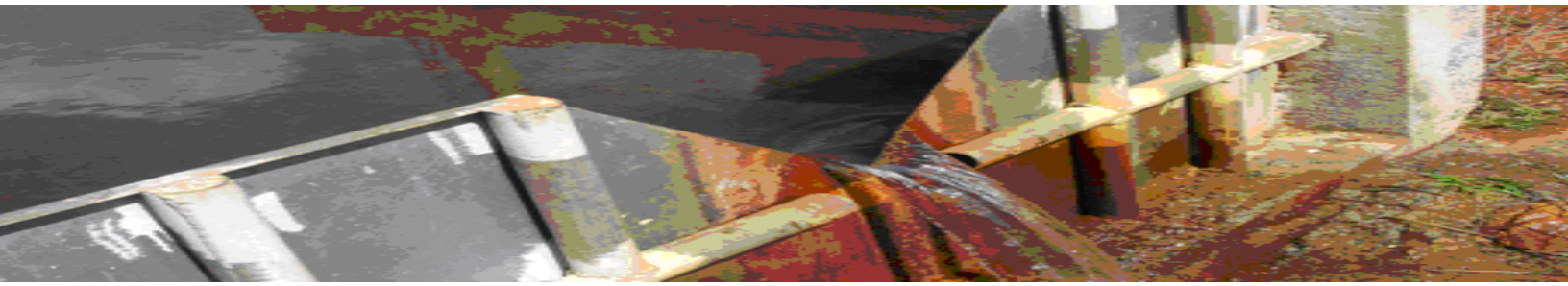
Barriers for water

About the decision-making process regarding locations for new small dams in the Preto River Basin in the Federal District, Brazil



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"Agua de beber, give the flower water to drink"

Antonio Carlos "Tom" Jobim - Vinícius de Moraes – Brazil, 1964

Summary

Water scarcity during dry seasons is a common phenomenon in semi-arid areas with a bi-seasonal (dry-rainy) climate due to increases in agricultural activities. Small dams are hydraulic structures constructed to retain water during the rainy season in order to make it available during the dry season, herewith contributing to an equalized water distribution throughout the year and diminishing water scarcity during the dry season. The Preto River Basin (PRB) in the Federal District (DF) in Brazil is an example of a region characterized by a semi-arid bi-seasonal climate using small dams to cope with water scarcity during the dry season.

Until today, the focus of research regarding small dams has been on *existing* small dam ensembles. This research revealed interactions between water use, policy, physical system behaviour and institutional frameworks. In the PRB *new* small dams are planned to be constructed. An important aspect of planning new small dams is the location choice for these dams.

The process leading new small dams in the PRB in DF has been characterized by uncertainty concerning responsibility, lack of information and therefore conflicts and resistance regarding those dams, until it collapsed in 2006. This can be perceived as being problematic, since water scarcity is an increasingly urgent issue and small dams form a favourable and relatively uncomplicated way of coping with this scarcity during the dry season.

This research focuses on the policy process leading to a location choice for new small dams based on specific requirements imposed by the interplay between environmental/physical characteristics, stakeholders and the institutional framework of the PRB in DF. It does so by formulating a Programme of Requirements (PoR) for locations for new small dams that comprises those three aspects. The research question posed is: ***What are the minimal requirements for locations for new small dams and in what way can these requirements coherently contribute to the process leading to a location choice for new small dams in the Preto River Basin in the Federal District, Brazil?***

Regarding the interplay between institutions, stakeholders and the physical system, concepts such as trust, accountability and good governance play an important role. Trust leads to compliance and good governance contributes to mutual trust between stakeholders involved. Accountability refers to public responsibility in the decision-making process.

In order to find an answer to the research question, this research is sub divided into parts. After a research framework has been established, the following components shape this report:

- An analysis of the current situation, which include the case history of the small dams project and expected changes brought about by the implementation of new dams. The institutional framework

and stakeholder networks, water balance and physical system behaviour are also analysed. These analyses show (among other things) a high rate of governmental stakeholders participating in the process leading to a location choice for new small dams;

- A model of the impacts of new small dams on the physical behaviour and the potential role of policy-makers regarding these impacts is made. This model is based on water balance accounting principles and built with software called the Water Evaluation and Planning system (WEAP);
- A design of a set of institutional arrangements that allow policy-makers to test whether the requirements listed in the PoR are indeed the minimal requirements put forth by the aspects researched. The set of institutional arrangements also improves communication of information, trust and compliance of stakeholders;

Consequently, an interpretation addresses the results put forth by earlier parts of the research.

Based on the research carried out, the most important conclusions are related to the observations that

- Governmental stakeholders are expected to have a leading role in the decision-making process leading to a location choice for new small dams by all stakeholders
- The focus of these governmental parties should be on improving and maintaining a solid trust-relationship with other stakeholders

Instruments for achieving a solid trust relationship are dependent on well-defined institutional arrangements with an integrative character. Some of these arrangements are well defined participation moments, complete information and meticulously and transparently carried out processes and procedures imposed by law and policies.

The process leading to a location choice for new small dams should be characterized by integration of information and communication to (potential) stakeholders. Based on the conclusions and the quality of the process leading to a location choice for new small dams, two types of recommendations are made.

- Further research must encapsulate detailed and site-specific information, while not loosing system-impacts of location choices for new small dams out of sight.
- Policy-makers are recommended to respect the institutional arrangements designed in this research in terms of agenda, frequency and information contents and to keep an open attitude with respect to future changes of stakeholder composition or system behaviour.

Preface

With finalizing this thesis report, my Systems Engineering, Policy Analysis and Management (SEPAM) programme at the faculty of Technology, Policy and Management comes to an end as well. After more than six years of studying, I am glad to be able to say that I am very pleased with the choices I made during my student life. Almost every student – I think – has to overcome a phase that is characterized by uncertainty regarding the education of his choice. I was lucky enough to have this fashionable "identity crisis" after two years of studying, