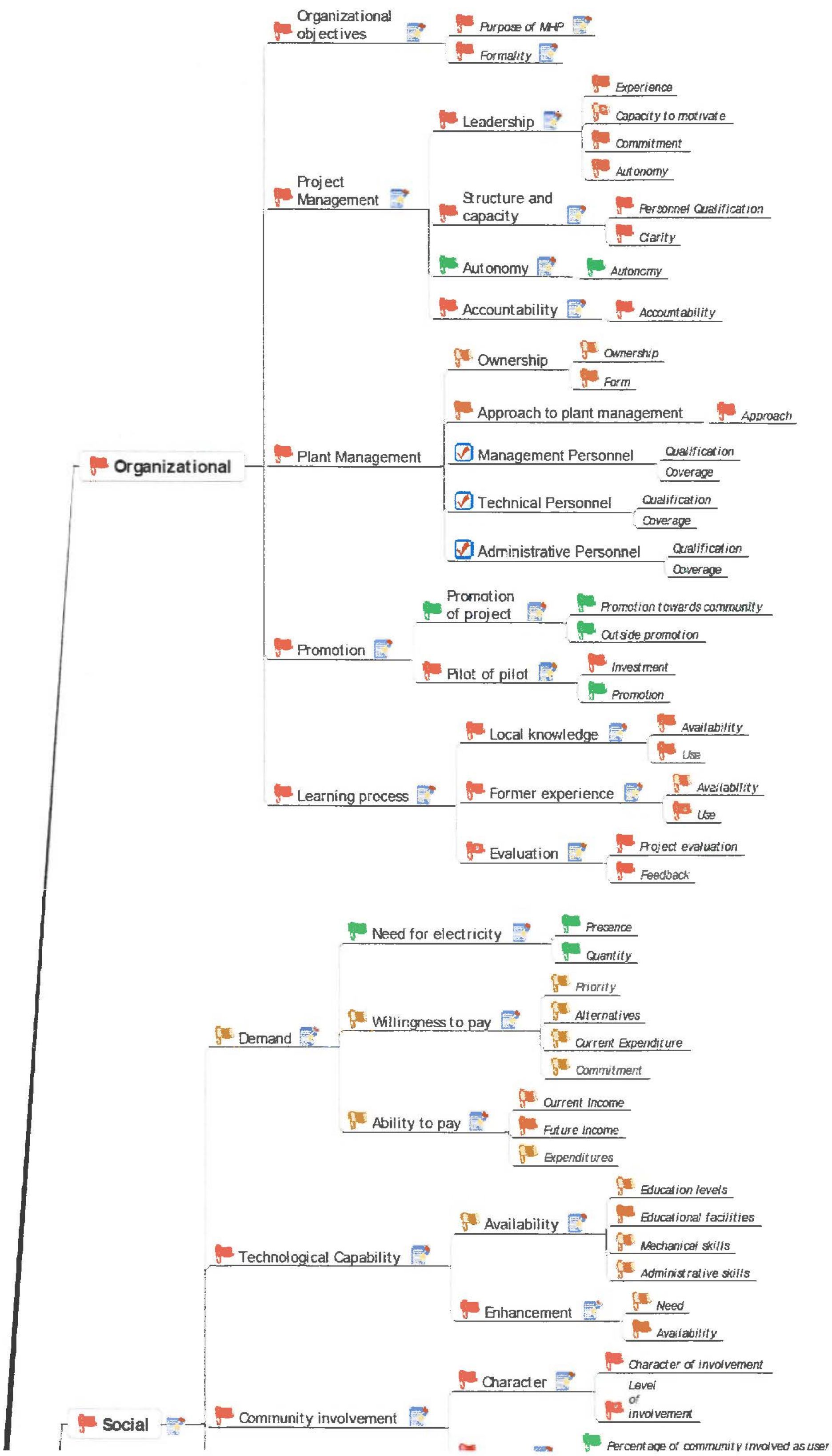
The model actually works from right to left: First the outcome of the different indicators is decided. On the basis of these indicators the outcome of the sub factors is decided, and on basis of these sub factors the outcome of the factors is decided.

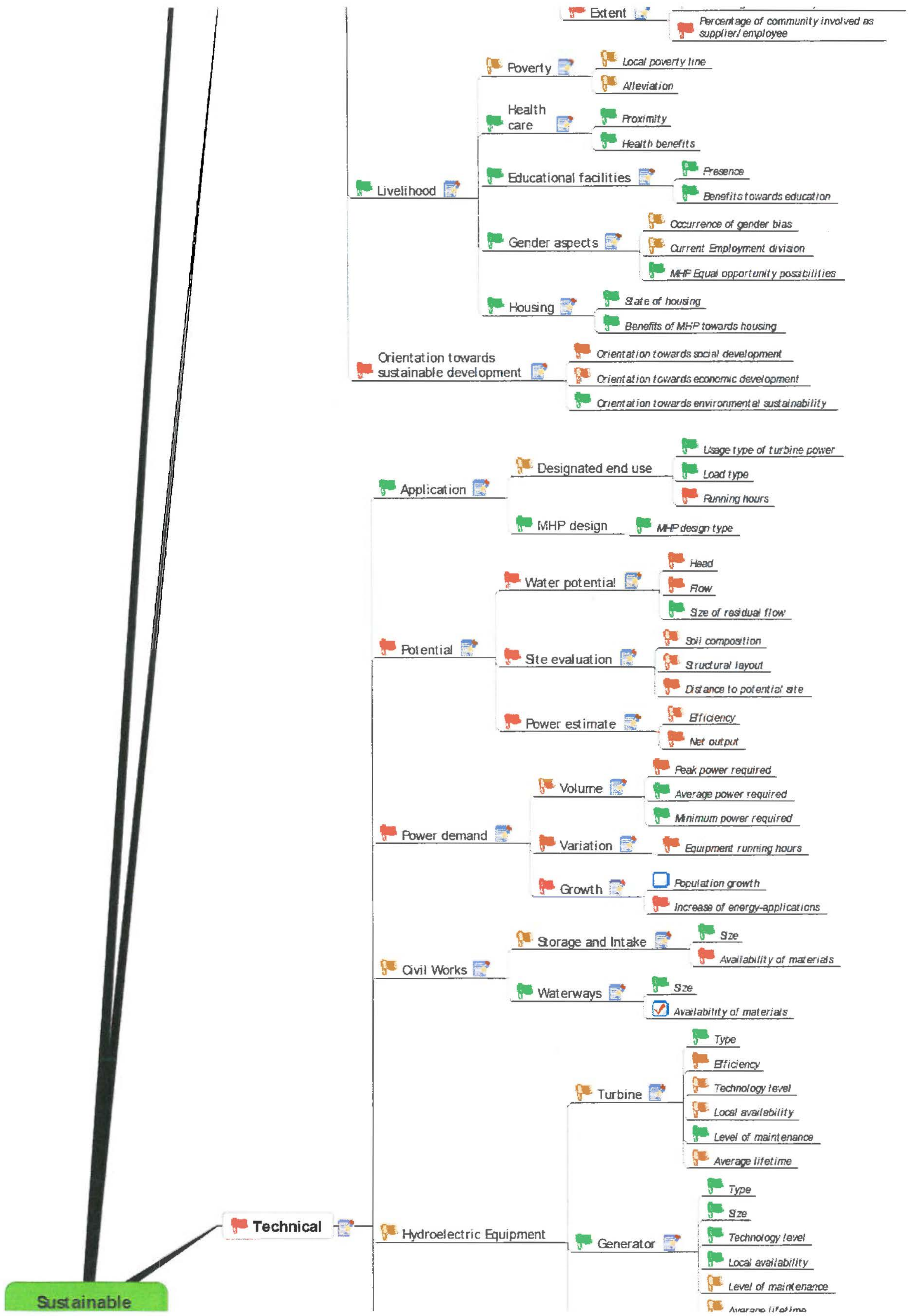
From the graphical output it can be quickly deduced that there are many things wrong with the Palumeu project. Only the environmental category performs well; in all other category the majority of indicators indicate a negative influence.

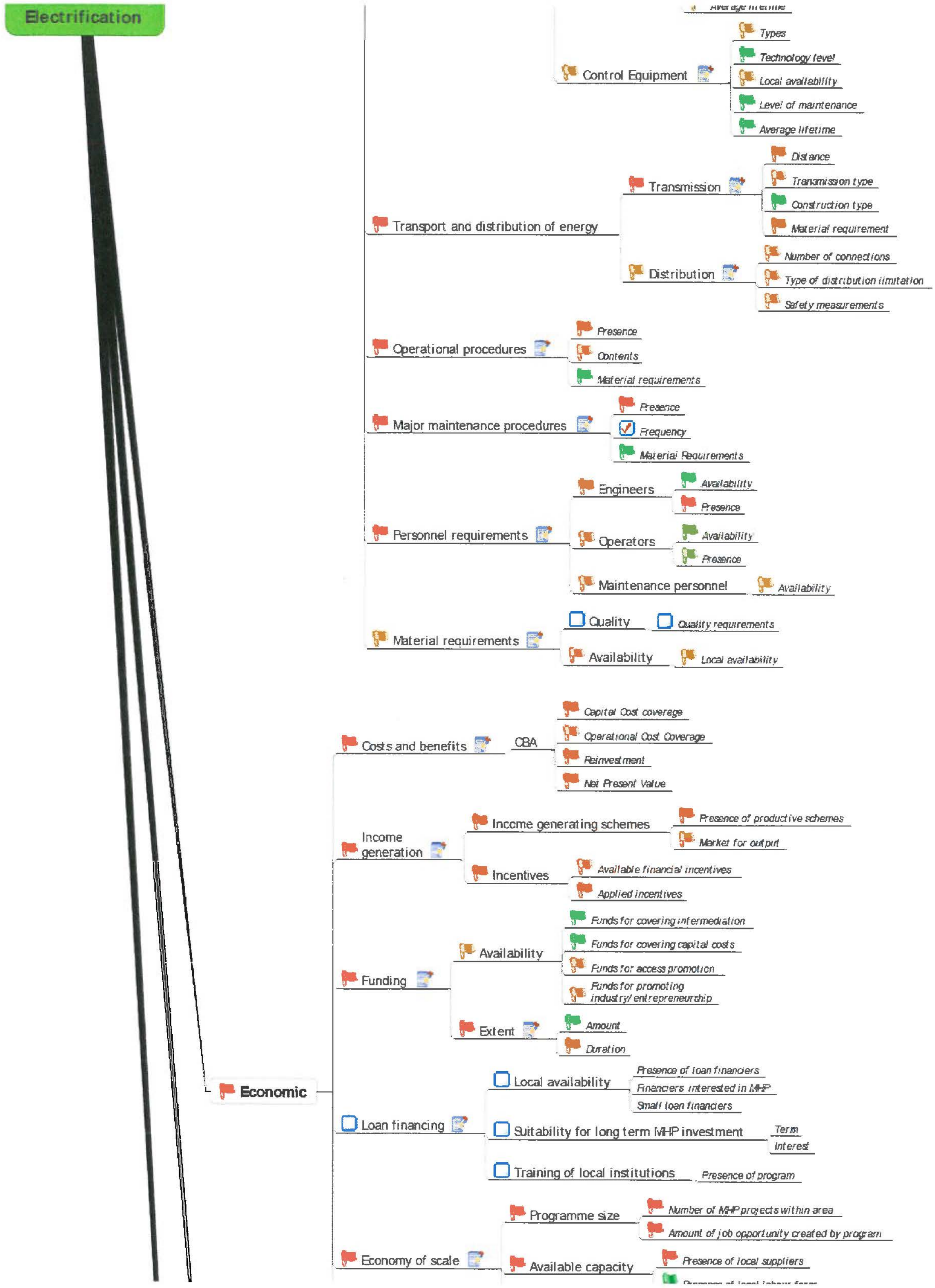
Text output
The lack of clarity of the text output is one of the major shortcomings of the model's software design. The unedited text output is an incoherent listing of data and calculations on the current project, calculations, as well as all the accumulated information (best practice advice, links to relevant documents) that has already been incorporated into the model. This means that a lot of text has to be deleted and the texts on the current project edited for the output to be readable.
In the text output the main heading of a chapter represents the different categories (1 to 6). The sub headings represent the factors (e.g. 1.1, 1.2, 3.5) and sub factors (e.g. 1.2.1, 3.4.2).
The indicators for analysing a sub factor are represented by the underlined headings under each sub factor (e.g. Level of involvement or Availability of materials).

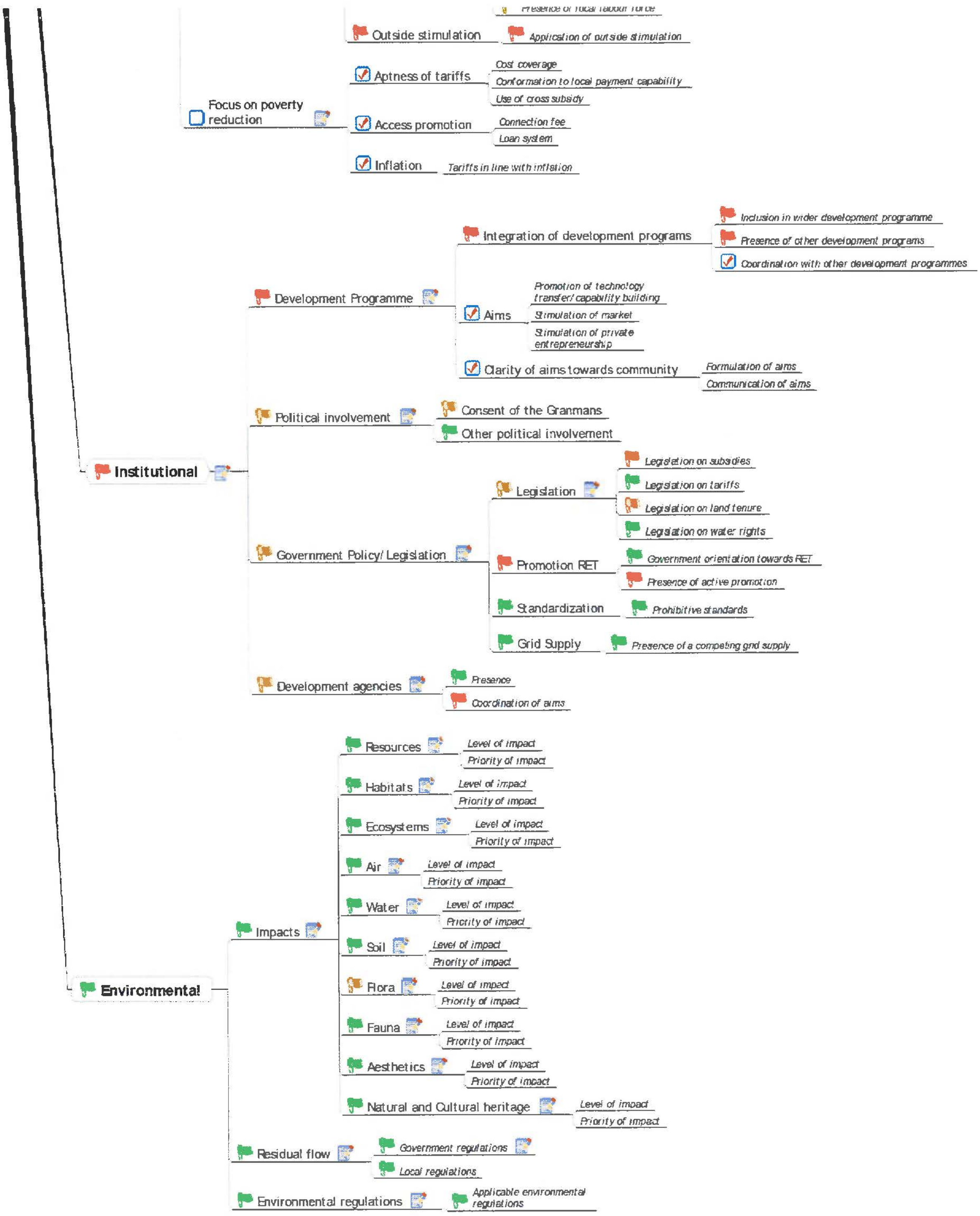
In the unedited text output, the outcome that has been set for each indicator is represented by a flag, the same as in the graphical output. This means that in order to know the nature of the output, the text output would have to be printed in colour. In order to make this output readable in black and white the flags have been substituted with a text version. After a summary text on each indicator, the following statement is given:
Indicator: (NEGATIVE/CAUTIOUS/POSITIVE)

2. Graphical output




Extent
Percentage of community involved as supplier/employee
Poverty
Local poverty line
Alleviation
Health care
Proximity
Health benefits
Livelihood
Educational facilities
Presence
Benefits towards education
Gender aspects
Occurrence of gender bias
Current Employment division
MHP Equal opportunity possibilities
Housing
State of housing
Benefits of MHP towards housing
Orientation towards sustainable development
Orientation towards social development
Orientation towards economic development
Orientation towards environmental sustainability
Application
Designated end use
Usage type of turbine power
Load type
Running hours
MHP design
MHP design type
Potential
Water potential
Head
Flow
Size of residual flow
Site evaluation
Soil composition
Structural layout
Distance to potential site
Power estimate
Efficiency
Net output
Power demand
Volume
Peak power required
Average power required
Minimum power required
Variation
Equipment running hours
Growth
Population growth
Increase of energy-applications
Civil Works
Storage and Intake
Size
Availability of materials
Waterways
Size
Availability of materials
Technical
Hydroelectric Equipment
Turbine
Type
Efficiency
Technology level
Local availability
Level of maintenance
Average lifetime
Generator
Type
Size
Technology level
Local availability
Level of maintenance
Sustainable


Electrification
Control Equipment
Types
Technology level
Local availability
Level of maintenance
Average lifetime
Transport and distribution of energy
Transmission
Distance
Transmission type
Construction type
Material requirement
Distribution
Number of connections
Type of distribution limitation
Safety measurements
Operational procedures
Presence
Contents
Material requirements
Major maintenance procedures
Presence
Frequency
Material Requirements
Personnel requirements
Engineers
Availability
Presence
Operators
Availability
Presence
Maintenance personnel
Availability
Material requirements
Quality
Quality requirements
Availability
Local availability
Economic
Costs and benefits
CBA
Capital Cost coverage
Operational Cost Coverage
Reinvestment
Net Present Value
Income generation
Income generating schemes
Presence of productive schemes
Market for output
Incentives
Available financial incentives
Applied incentives
Funding
Availability
Funds for covering intermediation
Funds for covering capital costs
Funds for access promotion
Funds for promoting industry/entrepreneurship
Extent
Amount
Duration
Loan financing
Local availability
Presence of loan financiers
Financiers interested in MHP
Small loan financiers
Suitability for long term MHP investment
Term
Interest
Training of local institutions
Presence of program
Economy of scale
Programme size
Number of MHP projects within area
Amount of job opportunity created by program
Available capacity
Presence of local suppliers



Outside stimulation
Application of outside stimulation
Aptness of tariffs
Cost coverage
Conformation to local payment capability
Use of cross subsidy
Focus on poverty reduction
Access promotion
Connection fee
Loan system
Inflation
Tariffs in line with inflation
Integration of development programs
Inclusion in wider development programme
Presence of other development programs
Coordination with other development programmes
Development Programme
Promotion of technology transfer/ capability building
Aims
Stimulation of market
Stimulation of private entrepreneurship
Clarity of aims towards community
Formulation of aims
Communication of aims
Political involvement
Consent of the Granmans
Other political involvement
Institutional
Legislation on subsidies
Legislation
Legislation on tariffs
Legislation on land tenure
Legislation on water rights
Government Policy/ Legislation
Promotion RET
Government orientation towards RET
Presence of active promotion
Standardization
Prohibitive standards
Grid Supply
Presence of a competing grid supply
Development agencies
Presence
Coordination of aims
Resources
Level of impact
Priority of impact
Habitats
Ecosystems
Air
Water
Impacts
Soil
Environmental
Flora
Fauna
Aesthetics
Natural and Cultural heritage
Residual flow
Government regulations
Local regulations
Environmental regulations
Applicable environmental regulations

3. Text output from model for Palumeu assessment

Sustainable Electrification
Palumeu Scenario

1. Organizational

In the organizational category, most indicators are set to negative. The METS, the community of Palumeu and the lead engineer all seem to have a different take on what the most important objective of the project is. This leads to confusion and miscommunication. The lack of experience and proper coverage of all the required engineering fields in the project management has a negative influence on the teams ability to design and construct a technologically sound MHP installation that will deliver the expected year round electricity to the village.
No proper preparations have been made for plant management, which means that the ability of the MHP to perform well in the operational period is uncertain.
Because the Palumeu project is a pilot project, serving as an example to future projects, extra care should have been taken to ensure the solidity of the project. This has not been done. A final note in this category is the fact the project team does not make use of the past experiences or local knowledge to achieve an optimal design.

On general, the factors in the organizational category indicate a negative outcome on the chance for a sustainable MHP
Indicator: NEGATIVE

1.1 Objective

Indicator: NEGATIVE

<u>Purpose of MHP</u>
-METS: Energy for resort
-Village: Electricity to run a variety of luxury equipment, far more then just lighting
-Lead Engineer: Prestige pilot project, completion of a functioning system.

There is no specification of profit generating scheme.

Indicator: NEGATIVE

<u>Formality</u>
The only contractual agreements are between the WMM and the UNDP for reception of funds and between ADEK and WMM for responsibility of construction. There is no formal mission statement on the purpose/objective of the MHP.

Indicator: NEGATIVE

1.2 Project Management

Indicator: NEGATIVE

1.2.1 Leadership

It is unclear who the leader of the project is. There is a form of unofficial committee formed by the University coordinator, the chairman of the WMM and the director of the METS. The chairman of the WMM has the final say in finances, whereas for travel to the village the director of the METS plays a deciding role. The University design team is not free to travel to the village at any time (dependent on free seats in the tourist flight). All decisions regarding the design and construction process are left up to the University coordinator. For the purpose of the assessment he will be considered the principal leader.

Experience
The lead designer (University coordinator) has no previous experience in the field of micro hydro. In fact, no one on the design team does. Former project experience: Unknown

Indicator: NEGATIVE

Capacity to motivate
Project leader is clearly a passionate man and not afraid to get hands dirty out in the field. However, there is evidence that has leadership is thoroughly accepted. One explicit order not to deploy slash and burn farming in the area was ignored, causing the loss of a storage hut and cement.

Indicator: CAUTIOUS

Commitment:
The ADEK has a responsibility until the completion of the project. However, during the field research period several members of the original team gradually withdrew from the project, leaving responsibility to the leader. Leader was simultaneously committing to several upcoming MHP projects.
Do to the remoteness of the village, the only one of the leading project members with social ties is the chairman (and seemingly sole board member) of the WMM. It is clear that commitment will not last beyond plant finish.

Indicator: NEGATIVE

Autonomy
The project leader is subject to a complex system and does not have true autonomy. Finances are in control of the WMM, travel is in control of the METS.
A Dutch citizen, Mr. van der Werke, with a long time affiliation with the village of Palumeu, considered as the original initiator of the micro-hydro idea, has been out of the planning for medical reasons, but came back recently. He was so dissatisfied with the project planning that he expressed the intention to come back with his own crew and complete the electrification project his own way. Villagers seem to put great trust in his opinion.

Indicator: NEGATIVE

1.2.2 Structure and capacity

Indicator: NEGATIVE

Personnel Qualification
The original engineering team consist of engineers of the University's infrastructure department: two hydrologists and a civil engineer.
Electronics department was only contacted once the team started experiencing difficulties with getting the generator functional. Two electrical engineers were from then on involved in an advisory role.
No mechanical engineers were part of the project.
No researcher with experience in the social sciences to assess village's usage statistics
This means that not al fields were covered.

None of the personnel had experience with the deployment of micro hydro projects.

No extra training was reserved for the engineers involved in the project.

Indicator: NEGATIVE

Clarity
Within the University team the hierarchy is clear: Mr S. Naipal is the University coordinator and leader. At the Palumeu site there is no clear hierarchy in local leaderships and related

responsibilities. Although the kapitein stands above the foremen Apau and Anasinge in village hierarchy, these two report back to the University coordinator. As village spokesman the kapitein carries responsibility for the success of any communal effort. However, the foremen seem to function parallel to the kapitein in some respects of this project, thereby making it unclear who is locally responsible for different project aspects.

Indicator: NEGATIVE

1.2.3 Autonomy

Indicator: POSITIVE

<u>Autonomy</u>
The committee formed by the University coordinator, the chairman of the WMM and the director of the METS functions without outside interference.
The University coordinator has a responsibility to the faculty to adhere to the contract between the University and the WMM, but is not subject to evaluation nor does he have to justify his decisions other then to the two other committee members.
The chairman of the WMM has a responsibility towards the village, as the foundation in theory represents the village. The kapitein indicates that there are long lapses between contacts, and there is no clear form of reporting towards the village.
The director of the METS does not have to report to anyone.

There is one primary sponsor, the UNDP, to whom the spending of the grants has to be justified. This means that the UNDP expects a project proposal and budget upfront and an intermediate evaluation halfway during the construction phase for the second half of the grant. The UNDP does not in anyway interfere with the project management.

Indicator: POSITIVE

1.2.4 Accountability

Indicator: NEGATIVE

<u>Accountability</u>
There was one scheduled form of performance evaluation, which is the intermediate evaluation to the UNDP. The specifics of this evaluation are unknown.

There are no other forms of performance reviews scheduled.

The only contractual liability lies with the University to finish the project. No penalties are stipulated in the contract.

Indicator: NEGATIVE

1.3 Plant Management

Indicator: NEGATIVE

1.3.1 Ownership

Indicator: CAUTIOUS

<u>Ownership</u>
It is the stated purpose that the project should be the property of the community of the village of Palumeu. This was stated in the grant contract between the UNDP and the WMM.
The WMM receives the grant, however university signed liability contract, not the WMM. Ownership of structure will belong to village. The village, however, is not a legal entity.

Indicator: CAUTIOUS

Form
There have been no clear plans drawn up for how the ownership structure of the MHP site should work. It is in fact unclear who will have responsibility over the operation and management of the structure. There is a vague notion along the committee member that the METS will employ (and pay) local inhabitants to take care of the structure. This however would imply that the METS is the owner of the structure, which is in clear violation of the grant stipulations with the UNDP.

Indicator: NEGATIVE

Note:
There seems to be no provisions made at all for the operational phase of the project.

1.3.2 Approach to plant management

Approach
There have been no plans drawn up on what approach will be used for running the MHP station. There is a general statement that it should provide power to both the village and the METS. This should lead to cost reduction on fuel expenditure for both. However, there are no indications of the project being put to an otherwise profitable use.

Indicator: NEGATIVE

1.3.3 Management Personnel

As there are no plans drawn up for the management of the plant, there is no information on these indicators.

Indicator: blank

1.3.4 Technical Personnel

As there are no plans drawn up for the management of the plant, there is no information on these indicators.

Indicator: blank

1.3.5 Administrative Personnel

As there are no plans drawn up for the management of the plant, there is no information on these indicators.

Indicator: blank

1.4 Promotion

Indicator: NEGATIVE

1.4.1 Promotion of project

Indicator: POSITIVE

Promotion towards community
The community has been extensively involved in the project and a great deal of enthusiasm was created.
There were several kroetoes with the whole village and several dignitaries, including the Granmans from both villages. The advantages of having a renewable electricity system were explained. As a result in the beginning of the project the entire community as a whole put an incredible effort into the collection of locally available materials for the construction of the dam and into the construction of a temporary dam.

There was no extra focus laid on the responsibility of ownership of the structure.

Indicator: POSITIVE

Outside promotion
The University coordinator has been promoting the use of micro hydrology in several villages in the hind lands and has attracted the interest of the government with this project. Although there was no promotion made to attract sponsors to this particular project, there has been a lot of interest from other communities for starting similar projects.

Indicator: POSITIVE

1.4.2 Promotion of pilot

Indicator: NEGATIVE

Investment
Although this is supposed to be a pilot project, no extra expenditure was made to ensure its success. None of the members involved have any previous experience with micro hydro projects, and no extra provisions have been made to remedy this shortcoming. Also, in stead of a conservative, proven design, the University team decided to make their own design. The turbine is a propeller turbine being constructed by a local mechanical engineering company for whom this is a first and who rely on the University coordinator for design advice.

Indicator: NEGATIVE

Promotion
The fact that a pilot was being deployed and that the success of this project might ignite more was reasonably well promoted. The project received attention the national newspapers and the government indicated interest in the outcome of the project in light of its own issues with the provision of fuel to the hind lands.

Indicator: POSITIVE

1.5 Learning process

1.5.1 Local knowledge

Indicator: NEGATIVE

Availability
No inventory was made by the project management of locally available knowledge on the critical factors. The design and instigation of the project is a top down design, with the committee in Paramaribo making the decisions and issuing orders to the local inhabitants. The inhabitants have trouble communicating information towards the project team, because of the lack of communication.

Indicator: NEGATIVE

Use
As there was no inventory of local knowledge made by the project management, none was incorporated into the design.

Indicator: NEGATIVE

1.5.2 Former experience

Indicator: NEGATIVE

Availability
There is only one former micro hydro project to draw information from. This is the Poketi project. The available written data on this project is scarce. Only one report was still in possession of the

BWKW. The main project leader is however still available in Paramaribo for consultation. [DelPrado, Niekoop]

Indicator: CAUTIOUS

<u>Use</u>
The lead designer (UC) has acquired the one report available on the Poketi project. The Poketi project leader has not been consulted on the Palumeu project. [Naipal]

Indicator: NEGATIVE

1.5.3 Evaluation

Indicator: NEGATIVE

<u>Project evaluation</u>
There are no scheduled evaluation points during the project.
This research can be considered such an evaluation. However, it was not initiated by the project management team but by the department of electrical engineering who had only an advisory role in this project.

Indicator: NEGATIVE

<u>Feedback</u>
As there are no scheduled evaluation points there have also been no provisions made for feedback of this project for future references. Although at first there were reports kept on the site visits these reports have stopped at a certain point. There have been no structured evaluations on the progress of the project.

Indicator: NEGATIVE

Outside of model

Issue of Communication
-The villagers mention lack of information from Paramaribo. The reasons for stagnation of construction activities are not known and people have to guess whether there will be sufficient power available for everyone. Some of them fear that they will be excluded from supply.
They request that their houses should not be skipped.
-There is confusion on the final use of electricity. The villagers anticipate enough power to connect all desired devices. A few households have already bought refrigerators and other apparatus.
Visiting tourists, claiming expertise in the field op hydropower generation, stated their doubts about the technical feasibility of the project.
- The original initiator of the micro-hydro plan came back recently. He was so dissatisfied with the project planning that he expressed the intention to come back with his own crew and complete the electrification project his own way.
- The local foremen indicate long lapses in communication with the University project team, creating uncertainty over when and how to prepare for further construction.
- The Kapitein indicates dissatisfaction with the information provided from Paramaribo

2. Social

In the social category, the indicators on the following factors or set negative:
Community involvement, technological capability and orientation towards sustainable development.
Especially the lack of proper community involvement is an error in project execution which is listed in literature as one of the major mistakes with electrification projects worldwide. The lack of a development orientated extension program (also reflected in the lack of technological capability enhancement) means that the project, even if technologically sound, will not achieve the goal of sustainable development.
The livelihood factor is set to positive, indicating that the project will at least not have any negative effects on the livelihood situation.

The demand factor is set to cautious, because the project team clearly did not do a proper job of investigating the actual volume and nature of the electricity needs of the community, and absolutely no investigation into their willingness and ability to pay for future operation of the plant.

On general, the factors in the social category indicate a negative outcome on the chance for a sustainable MHP

Indicator: NEGATIVE

2.1 Demand

Indicator: CAUTIOUS

2.1.1 Need for electricity

Indicator: POSITIVE

Presence
There is a need for electricity for both the village and the METS. The main need arises from:
-Economic considerations: Transportation costs make fuel for lighting and generators expensive
-Primary services: Freezers for storing perishable goods, Lighting for night and morning
-Luxury equipment: Televisions and stereo players are regularly used in the village

Village:
At current the village does not possess a stable energy supply. There is one central solar freezer. The village has been steadily growing because of the employment/income opportunity offered by the METS. The one central freezer is being used at its maximum capacity. Villagers indicate the need for more freezers.
The villagers possesses several small generators which run frequently to provide power to luxury equipment such as television, stereo and DVD players as well as some electrical lighting.
Transportation costs severely increase the costs of lighting through kerosene and running small generators.
There is need for wood sawing equipment for sawing planks and building better houses
METS:
The METS has several solar panels in place to power part of the lighting and freezer unit. The batteries of these units are due to be replaced and the METS is looking for alternatives as it considers the solar equipment expensive.
A generator has to be run to power the majority of the lighting for the tourist lodges.
Up to three times a day a water pump is activated to provide water for the lodges.

Indicator: POSITIVE

Quantity

Inventory of village equipment

	Number	Average Power(W)
Domestic lights*	102	40**
Refrigeration	8	165
Radio's	17	10
Transmitters	3	30
Television/	8	100
Power tools	3	1500

*At current only a small number of households actually do possess electrical lighting. The rest make use of kerosene lighting The number of domestic lights is assessed by counting all the living units and assigning one lamp to each area that will be used at night and require an independent light source
**This is the power usage of the average electrical light bulb. More on this in the technical demand section

METS equipment

	Number	Average Power(W)
Domestic lights	60	9
Refrigeration	3	165

Transmitters	1	30
Television/	1	100
Power tools	1	1500
Water pump	1	4000

Estimated number of (greater) family units: 17
Estimated number of households: 60

The distribution of the use of the equipment and running hours is presented in section technical. From this calculation the following load demand is expected:
Minimum: 2 kW
Maximum: 6 kW
Daily usage: 81kWh.

Village alone:
Minimum: 1.52
Maximum: 4.15
Total daily: 61.0583

METS alone:
Minimum: 0.53
Maximum: 4.53
Total daily: 20.0024

As to the estimated growth of demand:
At current Palumeu counts a population of approximately 230 inhabitants/ 60 households (see note).
No data on population spread.
No data on growth statistics, although it is indicated that due to the steady employment offered by the METS is causing growth in the village.

Note: Where it is the usual tradition with the Inheemsen that in the case of marriage the man moves to the village of the woman, in the case of Palumeu the opportunity for employment and earning money of selling souvenirs to tourist has caused some reverse movement.

Indicator: POSITIVE

Notable:
The demand figures for lighting are based on the number of domestic units. It is however unclear what number of inhabitants actually live in Palumeu. While having a residence in Palumeu, a lot of inhabitants are away from the village for longer periods of time when they return to their birth village (either Tepu or Aptina). Some inhabitants work in Paramaribo and only return for certain periods.

2.1.2 Willingness to pay

Indicator: CAUTIOUS

Priority
Although there is a desire/need for electricity, there is at current no real lack of electricity. Fuel is expensive but available. The current solar facilities are still functioning. The need for electricity is not an urgent one.

Indicator: CAUTIOUS

Alternatives
The current alternatives for MHP generation are solar and diesel power generation, both of which are being utilised.

Indicator: CAUTIOUS

Current Expenditure
No figures on village expenditure on fuel.

Estimated figures on lighting and refrigeration:
See CBA sheets (4.1).

Indicator: CAUTIOUS

Commitment
No data on villagers' commitment to paying for the electricity.
Notable:
The chairman of the WMM proposed that the labour put into the construction by the village would be rewarded by providing the energy towards the village for free for a still to be determined number of years.
The Kapitein proposed that since the structure was in Palumeu possession they should not have to pay for the electricity. The METS would get free use of the electricity in return for taking care of the upkeep.

Indicator: CAUTIOUS

2.1.3 Ability to pay

Indicator: CAUTIOUS

Current Income
Inheemse villages inherently run on a (near) subsistence economy. The inhabitants plant and hunt for food and traditionally acquire what they need through hunting and barter. When in need of money an Inheemse will either sell something or seek temporary employment until the need is fulfilled.

At Palumeu there are some villagers with monetary income.

Local employment	Number of villagers	Income(approximate) per month
Nurse	2	300-500 SRD
Teachers	2	500 SRD
Airport personnel	3	300-500 SRD
METS personnel*	10	250 SRD
Local store owner	1	unknown

Although the METS continuously employs 10 local people, these are not always the same 10. The local METS resort manager indicates that some villagers seem to have trouble grasping the concept of steady employment. When money is not necessary or worth working for at the moment, employees often just don't show up. This means that from the METS there is a steady outflow of 10 times 250 SRD per month towards the village, but the spread throughout the village is unknown. There is further some random income from selling souvenirs to tourists.
Since the village runs at a near subsistence economy, al the money earned is almost purely profit. Without more information on how this income is spread throughout the village no valid assessment can be made on the average income level throughout the village and thus their ability to pay.

Notable: This index only relates do the villagers employed locally. There seems to be a number of people to who officially live in Palumeu but whose are stationed elsewhere, while part of their incomes still flows back to the families in Palumeu. This portion of income could have a significant effect of the monetary statistics in Palumeu.

Indicator: CAUTIOUS

Future Income
There are no plans of putting the MHP towards productive use that will create job opportunities in the area. This means that there will be no increase in income generation for the community as a result of the project.

Indicator: NEGATIVE

Expenditures

Current expenditures: No accurate figures on current expenditure. Main expenditure seems to be on:

Expenditure	Unit price
Batteries	20 SRD/battery
Bullets	3 SRD/bullet
Fuel	7 SRD/litre

The MHP should cause a large reduction in current expenditures on fuel, both for the Village and the METS.
Without exact usage figures it is not possible to give a valid assessment on the amount of many spend on the diverse expenditures.

There is no prognosis for the amount of money it will take to keep the MHP operational.

From general: MHP stations are listed as being one of the least expensive types of energy providers when it comes to the operational costs. In light of the costliness of fuel and fuel transportation to the Palumeu site, the tentative assessment is that the savings on fuel expenditure for the METS should at least be enough to provide the operational costs.

Indicator: CAUTIOUS

Notable on this part:
The project team performed only a cursory inquiry into the community electricity demand. There is only one inventory inventorying what electrical equipment was present. No information on the frequency of usage of this equipment was gathered. No research was performed into the willingness or ability of the community to invest in the MHP once it was operational.

2.2 Technological Capability

Indicator: NEGATIVE

2.2.1 Availability

Indicator: CAUTIOUS

Education Levels
No data on the average educational level.

Indicator: CAUTIOUS

Educational facilities
The only educational facility in close proximity is the Kauffman elementary school. There are no nearby educational facilities which offer training in mechanical or administrative areas.

Indicator: NEGATIVE

Mechanical skills
No data on the available mechanical skill
From General: In most villages there will be local inhabitants with basic mechanical skill needed for upkeep of outboard motors and power tools. With additional training, these people could possibly be trained for the upkeep of the MHP station.

Indicator: CAUTIOUS

Administrative skills
No data on the available administrative skills
From General: Inheemsen expert note that extra attention will have to be paid to train the Inheemsen in working with abstract concepts such as write off value.

Indicator: CAUTIOUS

2.2.2 Enhancement

Indicator: NEGATIVE

Need
If the villagers are to be able to run the MHP station, further training will be required.
Indicator: CAUTIOUS

Availability
There were no provisions made to include further training into the community. This means that execution of the project will not bring about a significant increase in local technological capability.

Indicator: NEGATIVE

2.3 Community involvement

Indicator: NEGATIVE

Phase	Character of Involvement	Level
Conception:	Passive	Informed of plans, cooperation asked
Design process:	None	-
Construction:	Active	Labour duties, Monitoring duties
Operation	unknown	Unknown.

2.3.1 Character

Indicator: NEGATIVE

Character of involvement
Conception: The conception of the MHP station was made by van der Werke, who then proceeded enlist the help of the chairman of the WMM and the University. Once a concept plan was conceived, a kroetoe was organised and the village community was informed of the plans and shown a scale model of what the MHP would look like. The cooperation of the villagers in construction in return for free energy was asked. The villagers did not have an active involvement in the conception process
Design process: The villagers did not have any involvement in the design process
Construction: During the construction phase the villagers were actively involved as labourers in the project. Two were trained to act as local foremen and to perform regular water level recordings for the University project team.
Operation: There are no clear plans developed for the operational phase of the project.

From General: Best practice advice states that the local community should be actively involved in all project phases. This to create the local ownership feeling and to ensure design and construction do not conflict with local situation and wishes.

Indicator: NEGATIVE

Level of involvement
During the construction phase the villagers were actively involved as labourers. There was no local representative involved on the management level.

Indicator: NEGATIVE

2.3.2 Extent

Indicator: NEGATIVE

Percentage of community involved as user
It is the purpose of the project to provide electricity to everyone in the village, so the involvement as user should be 100%.

Indicator: POSITIVE

Percentage of community involved as supplier/employee
There are no plans on what number of local residents (if any) will be involved on a local level. At current, only the two foremen are being employed to perform the monitoring of the construction site.

Indicator: NEGATIVE

2.4 Livelihood

Indicator: POSITIVE

2.4.1 Poverty

Indicator: CAUTIOUS

Local poverty
There is no data on the average income level for the community of Palumeu. Most of the village functions on the basis of subsistence economy. Due to the presence of wildlife, fish and harvest from local plantation, there is at least no shortage of food for the village.

Indicator: CAUTIOUS

Alleviation
No plans have been drawn up yet that indicate the MHP project will alleviate poverty by means of employment opportunity or income generation. The MHP is not expected to have any negative effects on the poverty situation in the village.

Indicator: CAUTIOUS

2.4.2 Health care

Indicator: POSITIVE

Proximity
There is a clinic of the MZS situated in the village, staffed by to local nurses.

Indicator: POSITIVE

Health benefits
Palumeu is malaria territory. One average there is always one malaria patient in the area. Provision of electricity could be used to power an electronic microscope at the local clinic which would increase the local capability of identifying the malaria disease early on.

MHP can power water pump which would improve hygiene.

Indicator: POSITIVE

2.4.3 Educational facilities

Indicator: POSITIVE

Presence
There is one elementary school situated in the village, staffed by two teachers and one headmaster. There are no educational facilities higher then elementary level situated anywhere in Sipaliwini.

Indicator: POSITIVE

Benefits towards education
One local teacher indicated that access to electricity might improve the willingness of teachers to stay stationed in Palumeu. This would decrease the chances of teacher shortage at the local school, thereby improving on the local education.

Indicator: POSITIVE

2.4.4 Gender aspects

Indicator: POSITIVE

Occurrence of gender bias
No data collected
From general: Traditionally there is a strict division of roles for men and women. Young man hunt and perform services such as woodcutting. Boats men are always men. The gardens are tended to by old men and young women. The women take care of household chores such as cooking and cleaning.
From observation it would seem that the village of Palumeu adheres to these roles.

Indicator: CAUTIOUS

Current Employment division

Gender	Number of villagers with steady monetary income*
Men	8
Women	10

* This is only the number of villagers inventoried during the initial field excursion

From the number of villagers inventoried, it would seem that there is a pretty even division of income between both genders. However, this is not based on a proper survey.

Indicator: CAUTIOUS

MHP Equal opportunity possibilities
By providing lighting at night the MHP station will provide the opportunity to practice craftsmanship both daily and nightly. This will offer the villagers (both men and women) the opportunity to increase their production of tourist souvenirs, thereby increasing their chances of income. (NOTE: See economic). This advantage will way heavier towards the women, as they are structurally occupied during the day, while the men's daily occupation varies according to the need for hunting.

There are no plans yet for productive output of the MHP, so it is not possible to assess how these might affect the gender role division in Palumeu.

Indicator: POSITIVE

2.4.5 Housing

Indicator: POSITIVE

State of housing
The housing in Palumeu is slowly changing from nomadic to permanent. A lot of the houses are built in the traditional style: half open and initially build to be abandoned when the local planting-gardens were exhausted. Most of these houses have been gradually upgraded to provide permanent housing. New, solid houses are currently being built by those who can afford it.

Indicator: POSITIVE

<u>Benefits of MHP towards housing</u>
Most roofs and in some cases parts of the huts are made out of palm leaves. By switching from kerosene fuelled lamps to electricity the risk of fire will be reduced.
One of the possible applications for the MHP offered by the villagers would be a small saw mill which would greatly aid in the production of planks for building better houses.

Indicator: POSITIVE

2.5 Orientation towards sustainable development

Indicator: NEGATIVE

<u>Orientation towards social development</u>
There are no specific plans drawn up to utilize the generated electricity to ignite further social development.

Indicator: NEGATIVE

<u>Orientation towards economic development</u>
There are no specific plans drawn up to utilize the generated electricity to ignite further economic development. One might however consider the cost reduction opportunities for the METS as a way of ensuring that the METS stays in the village, thereby securing a source of income.

Indicator: CAUTIOUS

<u>Orientation towards environmental sustainability</u>
One of the grounds for acquiring a grant from the UNDP/SGP was that the project would reduce the use of fossil fuel and therefore the emittence of CO2. The project can therefore be assumed as orientated towards environmental sustainability.

Indicator: POSITIVE

3. Technical

In the technical category the major impact comes from the factor "Potential". In light of the available data (or lack thereof) it is extremely unlikely that the project will be able to deliver the promised power output to the village. Even if this is possible, the demand loads calculated under the demand factor indicate that the power output would not be able to meet all of the needs presented in the social category. The MHP would not be able to sustain even a small growth scenario.
The issues surrounding the transmission line and the lack of preparation for operation and maintenance also have a negative influence on the outcome of the assessment.

On general, the factors in the technical category indicate a negative outcome on the chance for a sustainable MHP

Indicator: NEGATIVE

3.1 Application

Indicator: POSITIVE

3.1.1 Designated end use

Indicator: CAUTIOUS

<u>Usage type of turbine power</u>

The sole purpose of the MHP will be to provide electrical energy. No provisions have to be made in the design to allow for a switch between electrical or mechanical output.

Indicator: POSITIVE

Load type
At current the intended load type is fairly continuous. Load will remain steady to power refrigeration (and radio equipment) during the day, and increase to another level during the night for lighting. There will be the occasional peak for a water pump, but this will happen at scheduled times.

Indicator: POSITIVE

Running hours
The majority of the load will happen at night time. This means that a lot of capacity will be lost during the day if the project is sized towards this load.

Indicator: NEGATIVE

3.1.2 MHP design

Indicator: POSITIVE
MHP design type
There are no structures (irrigation structures, previous dams) of any kind in the area which have to be taken into consideration with the MHP design.
The size of the project means that there will not be extensive construction on waterways, only a simple dam or weir design with a turbine at the base.

Indicator: POSITIVE

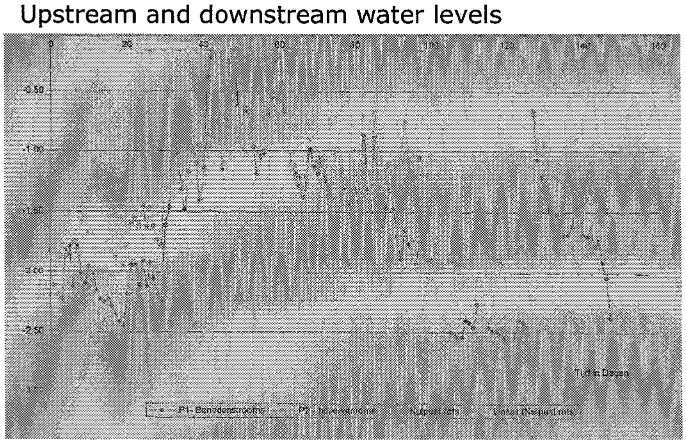
3.2 Potential

3.2.1 Water potential

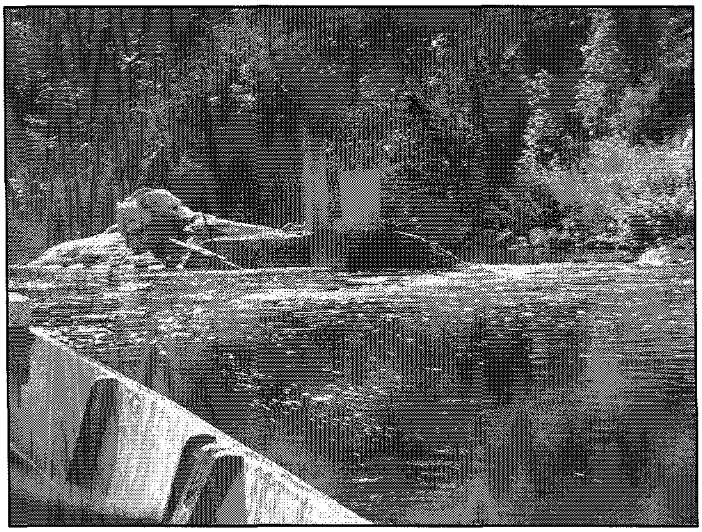
Indicator: NEGATIVE

Head
There is no exact measurement of the available head at the site at Panato creek.
Project files cite a head difference of 2-2.5 meters in the design plans. From water level measurements conducted at the site the water level naturally varies between 1 meter in the dry season and 0 m in the rain season. The goal of the UC is to construct a dam around a rock located in the rapids. The head difference between the top of the rock and the downstream flow varies between 2.5 and 0 meters.

Upstream and downstream water levels



Site at Panato with partially constructed dam



The Panato creek mouths into the (much larger) Tapanahony river. From general (Tapasoto measurements) The level of this river will rise 4 meters during the rain season. The flow at the mound of the Panato creek is inverted and the level of the Panato creek also rises, with the level of the downstream section rising further then that of the upstream section.
A local foreman indicates that in the rain season, the upstream and downstream sections of the Panato creek are level and the rapid is no longer visible. The maximum head difference only occurs during the dry season when there is almost no water in the creek.

The head difference is clearly severely dependent on the flow and can be expected to equal zero in the rain season, meaning that no power generation is possible.

Indicator: NEGATIVE

Flow
There is no sufficient information of the available flow at the site at Panato creek.
Project files cite three measurements. The first two were calculated by conducting a cross sectional velocity measurement. There are no details given on how the last figure (4 m3/s) was obtained.

Measurement date	Q(m3/s)
14.09.2002	0.488
14.02.2003	0.414
05.09.2003	4

The lack of information on the conduction of the last measurement, the extreme difference between this one and the first two and the fact that this measurement was conducted during the same seasonal period as the first casts some doubt on the validity of the number.
With only these three measurements it is not possible to construct a FDC and assign a 90% exceedence flow.

The flow of less then 0.5 m3/s combined with the low head indicates a very low potential
From general: There are no general figures available for the flow in that area. The nearest hydrological measurements are from the Tapasoto station located further downstream along the

Tapanahony river, but the numbers for that station are not usable for calculating flow in the Panato.
During the time period of this research no new flow measurements were made.

From general: The minimal design flow for most turbines is more then 10 m3/s. This means that the measurements fall well bellow any design specification.

Table 3.1 Minimum technical flow of turbines

Turbine type	Q_{min}
Francis spiral	30
Francis open flume	30
Semi Kaplan	15
Kaplan	15
Cross flow	15
Pelton	10
Turgo	10
Propeller	65

Indicator: NEGATIVE

Size of residual flow
The Panato creek is not used by the local people for travel or any other arrangement. There are no prohibitions that make a certain size residual flow necessary, so no loss of flow due to the residual flow.

Indicator: POSITIVE

3.2.2 Site evaluation

Indicator: NEGATIVE

Soil composition
No data on the soil composition available
The dam is supposed to be constructed on banks of the river, the river bed and reinforced by the rock situated in the river. No data was obtained on the stability of this surface other than through visual inspection.

From Poketi: During the rainfall there is very quick runoff and virtually no storage. This occurs despite the dense foliage. This would indicate a fairly thin soil layer upon an impenetrable layer, mostly rock. The distance to Poketi however is too great to extrapolate this to the Panato creek.

Indicator: CAUTIOUS

Structural layout
A cross sectional of the MHP site together and a photograph of the site are combined to form a structural layout of the area. Since there is no information on soil composition included in this map this does not deliver any assurances as to the stability of the proposed construction.

Indicator: CAUTIOUS

Distance to potential site
There are no exact measurements done on the distance between Palumeu and the proposed site at Panato. On report mentions the distance as being approximately 2 km, a later report estimates 5 km. Measured from an aerial map the direct distance from the site to the Palumeu village is 3.5 km.
The preferred distance is less than 2 km because the increased voltage drop will create the necessity for high voltage transmission lines.

Indicator: NEGATIVE

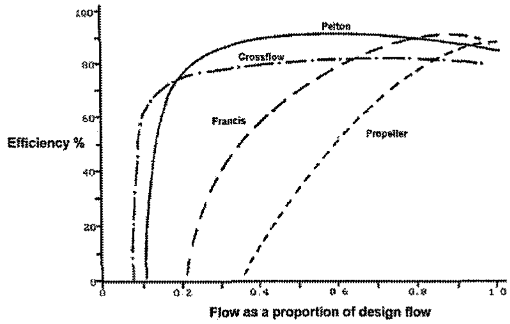
3.2.3 Power estimate

Indicator: NEGATIVE

<u>Efficiency</u>
Structure-efficiency
No data on the losses within the structure. As there are no waterways planned, the water will pass directly through the turbine, no significant losses have to be expected here.

Electrical Equipment efficiency
No data on losses within the equipment.

Part-flow efficiency
No data on the actual part flow efficiency of the turbine.
The proposed design is for a propeller turbine. This turbine is locally constructed and at the moment of this research was still being tested and experiencing difficulties.



From general: This type of turbine has the worst part flow efficiency curve of all turbines. If the flow falls to more than 40% of the designed rate, the efficiency drops to zero. Combined with the extreme fluctuation in flow of the Panato the efficiency of the turbine depends greatly on what flow the turbine is designed for.

For efficiency the standard value for first estimation is 50%.

Indicator: CAUTIOUS

<u>Net Output</u>

$P = \eta \rho g H Q$

Q: $0<Q<0.5$ m3
H: $0<H<2$ m
η: 50%
=> P: $0<P<$ 5kW
The estimated output would be 5 KW in optimum conditions, 0 when either the head difference equals zero (height of rain season) or the flow approaches zero (dry season).

Indicator: NEGATIVE

3.3 Power demand

There have been no plans drawn up on how exactly the power will be used within the village In order to make an estimate of the expected load, several load tables are constructed.
Lacking true figures, an assessment is made based on the 5 kW proposed by the university project team.

Indicator: NEGATIVE

3.3.1 Volume

Indicator: CAUTIOUS

Appendix D: Output of the model application to the Palumeu project

Scenario	Minimum(kW)	Peak(kW)	Usage(kWh per day)	Average(kw)
9 W	2.1	6.5	81.1	3.4
20 W	2.1	6.5	87.6	3.6
40 W	2.1	8.1	99.2	4.1

<u>Peak power required</u>
The peak power required based on the currently present equipment and running hours in the village ranges between the 6.5 kW and the 8.1 kW depending on what kind of lighting scheme the village chooses. This is more than the estimated 5 kW provided by the MHP.

Indicator: NEGATIVE

<u>Average power required</u>
The average power required lies within a range of 3.4 kW to 4.1 kW. This means that on average, the MHP should be able to meet the power requirements if the load can be adjusted in such a way that the peak power load does not exceed the 5 kW. The plant factor ranges from 68% to 82%. This means that the plant is not oversized for the demand at hand.

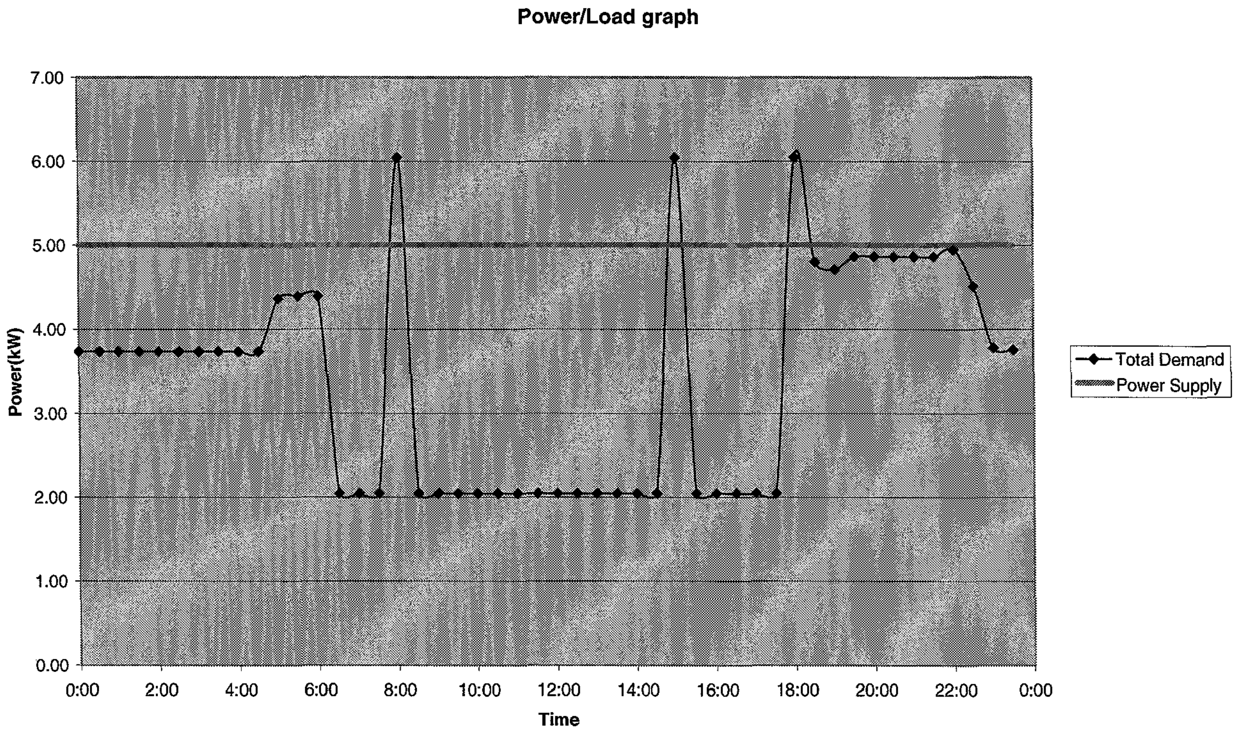
Indicator: POSITIVE

<u>Minimum power required</u>
The minimum power required for powering the refrigeration units is 2.1 kW. The 5 kW should be enough to provide the minimum requirements.

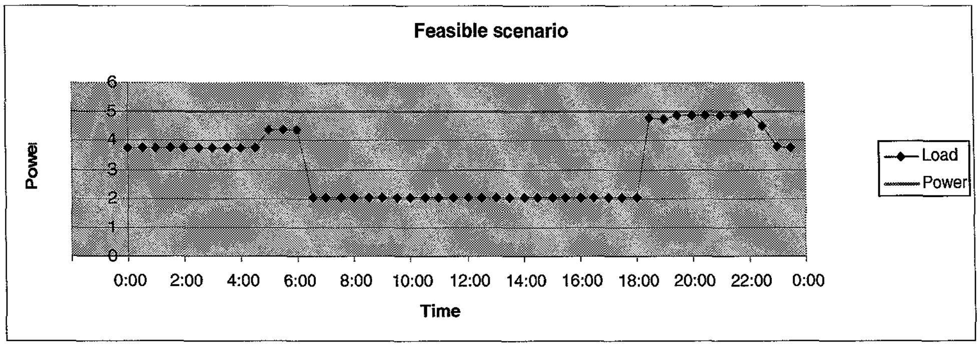
Indicator: POSITIVE

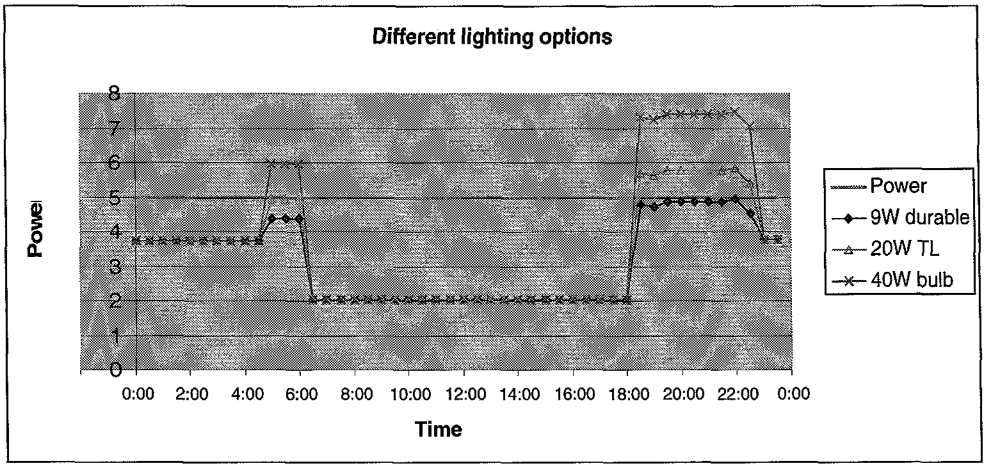
Device	Number	Average power(W)	Running hours	Average load	Total(kW)
Domestic lights:	102	9	5:00 to 6:30	50%	0.46
	102	9	18:30 to 23:00	80%	0.73
					0.00
Refrigeration units	8	165	24 hours	100%	1.32
					0.00
Radio units(receive)	17	10	5:00 to 22:30	100%	0.17
Radio units(transmit)	3	30	2 unknown, 1 5:30 to 22:30	33%	0.03
Television/DVD	8	150	19:30 to 22:30	13%	0.15
					0.00
Water pumps	0	4000	unknown		0.00
					0.00
Cooking plates	0	0	unknown		0.00
					0.00
Street lighting	18	100	18:30 to 06:30	100%	1.80

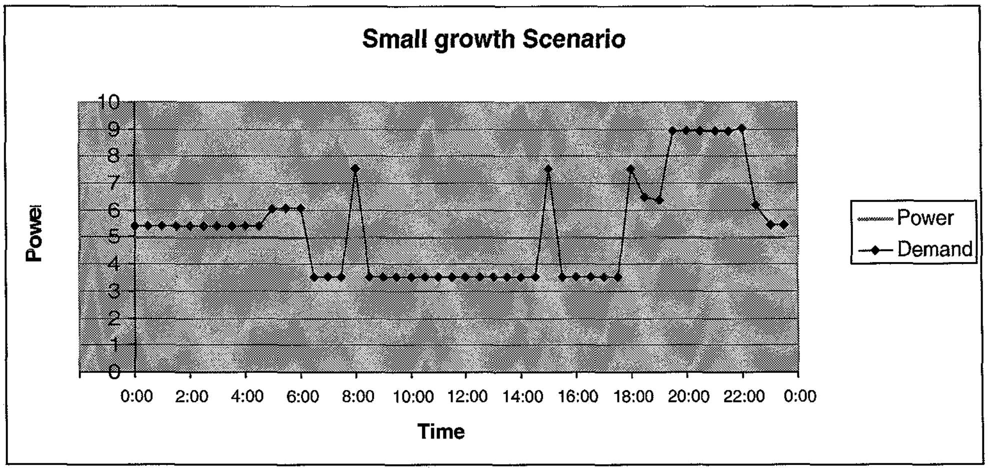
Device	Number	Average power(W)	Running hours	Average load	Total(kW)
Tourist lodgings indoor lights	32	9	18:30 to 19:00, 22:00 to 22:30	30%	0.09
Central meeting hut lights	4	10	18:30 to 0:00	50%	0.02
Head building lights	14	9	18:30 to 23:00	20%	0.03
Outdoor lighting	10	9	18:30 to 06:00	100%	0.09
					0.00
Refrigeration units	3	165	24 hours	100%	0.50
					0.00
Radio units(receive)					0.00
Radio units(transmit)	1	30	24 hours?	100%	0.03
					0.00
Television/DVD	1	150	random	0%	0.00
					0.00
Water pumps	1	4000	Trice a day (08:00, 15:00 and 18:00) on Monday and Friday	100%	4.00
					0.00
Cooking plates	0	0	unknown		0.00



This is one feasible scenario.	Same scenario	Scenario2:
	Demonstration of difference between:	
Notable restrictions:	9W durable lights	1 tv/family circle
Max 18*100W streetlights	20 W TL lights	1 refrigerator/family circle
9W lamp option	40W bulbs	20 streetlamps
No water pump for METS		1 water pump (METS)
No power tools	with METS using 9W option	no power tools
No growth/change of social behaviour		9 W option
Graph 1: Feasible scenario		Graph 2: Expected scenario


Feasible scenario
Power
6
5
4
3
2
1
0
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time
Load
Power


Different lighting options
Power
8
7
6
5
4
3
2
1
0
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time
Power
9W durable
20W TL
40W bulb


Small growth Scenario
Power
10
9
8
7
6
5
4
3
2
1
0
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time
Power
Demand

Scenario	Minimum	Peak	Usage	Average
9 W	2	5	75	3.1
20 W	2	5.8	80	3.3
40 W	2	7.5	89	3.7

3.3.2 Variation

Indicator: NEGATIVE

Equipment running hours
Refrigeration units will be connected to the power net around the clock. Lighting will be switched on in the evenings and in the mornings, and the METS water pump runs trice a day. These will form the major loads. The load is not evenly spread over the day, which means that power is being wasted during the low-load hours.

Indicator: NEGATIVE

3.3.3 Growth

Indicator: NEGATIVE

Population growth
No data has been acquired on the average population growth in Palumeu. [see social]. No assessment can be made based on this indicator.

Indicator: Blank

Increment of energy-applications
At the moment there are 8 refrigeration units present within the village. One is the communal refrigeration that currently runs on solar power; the other seven have already been bought based on the expectation of electricity from the MHP. It is expected that each family unit will acquire at least one refrigerator and one television/video (or DVD) set. If this expectation is put into the load table, [Small growth scenario graph] the average power required rises to 5.3 kW, meaning that the MHP plant is undersized. This is only a small growth scenario, not accounting for any washing machines or power tools that are very likely to be used once the electricity is available.

From general: In the village of Langamankondre the presence of around the clock electricity caused a rapid increase in luxury electrical equipment, even though the electricity used had to be paid for. This trend indicates that it would be wise to make an inventory of possible electrical luxury equipment and anticipate for this in the demand estimation.

Indicator: NEGATIVE

3.4 Civil Works

Indicator: CAUTIOUS

3.4.1 Storage and Intake

Indicator: CAUTIOUS

Size
The MHP design requires only the build of a small dam. The Panato creek at that point is approximately 11 meters wide. The turbine will be built in at the base of this dam. This means that the amount of material and construction needed to build the storage and intake is minimal.

Indicator: POSITIVE

Availability of materials

The dam is being constructed using rocks, gravel and sand locally collected by the community. Wood is extracted from the local forest. Cement and steel bars for concrete reinforcement are not locally available have to be flown in from Paramaribo.
At one point a fire at the sight wiped out one of the storage huts and a large but unknown quantity of cement was lost. At the same there was a shortage of cement at one point caused by an unusual stormy season in the Caribbean. Because of this there is a shortage of cement for the building of the dam.

Indicator: NEGATIVE

3.4.2 Waterways

Indicator: POSITIVE

Size
The design for the MHP does not call for the construction of any channels or for the use of a penstock. This will decrease the amount of construction and maintenance needed for the MHP plant.

Indicator: POSITIVE

Availability of materials
As there is no need for the construction of any waterways, this indicator is not valid.

Indicator: Blank

3.5 Hydroelectric Equipment

Indicator: CAUTIOUS

3.5.1 Turbine

Indicator: CAUTIOUS

Type
Two types of turbine are best suited for low head sites: Crossflow (Banki) and the Propeller type turbine. Because of the low power output at the Panato creek the specific speed of the turbine will have to be relatively high: 500-1500 depending on the speed increase do to gearing mechanisms. This means that impulse turbines such as the crossflow are not suitable for this site.
Best choice here would be a propeller type turbine, either a standard type or a Kaplan.

The turbine type chosen for this project is a propeller type turbine constructed by a local mechanical engineering company.

Indicator: POSITIVE

Efficiency
Standard propeller type: This type of turbine has the worst part flow efficiency curve of all turbines. If the flow falls to more than 40% of the designed rate, the efficiency drops to zero. This means that the propeller type is best used if the flow is reasonably constant and close to the design flow.
According to the local population and rainfall figures from the Tapanahony this is not likely [see potential].
Kaplan: The pitch of the propeller blades of the Kaplan turbine can be adjusted to optimize its functioning to the actual flow. This allows the Kaplan to have a very good part flow efficiency profile: It will function at maximum efficiency till 80% below design flow.
From general: The variable pitch design involves complex engineering making the Kaplan disproportionally expensive for small scale projects. It is only used in large scale plants.
The original design mentioned in the case files called for a Kaplan turbine, but this was abandoned once the designers became familiar with the extreme costs.

The turbine being used for the Palumeu site is the propeller type.

Note: In this situation the only reasonable choice left is for a standard propeller turbine. However, these kinds of turbines only function well at their design flow rate and do not allow for variation. This means that the turbine will have to be designed for the most common flow. More knowledge on the flow profile of the Panato creek is needed for this.

Indicator: NEGATIVE

<u>Technology level</u>
The Propeller type turbine is a reaction type which is generally harder to construct than impulse type turbines because they require the construction of carefully profiled casing (cavitation) and profiled blades.

According to the director of the company constructing the Palumeu turbine the construction of the propeller type should fall well within the mechanical skill available. The company does not have any previous experience actually constructing a propeller turbine and is still working on a trial and error basis.

Indicator: CAUTIOUS

<u>Local availability</u>
There are no local turbine manufacturers of any sort within Suriname.
There are mechanical engineering companies located in Paramaribo with the potential to construct turbines. Whether or not this potential will be deployed depends on the market for these turbines.

Indicator: CAUTIOUS

<u>Level of maintenance</u>
Reaction type turbines have less tolerance for sand and other particles in the water then impulse turbines and because of the pressure casing the working parts are less easy to access.
The Panato has a relatively high content of debris from the tropical rainforest and the riverbeds upstream of the site. Special care will have to be taken to filter this debris out. This will mean regular weekly maintenance on the trash racks. In the dry season the turbine tube will have to be cleaned of sedimentation due to the low –or absence of- flow.
REMACON estimates that bearings and pressure seals will have to be checked and possibly replaced once per 1-2 years, depending on operating intensity. Bearings will have to be lubricated once in 4 weeks. [Link to Personnel]

The level of maintenance on the turbine is expected to be reasonably low throughout the year with an annual peak when the bearings and possibly seals have to be replaced.

Indicator: POSITIVE

<u>Average lifetime</u>
REMACON estimates the lifetime of the propeller to lie anywhere between 5 and 10 years, having no previous experience with micro hydrology. On average turbines or estimate to last more then 15 years. As REMACON indicates, their lack of experience in this area means that there is no certainty to there estimation. [Link to CBA]

Indicator: CAUTIOUS

3.5.2 Generator

Indicator: POSITIVE

<u>Type</u>
The best type of generator for a stand alone grid would be a synchronous type generator which provides its own excitation current.
The current generator being tested by the project team is a synchronous generator.

Indicator: POSITIVE

<u>Size</u>

Standard generators are not suitable for micro hydro application because the alternations in the power factor could cause over current in the generator windings. A specially protected generator have to be used or, as a compromise, a generator that is approximately 50% oversized and therefore able to handle the load.
For the expected 5 kW load at Palumeu a 7.5 kW standard generator would be required.

The donated generator is a 10 kW generator.

Indicator: POSITIVE

<u>Technology level</u>
The generator is of a type commonly used in Suriname for generating electricity through diesel generation. Local technicians are well known with the technology. [Link to Personnel]

Indicator: POSITIVE

<u>Local availability</u>
There are several stores within Paramaribo selling several types of generators. Due to the problems with electricity generation there is a reasonable market for generators.

Indicator: POSITIVE

<u>Level of maintenance</u>
As standard, the generator bearings would have to be checked for noise and vibrations weekly. Brushes would have to be checked monthly and major maintenance would have to occur annually. The drive belt between the generator and the turbine should also be replaced every 2-3 months. Experience with local generators learns that in the tropical jungle electrical equipment needs a tighter maintenance schedule do due the combination of relatively high moisture density and ambient temperature. The level of maintenance on the generator is expected to be medium to high throughout the year with an annual peak for major maintenance. [link to CBA]

Indicator: CAUTIOUS

<u>Average lifetime</u>
As the donated generator is second hand and no data on its previous use or its age is known, no estimation can be given on its life time. This can however be estimated as less then the standard 5-8 years. [Link to CBA]

Indicator: CAUTIOUS

3.5.3 Control Equipment

Indicator: CAUTIOUS

<u>Types</u>
At current no plans have been drawn up for any kind of speed or load control for the MHP station. However, the project team has indicated a preference to make use of electronic load control (ELC). These are both cheaper and easier to maintain than mechanical governors.

Indicator: CAUTIOUS

<u>Technology level</u>
ELC devices have become standard practice in MHP projects world wide. The design is of low level technology.

Indicator: POSITIVE

<u>Local availability</u>
No data on local availability of electronic load control devices for MHP application.
In light of the level of technology, it should be possible to design and fabricate these locally.

Indicator: CAUTIOUS

Level of maintenance
The ELC requires minimal maintenance; dusting and the occasional check for corrosion. In the jungle extra care will have to be taken to make sure bugs do net enter to the ventilation holes.

Indicator: POSITIVE

Average lifetime
The ELC is basically a small collection of electronic components which will have to be replaced at different intervals. As such, the system as a whole has an indefinite lifetime.

Indicator: POSITIVE

3.6 Transport and distribution of energy

Indicator: NEGATIVE

3.6.1 Transmission

Indicator: NEGATIVE

Distance
No exact measurement has been made on the transmission distance. Straight distance from aerial map: 3.5 km. Estimated actual distance: approximately 4 km.
Distance exceeds recommended 2km.

From calculator:

Conductor size(AWG)	Power loss(4 km, 240V/5kVA
Less then 4	Complete
4	98%
3	78%
2	62%
1	54%
1/0	49%
2/0	39%
3/0	31%

Indicator: NEGATIVE

Transmission type
At current the project is budgeted for a single phase, low voltage transmission line which will not be adequate to cross the distance. However, the project team is looking into the possibility of a 3 phase high voltage transmission line.

Indicator: CAUTIOUS

Construction type
The choice has been made for an above ground transmission line, requiring less construction than an underground line.
Still to be investigated: crossing of airfield near the village.

Indicator: CAUTIOUS

Material requirement
Materials for high voltage transmission line are not available locally and will have to be flown in. Because of the weight of the materials this will place an extra strain on the transport budget.

Indicator: NEGATIVE

3.6.2 Distribution

Indicator: CAUTIOUS

Number of connections
The number of connection units will be approximately 64 (including the METS, counting as one) if the whole of the village is to be connected. No allowances have been made for possible new connections due to growth of the village.

Since there are no growth numbers on Palumeu it is uncertain how many new connections can be expected annually. In light of the settling trend round Palumeu it is probable that there will be some growth in the village, requiring new connections.

Note:
-As Palumeu is in a transitional phase housing-wise, allowances have to be made in the distribution design to accommodate the move of villagers to improved housing.

Indicator: CAUTIOUS

Type of distribution limitation
No plans have been made for distribution. It is unclear whether distribution will be metered or whether a fixed limit will be applied. In most small electrification scheme metering is considered to be too expensive.
From general: In most of the Marron villages that have electricity through government provided diesel, houses have already been provided with metering units. This would make metering feasible. In Palumeu only the school and airports buildings have meters.

Best practice choice would be to apply fixed limits to distribution.

Note: From general: Experience with solar equipment learns that villagers do not always adhere to limitations set. It is likely that ways will be sought to circumvent fixed limits when the need arises. Special care should be taken to ensure that this does not happen: Either to organisational means [plant management] or technical means such as an auto power limiter which is stored in an inaccessible or public place.

Indicator: CAUTIOUS

Safety measurements
Housing in Palumeu can range from two storey buildings to houses with a head-high roof. Distribution will be done by above ground wire. Because of the low height of the houses, extra security measures will have to be taken to make sure the wiring will not pose a danger to the villagers.

Indicator: CAUTIOUS

3.7 Operational procedures

Indicator: NEGATIVE

Presence
No plans have been drawn op for the operational period. This means that there are no operational procedures in place.

Indicator: NEGATIVE

Contents
No operational procedures have been drawn up. No assessment can be given on the completeness of the procedures.

From general: Each operating schedule should contain detailed descriptions for starting up and shutting down the system. As the current project team is still experimenting with the workings of the system, it is highly unlikely that adequate procedures can be drawn up before they have done this procedure on site several times themselves. Such testing has not been scheduled, meaning that it is probable that what procedures are drawn up will be inadequate.
Regular maintenance of the transmission line will require extra attention. According to the foremen the local forest grows fast. It took two weeks for the two foremen two clear a walking path from the Panato back to the village.

Indicator: CAUTIOUS

Material requirements
No operational procedures have been drawn up.
From general: Most materials and equipment required for standard operation of the MHP system will already be available at Palumeu for the maintenance of METS electrical generators, water pump and power tools. Since the METS has weekly flights out to the Palumeu location, provision of necessary material should pose no problem.

Indicator: POSITIVE

3.8 Major maintenance procedures

Presence
No plans have been drawn op for the operational period. This means that there are no procedures in place for major maintenance and replacement.

Indicator: NEGATIVE

Frequency
Major maintenance can be expected to include: maintenance on the turbine (within 5-10 years, Remacon), replacement of the generator (unknown timeframe) and maintenance on the dam (unknown time frame).
No maintenance procedures have been drawn up. No assessment can be given on the adequateness of scheduled maintenance frequency.

Indicator: Blank

Material Requirements
Materials for major maintenance procedures will have to be flown in from Paramaribo. Acquiring material there should not pose any problems. The only scarce material at the time of construction is the cement for the building (and future repair) of the dam, but the cement shortage is not expected to be a structural problem in the future.

Indicator: POSITIVE

3.9 Personnel requirements

Indicator: NEGATIVE

3.9.1 Engineers

Indicator: NEGATIVE

Availability
Sound technical design of the MHP requires presence of civil, electro and mechanical engineers. Within these engineering fields are all present within the Faculty of Technological Sciences of the ADEK.

Indicator: POSITIVE

<u>Presence</u>
In the project team for the Palumeu MHP only the civil engineering field was covered.
Indicator: NEGATIVE

3.9.2 Operators

Indicator: CAUTIOUS

<u>Availability</u>
The MHP will require operators for daily operational procedures.
The technology level required for daily tasks is reasonably low and comparable to the technology level required for upkeep of local generators, power tools and outboard motors. It should be possible to recruit personnel from the local population.

Indicator: POSITIVE

<u>Presence</u>
No provisions have been made yet for the operational period.
The two foremen have indicated interest in fulfilling a position as operator. Due to the length of the project however at least one of the foremen is currently considering taking up gold mining to ensure income instead of waiting for a unsure position as plant operator.

Indicator: CAUTIOUS

3.9.3 Maintenance personnel

Indicator: CAUTIOUS

<u>Availability</u>
The electronic or mechanical skill for major maintenance or repairs is not locally available. Personnel will have to be flown in from Paramaribo. Although this should not be a problem due to the weekly METS flights, Remacon indicates that tariffs for flying out to Palumeu would be substantially higher then in Paramaribo.

Indicator: CAUTIOUS

3.10 Material requirements

3.10.1 Quality

<u>Quality requirements</u>
No information obtained on the quality of the materials used.

Indicator: blank

3.10.2 Availability

<u>Local availability</u>
All materials for construction and maintenance of the MHP station are available within Paramaribo. Transportation costs to Palumeu might pose an economic restriction, but technically there are no provisions against the material being available at the Palumeu site.

Indicator: CAUTIOUS

4. Economic

In the economic category, the negative outcome of the Cost Benefit analysis has a major impact on the outcome of the assessment. The amount of cash inflow needed to make the project profitable or at least reach a break even point in cash flow after ten years, are of such magnitude that the project can be deemed unfeasible from an economic point of view. The fact that there is no income

generating scheme is a shortcoming that is greatly stressed in literature as one of the major causes for failure with such projects.
Furthermore, the fact that the Palumeu project is at present the only MHP project being conducted means that the project can not profit from the benefits that the presence of a large MHP orientated industry/market could bring.

The section on loan financing is left blank. No data for this factor was acquired because of the time constraints of the field research.

On general, the factors in the economic category indicate a negative outcome on the chance for a sustainable MHP.

Indicator: NEGATIVE

4.1 Costs and benefits

Indicator: NEGATIVE

Project Budget	
Category	Expenditure (US$)
Equipment	25,450
Material	13,000
Workshop	10,000
Training/Capacity Building	6,000
Education\Awareness	3,500
Labour	15,500
Transport	16,000
Contracts	4,000
Administration	1,500
Monitoring/Evaluation	3,000
Sharing Experiencing/Networking	2,000
Total	99,950

Additional budget transmission line:

Description	Amount
16000 m aluminium wire AWG 3/0 @ US 2.05	U$35,800.00
2 sets lighting arresters 6 — 10 kV	U$ 520.00
2 sets 3-phase cut outs complete	U$ 1,230.00
2 pieces. Transformers 10 kVA 3 x 220 Volt + null 3 x3100 Volt + null Frequency: 60 Hz.	U$ 15,060.00
2 set safety switches 4 x 40 Amp. To be places at the beginning and the end of the net.	U$ 1130.00
Earth installations for the lighting arresters, cut out, with the earth wires and switches.	U$ 1710.00
70 pieces wooden poles 7 x 7 x 11 m. long	U$ 7,700.00
15 pieces threat anchors with isolates.	U$ 3,100.00
Transportation costs of materials	U$ 12,000.00
Transportation of technicians and experts to the site and visa versa	U$ 6,600.00

Connecting cable, cable work, fuse boxes (about 50), fuse wires and safety wires, economy lamp	U$ 4,500.00
Additional transportation of cement for the final construction of the dam (one charter U$2000 + 40 packs cement (U$300)	U$ 2,300.00
Subtotal	U$ 91,650.00
Unforeseen	U$ 2,000.00
Total	U$ 93,650.00

CBA Sheets

Percentages
i = nominal interest rate = 18 % p = inflation rate = 7 %
r = real interest rate = (1+i / 1+p) - 1 = (1,18 / 1,07) - 1 = 0,103 = 10,3 %

Disconto factor = $1 / (1+r)^n = 1 / 1{,}103^n$ n = number of years from year 0
Surinaamse Bank nv
Tariffs per 19/12/05
consumer loan 18%
Inflation charges 6 @ 7%
Savings account 3%

Current estimated expenditure for lighting and refrigeration:			
Village			
Annual kerosene expenditure for lights	7,818	US$	
Reinvestment for Solar batteries	405	US$	Every 5 years
Reinvestment for Solar panels and controls	720	US$	Every 10 years
Mets			
Annual fuel expenditure lighting and refrigeration	1,591	U$	
Reinvestment for Solar batteries	810	U$	
Reinvestment for Solar panels and controls	1,340	U$	
Annual Mets plus Village	9,410	U$	
Estimated annual expenditures MHP station			
Salaries (2 operators/administrators)	2,400	U$	
Annual maintenance& equipment costs	2,250	U$	
Total annual operating costs	4,650	U$	
Major overhaul of hydroelectric equipment(including generator replacement)	7,846	U$	every 10 years
Major overhaul of Civil works	19,500	U$	every 20-40

Cash flow after 10 years not discounted for UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted	Cumulative
0	-193.600	0	-193.600	1,000	-193.600	-193.600
1	-4.650	9.410	4.760	0,907	4.315	-188.841
2	-4.650	9.410	4.760	0,822	3.912	-184.081
3	-4.650	9.410	4.760	0,745	3.547	-179.322
4	-4.650	9.410	4.760	0,676	3.216	-174.562
5	-4.650	10.625	5.975	0,613	3.660	-168.588

6	-4.650	9.410	4.760	0,555	2.643	-163.828
7	-4.650	9.410	4.760	0,503	2.396	-159.069
8	-4.650	9.410	4.760	0,456	2.172	-154.309
9	-4.650	9.410	4.760	0,414	1.970	-149.550
10	-12.496	12.685	189	0,375	71	-149.361
				NPV =	-165.699	-149.361

Cash Flow and NPV after 10 years at current expenditures WITH UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	- 193,600	48,950	- 144,650	1.000	-144,650	-144,650
1	-4,650	9,410	4,760	0.907	4,315	-139,891
2	-4,650	9,410	4,760	0.822	3,912	-135,131
3	-4,650	9,410	4,760	0.745	3,547	-130,372
4	-4,650	9,410	4,760	0.676	3,216	-125,612
5	-4,650	10,625	5,975	0.613	3,660	-119,638
6	-4,650	9,410	4,760	0.555	2,643	-114,878
7	-4,650	9,410	4,760	0.503	2,396	-110,119
8	-4,650	9,410	4,760	0.456	2,172	-105,359
9	-4,650	9,410	4,760	0.414	1,970	-100,600
10	-12,496	12,685	189	0.375	71	-100,411
				NPV =	-116,749	-100,411

Max investment at current savings to reach zero cash flow in ten years

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	-44,239	0	- 44,239	1.000	-44,239	-44,239
1	-4,650	9,410	4,760	0.907	4,315	-39,480
2	-4,650	9,410	4,760	0.822	3,912	-34,720
3	-4,650	9,410	4,760	0.745	3,547	-29,961
4	-4,650	9,410	4,760	0.676	3,216	-25,201
5	-4,650	10,625	5,975	0.613	3,660	-19,227
6	-4,650	9,410	4,760	0.555	2,643	-14,467
7	-4,650	9,410	4,760	0.503	2,396	-9,708
8	-4,650	9,410	4,760	0.456	2,172	-4,948
9	-4,650	9,410	4,760	0.414	1,970	-189
10	-12,496	12,685	189	0.375	71	0
				NPV =	-16,338	0

Needed annual flow to reach zero NPV with UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	-193,600	48,950	-144,650	1.000	-144,650	-144,650
1	-4,650	28,990	24,340	0.907	22,067	-120,310
2	-4,650	28,990	24,340	0.822	20,006	-95,970
3	-4,650	28,990	24,340	0.745	18,138	-71,630
4	-4,650	28,990	24,340	0.676	16,444	-47,290
5	-4,650	28,990	24,340	0.613	14,909	-22,950
6	-4,650	28,990	24,340	0.555	13,517	1,390
7	-4,650	28,990	24,340	0.503	12,254	25,730
8	-4,650	28,990	24,340	0.456	11,110	50,070
9	-4,650	28,990	24,340	0.414	10,073	74,410
10	-12,496	28,990	16,494	0.375	6,188	90,904
				NPV =	57	90,904

IRR = 10.31%

	Required inflow for zero NPV		Extra expenditure
Total costs	28,990	9,410	19,580
Village(61 kWh/day)	21,832	7,818	14,014
Per Family unit	1,284	460	824
Per household	364	130	234
Mets (20 kWh/day)	7,158	1,340	5,818

Mets covers all extra expenditures scenario:

	Total annual(US$)	Per kWh(US$)	Per kWh (SRD)
Total expenditures	21,172	2.90	7.98
Extra expenditures	19,832	2.72	7.47

Needed annual flow to reach positive cash flow with UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	-193,600	48,950	-144,650	1.000	-144,650	-144,650
1	-4,650	19,900	15,250	0.907	13,826	-129,400
2	-4,650	19,900	15,250	0.822	12,535	-114,150
3	-4,650	19,900	15,250	0.745	11,364	-98,900
4	-4,650	19,900	15,250	0.676	10,303	-83,650
5	-4,650	19,900	15,250	0.613	9,341	-68,400
6	-4,650	19,900	15,250	0.555	8,469	-53,150
7	-4,650	19,900	15,250	0.503	7,678	-37,900
8	-4,650	19,900	15,250	0.456	6,961	-22,650
9	-4,650	19,900	15,250	0.414	6,311	-7,400
10	-12,496	19,900	7,404	0.375	2,778	4
				NPV =	-55,085	4

	Required inflow for positive cash flow (10yr)		Extra expenditure
Total costs	19,900	9,410	10,490
Village(61 kWh/day)	14,986	7,818	7,168
Per Family unit	882	460	422
Per household	250	130	119
Mets (20 kWh/day)	4,914	1,340	3,574

Mets covers all extra expenditures scenario:

	Total annual(US$)	Per kWh(US$)	Per kWh (SRD)
Total expenditures	12,082	1.66	4.55
Extra expenditures	10,742	1.47	4.05

Needed income from on site productive scheme to reach zero cash flow WITH UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	-99,950	48,950	-51,000	1.000	-51,000	-51,000
1	-4,650	10,535	5,885	0.907	5,335	-45,115
2	-4,650	10,535	5,885	0.822	4,837	-39,230
3	-4,650	10,535	5,885	0.745	4,386	-33,345
4	-4,650	10,535	5,885	0.676	3,976	-27,460
5	-4,650	10,535	5,885	0.613	3,605	-21,575
6	-4,650	10,535	5,885	0.555	3,268	-15,690
7	-4,650	10,535	5,885	0.503	2,963	-9,805
8	-4,650	10,535	5,885	0.456	2,686	-3,920
9	-4,650	10,535	5,885	0.414	2,435	1,965
10	-12,496	10,535	-1,961	0.375	-736	4
				NPV =	-18,244	4

Needed income from on site productive scheme to reach zero cash flow without UNDP grant

Year	Outflow	Inflow	Result	Disconto	Discounted cash flows	Cumulative cash flow
0	-99,950	0	-99,950	1.000	-99,950	-99,950
1	-4,650	15,430	10,780	0.907	9,773	-89,170
2	-4,650	15,430	10,780	0.822	8,861	-78,390
3	-4,650	15,430	10,780	0.745	8,033	-67,610
4	-4,650	15,430	10,780	0.676	7,283	-56,830
5	-4,650	15,430	10,780	0.613	6,603	-46,050
6	-4,650	15,430	10,780	0.555	5,986	-35,270
7	-4,650	15,430	10,780	0.503	5,427	-24,490
8	-4,650	15,430	10,780	0.456	4,921	-13,710
9	-4,650	15,430	10,780	0.414	4,461	-2,930
10	-12,496	15,430	2,934	0.375	1,101	4
				NPV =	-37,500	4

Capital cost coverage:
At present the project does not possess the budget to finish the necessary transmission line.

Indicator: [redacted]

Operational cost coverage
At estimated running costs and current expenditures on fuel and lighting, the project would be able to meet running costs.

	Cost covering expenditure for MHP(US$)	Current expenditures(US$)	Saving(US$)
Total costs	4,650	9,410	4,760
Village(61 kWh/day)	3,502	7,818	4,316
Per Family unit	206	460	254
Per household	58	130	72
Mets (20 kWh/day)	1,148	1,340	192

Reinvestment:
No provisions have been made for reinvestment at the end of lifetime for the hydro electric equipment or the civil works. From budget specifications:
Costs of installation of hydroelectric equipment: US$ 12,450,-
Costs for civil works: US$ 19,500,-

Indicator: [redacted]

Net Present Value:
From tables: Net present value for current scheme after 10 years is - US$ 165,699,-
Project is economically unsound.

Indicator: [redacted]

4.2 Income generation

There are no productive schemes linked to the MHP. Even if there were any, there is doubt as to whether or not there will be a market sell any produced goods on. Although it might be possible to find organisations willing to provide financial incentives to stimulate productive output, no such organisations have actually been engaged.
All this indicates that the MHP will not be put towards a financially productive output.

Indicator: NEGATIVE

4.2.1 Income generating schemes

Indicator: NEGATIVE

Presence of productive schemes
There are no plans for a using the MHP to power productive scheme. The villagers indicated interest in using the electricity for powering a small saw mill for building better houses. Possibly the planks sawed with this mill could be sold commercially. This option has not been included into the estimations for power demand however.

Indicator: NEGATIVE

Market for output
No data available on the availability of a possible market.
The METS and the village community itself are the only customers for any possible commercial output. For a larger market goods will have to be transported by canoe to other villages, thereby increasing the costs.

Indicator: CAUTIOUS

4.2.2 Incentives

Indicator: NEGATIVE

Available financial incentives
No data on the availability of possible financial incentives for promoting profitable schemes.
From general: In Kwamalasamutu villagers were stimulated by a help organisation in Paramaribo to produce traditional clothing and hammocks, which were transported and sold in Paramaribo, with the proceedings being returned to the village. This indicates that it is possible to find organisations willing to stimulate productive output.

Indicator: CAUTIOUS

Applied incentives
No incentives have been applied to this project as there is no productive output planned.

Indicator: NEGATIVE

4.3 Funding

Indicator: NEGATIVE

4.3.1 Availability

Indicator: CAUTIOUS

Funds for covering intermediation
As standard, the initial part of the fund granted by the SGP consists of a US$ 5,000 grant for conducting feasibility research. This part of the fund can also be used for the initial intermediation costs.
From general: Funds provided by the CDFS usually have a portion reserved for intermediation.

Indicator: POSITIVE

<u>Funds for covering capital costs</u>
There are a number of organisations and funds active in Suriname [Appendix B.12]
Funding arrangements unknown, but funding for covering capital costs is potentially available
The funding provided by the SGP was initially enough to cover the capital costs. However, for construction of the transmission lines, new funds will have to be obtained.

Indicator: POSITIVE

<u>Funds for access promotion</u>
Because it is still unclear how the financial arrangement for the operational phase of the MHP will be made, it is unclear whether funding will be needed for access promotion.
No data on the presence of small funds for access promotion.

Indicator: CAUTIOUS

<u>Funds for promoting industry/entrepreneurship</u>
No data on the presence of funds promoting private entrepreneurship.

Indicator: CAUTIOUS

4.3.2 Extent

Indicator: NEGATIVE

<u>Amount</u>
SGP: Funding up to 50.000 US$.
FOB: Funding up to 100.00US$
The budgeted costs for the MHP fall within range of the available funds.

Indicator: POSITIVE

<u>Duration</u>
The SGP fund covers the project from design to completion of the construction. There is no funding available for the operational phase of the project.
From general: CDFS indicates that on general, funding do not extend to the operational phase.

Indicator: NEGATIVE

4.4 Loan financing

Because of time constraints, no information gathered on the loan sector.

No data

4.5 Economy of scale

Indicator: NEGATIVE

4.5.1 Programme size

Indicator: NEGATIVE

<u>Number of MHP projects within area</u>
At current the Palumeu MHP is the only MHP being deployed anywhere in Suriname. There have been a number of villages expressing the desire to implement their own MHP and the government is currently reassessing the possibility of building a new MHP at the location of the former Poketi project, but no actual projects have yet been deployed.

Indicator: NEGATIVE

Amount of job opportunity created by program
The Palumeu MHP is a single project. This means that the program cannot create enough job opportunity to cause advantages such as mass production and steady labour opportunity that come from large scale programmes.

Indicator: NEGATIVE

4.5.2 Available capacity

Indicator: NEGATIVE

Presence of local suppliers
There are a number of suppliers for electrical generators in Paramaribo. However, there is no data obtained on the suitability of these generators for MHPs.
At the moment REMACON is the only company working on constructing a turbine. They do not have any prior experience on turbine construction. For turbine construction there are no other suppliers available.
Because of the difficulties experienced with the Palumeu project the director of REMACON indicates that it is doubtful whether or not they will be interested in future production.

Indicator: NEGATIVE

Presence of local labour force
Since Palumeu is the only MHP currently there is no shortage of capacity due to shortage of labour force.

Indicator: POSITIVE

4.5.3 Outside stimulation

Indicator: NEGATIVE

Application of outside stimulation
Currently there is no active outside stimulation for initiating MHPs. Although the interest expressed by the government is positive, there are no actual incentives being applied that will increase the number of MHPs being deployed.

Indicator: NEGATIVE

4.6 Focus on poverty reduction

No payment arrangement have yet been set for the MHP, so it is unknown if tariffs or a connection fee will even be set. No conclusions can be drawn on the aptness of these tariffs or the connection fee.

Indicator: Blank

4.6.1 Aptness of tariffs

Cost coverage
No payment arrangement have yet been set for the MHP, so it is unknown if tariffs will even be set and whether or not they will be cost covering for the operation of the MHP.

Indicator: Blank

Conformation to local payment capability
No payment arrangement have yet been set for the MHP, so it is unknown if tariffs will even be set and whether or not they will confirm to the local ability to pay.

Indicator: Blank

<u>Use of cross subsidy</u>
No payment arrangement have yet been set for the MHP, so it is unknown if tariffs will even be set and whether or not cross subsidy will be utilised to allow the poorer villagers to be connected through subsidy by the richer ones.

Indicator: Blank

4.6.2 Access promotion

<u>Connection fee</u>
No payment arrangement have yet been set for the MHP, so it is unknown if connection fees will even be set and whether or not they will be low enough to promote access of the whole community to the electricity.

Indicator: Blank

<u>Loan system</u>
With no connection fee set, it is unknown whether or not a loan system will be needed to allow the villagers to be able to pay the access fee.

Indicator: Blank

4.6.3 Inflation

With no tariffs planned it is unknown whether they will keep in line with the inflation.

Indicator: Blank

5. Institutional

In the institutional category, the lack of a broader development program aimed at Palumeu reflects poorly on the chances of the project for having a positive impact on sustainable development. Although there are a number of potential organisations in Paramaribo for initiating such programs in the area, this potential has not yet been exploited.
Although the government has displayed a positive interest in the outcome of the MHP and a positive attitude towards the outcome of the MHP, there are a number of issues -such as the legislation on land tenure, lack of subsidies and lack of active promotion of RET- decreasing the chances for a successful, long term sustainable MHP.
On general, the factors in the institutional category indicate a negative outcome on the chance for a sustainable MHP.

Indicator: NEGATIVE

5.1 Development Programme

There are no development programmes being deployed in Palumeu. For the MHP to actually ignite long term, sustainable development, such programs are essential. The lack of such programs can be seen as a negative contribution.

Indicator: NEGATIVE

5.1.1 Integration of development programmes

The Palumeu MHP is not imbedded into a broader development program aimed at either social, economic or environmental development. At current, there are no development programmes being deployed in the area. Therefore this indicator can be set to negative.
Indicator: NEGATIVE

Inclusion in wider development programme
The MHP project is a stand alone scheme, not part of any broader development program aimed at Palumeu.

Indicator: NEGATIVE

Presence of other development programs
At present there are not any other development programs active aimed specifically at Palumeu. There was a past project aimed at improving drink water ability which partly succeeded. See health. The MHP project might offer new possibilities in this area, but at the moment this possibility is not being considered.
There is a representative of the US Peace Corps stationed in Palumeu. Although he as at current assessing the possibility for implementing a project for teaching farming techniques to the villagers. No actual project has however been implemented yet.

Indicator: NEGATIVE

Coordination with other development programmes
As there are no programs being deployed in the area this indicator is not relevant.

Indicator: Blank

5.1.2 Aims

Indicator: Blank

Promotion of technology transfer/capability building
As the Palumeu MHP is not incorporated in a broader development plan and no other programs are being deployed in the area this indicator is not relevant.

Indicator: Blank

Stimulation of market
As the Palumeu MHP is not incorporated in a broader development plan and no other programs are being deployed in the area this indicator is not relevant.

Indicator: Blank

Stimulation of private entrepreneurship
As the Palumeu MHP is not incorporated in a broader development plan and no other programs are being deployed in the area this indicator is not relevant.

Indicator: Blank

5.1.3 Clarity of aims towards community

Indicator: Blank

Formulation of aims
As the Palumeu MHP is not incorporated in a broader development plan and no other programs are being deployed in the area this indicator is not relevant.

Indicator: Blank

Communication of aims
As the Palumeu MHP is not incorporated in a broader development plan and no other programs are being deployed in the area this indicator is not relevant.

Indicator: Blank

5.2 Political involvement

Indicator: CAUTIOUS

5.2.1 Consent of the Granmans

Both the Granman of the Trio and the Wayana were present at the first kroetoe with the villagers on the initiation of the project. Although both Granmans gave their consensus to the endeavour, the Granman of the Wayana noted that Apetina, the village where he was residing, was much larger then Palumeu and more important to the Wayana tribe. He gave his grant on the condition that his village should be the following village to receive such a plant.
Although the grant was given, if this condition is not adhered to the lack of future support of the Granman might cause problems for the Palumeu project and possibly other future projects in the area.

Indicator: CAUTIOUS

5.2.2 Other political involvement

Several government dignitaries were present during the first kroetoe were the idea for the project was presented. The ministry for Natural Resources has expressed interest in the outcome of the project, in light of there own plans for utilizing renewable energy sources instead of diesel in the hind lands. However, no government or political agent is actively involved in the project.

Indicator: POSITIVE

5.3 Government Policy/Legislation

The legislation on land tenure could be cause for future complications with the MHP. The lack of formal legislation on subsidies and of an active promotion of RET generally has a negative impact on the chances of an MHP for becoming a long term sustainable project. On the other hand, the lack of active government involvement through legislation and the fact that the government has displayed a positive attitude towards the use of MHP is considered as positive on the long term chances of success for such projects. The impact of this factor is therefore still uncertain.

Indicator: CAUTIOUS

5.3.1 Legislation

The MHP will not experience any negative influences from legislation on tariffs or water rights. However, there is no legislation which will allow the villagers of Palumeu to obtain subsidy for this project. Also, the formal legislation on Land tenure does not acknowledge local Inheemse property rights. This could lead to complications in the future. In light of this the Indicator on legislation is set to cautious.

Indicator: CAUTIOUS

<u>Legislation on Subsidies</u>
The government has no formal legislation in place on providing subsidies for electrification projects of any sort. The only type of subsidy is by providing an allocated fuel quantity to certain villages. Palumeu is not one of these villages, so there is no room for negotiating the exchange of this fuel quantity for some kind of subsidy.

Indicator: NEGATIVE
<u>Legislation on Tariffs</u>

In the coastal regions the tariffs are set by the EBS, which is a state owned company. Therefore the tariffs are indirectly set by the government.
Electricity provision for the hind lands falls under the ministry of Natural Resources. At current there is no legislation in place for tariff setting. Also, the Palumeu MHP is intended to be a privately owned structure. Tariff setting will be left up to the owners for the near future.

Indicator: POSITIVE

Legislation on Land tenure
From general: Suriname is one of the few countries that does not officially acknowledge native property rights.
This means that the land the MHP is build on is officially government property. The government, however, has never actually interfered with native property rights.
Along the Upper Suriname there have been some difficulties on this issue where a tourist resort was built by someone from outside the village on what the villagers themselves considered to be village property. There is a long standing lobby in Paramaribo for the government to acknowledge property rights.
Until this has been officially arranged, the MHP is susceptible to land issues.

Indicator: CAUTIOUS

Legislation on Water rights
No data has been collected on this indicator.
In view of the relatively small size of the Panato and the creek not being a transportation artery, the government will not impose any regulations on its use.

Indicator: POSITIVE

5.3.2 Promotion RET

Although the Government has a favourable attitude towards the use of RET in the inlands, there is no actual promotion of the use of these technologies for energy provision in the inlands. Active promotion would increase the chances for other RET projects, including MHPs being deployed which would in turn increase the changes for the current project by means of an increased market for production, technology support, loan systems etc. Lack of active promotion increases the chances for the Palumeu MHP ending up as a stand alone project.

Indicator: NEGATIVE

Government orientation towards RET
The government has no official policy on promoting RET. They are currently however actively searching for a solution to the difficulty with energy provision in the hind lands and RET is being considered as one of the solutions.

Indicator: POSITIVE

Presence of active promotion
There is no active promotion program in place to stimulate the use of RET.

Indicator: NEGATIVE

5.3.3 Standardization

Indicator: POSITIVE

Prohibitive standards
There has been no data collected on the presence of government imposed standards on the construction of MHPs or electrification. However, it is clear that if any such standards exist the government is not actively imposing them in the hind lands, so there will not be a conflict between choices based on best practice knowledge or budget restraints and imposed standards.

Indicator: POSITIVE

5.3.4 Grid Supply

Indicator: POSITIVE

<u>Presence of a competing grid supply</u>
Because of the distance to the capital and the presence of the tropical rainforest, a grid extension towards Palumeu is technically extremely difficult and financially extremely unfeasible.
This means that the MHP will never have to compete against grid provided electricity.

Indicator: POSITIVE

5.4 Development agencies

At the moment the only development area covered by a development organisation in the area is environmental sustainability: reduction of CO_2 by implementing the MHP. However, there are a number of potential organisations present in Paramaribo which might be interested in deploying programs in Palumeu. So the lack of active development agencies in the area could be solved by actively approaching those organisations.

Indicator: CAUTIOUS

<u>Presence</u>
The development agencies active in the Palumeu area at current are the US Peace corps and the SGP of the UNDP
From general: There are a number of organisations situated in Paramaribo which deploy projects in the inlands. This means that there are a potential number of organisations in place which could be approached for implementing development programs in Palumeu.

Indicator: POSITIVE

<u>Coordination of Aims</u>
There is no clear data on the aim of the US Peace Corps in Palumeu.
The officially stated aim of the SGP (UNDP) is to achieve a reduction of CO_2 production in Palumeu by sponsoring the construction of the MHP.

The aim of the SGP only covers development in the Environmental (Planet) area. Social and economic development is not covered by any agency active in the area.

Indicator: NEGATIVE

6. Environmental

On general, factors of this category will not have a negative impact on the MHP project.
There are no significant environmental impacts because of this construction. There is the expectation of CO_2 reduction, but no exact figures on this.
As the Panato creek does not play any part in local transportation, fishery, agriculture and/or drink water provision, there will not be any restrictions posed on the presence of a residual flow, leaving the project developers free in their design.
The project does not conflict with or will not experience any restrictions do to environmental regulations.

Indicator: POSITIVE

6.1 Impacts

With the exception of the indicator: Flora all indicators are considered positive. The MHP will not have any (significant) negative impacts on the environment. The impact on the local flora could be relatively high if a transmission line has to be constructed. However, this impact will not have a very high priority. Therefore the indicator on the environmental impacts can be set to positive.

Indicator: POSITIVE

6.1.1 Resources

Indicator: POSITIVE

Level of impact
No data on locally present natural resources. It is not likely that the MHP will in any way damage the presence of local resources.
Level of impact = zero

Priority of impact
Not applicable.

6.1.2 Habitats

Indicator: POSITIVE

Level of impact
There are no habitats near the MHP site. If there were, they would not be affected by the MHP.
Level of impact = zero

Priority of impact
Not applicable.

6.1.3 Ecosystems

Indicator: POSITIVE

Level of impact
No data on the composition of local ecosystems. The construction of the dam might lead to local swamp forming. The effects of this are unknown.
Level of impact = unknown

Priority of impact
In view of the size of the MHP it is considered that what damage might be inflicted will be negligible.
Priority of impact = low

6.1.4 Air

Indicator: POSITIVE

Level of impact
The MHP should reduce the production of CO2 output by replacement of diesel as a fuel source. No data on the amount of current CO2 production in Palumeu.
Level of impact = unknown

Priority of impact
The current production of exhaust gasses is not being viewed as troublesome and so the elimination of these is not viewed as having a high priority.
Priority of impact = low

6.1.5 Water

Indicator: POSITIVE

Level of impact
The MHP will not cause any pollution to the water.

Level of impact = zero

<u>Priority of impact</u>
Not applicable

6.1.6 Soil

Indicator: POSITIVE

<u>Level of impact</u>
The MHP construction itself will not damage the soil. However, the change from nomadic to settled behaviour caused by the presence of the METS and the promise of cheap energy has its effects on the slash and burn cycle in the area. Normally a piece of land will be left to recuperate for more than 5 years before it is planted on again. With the inhabitants of Palumeu staying in one area and increasing in number, this cycle is affected. Without more information, the effect on the soil composition can not be assessed.
Level of impact = Unknown

<u>Priority of impact</u>
In view of the still relatively small size of Palumeu the priority of this impact can be estimated as low.
Priority of impact = low

6.1.7 Flora

Because the construction of a transmission line can have a relatively high impact on the local flora, this indicator is set to cautious.

Indicator: CAUTIOUS

<u>Level of impact</u>
The impact on the flora depends on whether or not a high voltage line has to be constructed, which would involve clearing a wide path of several kilometres through the local forest. At the MHP site itself only a small portion growth has to be cleared.
Level of impact: Low (MHP only)/High (clearing a transmission path)

<u>Priority of impact</u>
The clearance of a broad transmission path is not viewed as having a much higher impact than the local slash and burn type of farming. Also, clearing a pad through the forest is not considered as having a significant impact in light of the relative smallness of such a path compared to the size of the tropical forest.
Priority of impact = medium

6.1.8 Fauna

Indicator: POSITIVE

<u>Level of impact</u>
In the design of the dam a pass through for fish is incorporated. No data on the presence of wildlife in the immediate vicinity of the site.
Level of impact= Low

<u>Priority of impact</u>
Priority of impact = negligible

6.1.9 Aesthetics

Indicator: POSITIVE

<u>Level of impact</u>
The dam and turbine housing will be a small but distinct mark in the tropical forest setting.
Level of impact = medium

<u>Priority of impact</u>
The site is so remote that it the impact is considered negligible.
Priority of impact = negligible

6.1.10 Natural and Cultural heritage

Indicator: POSITIVE

<u>Level of impact</u>
No natural or cultural artefacts will be damaged by the project.
Level of impact = none

<u>Priority of impact</u>
Not applicable

6.2 Residual flow

Indicator: POSITIVE

<u>Government regulations</u>
The government is not imposing any rules on the presence or the size of a residual flow.
The design is not prohibited in anyway by regulations on this.

Indicator: POSITIVE

<u>Local regulations</u>
Since the Panato is not a transportation artery, fishing ground or responsible for drink water provision, the local population does not have any specific interests in the presence of a residual flow.
The design is not prohibited in anyway by local interests on this.

Indicator: POSITIVE

6.3 Environmental regulations

Indicator: POSITIVE

<u>Applicable environmental regulations</u>
There are no specific environmental regulations imposed by the government in the area.

Indicator: POSITIVE

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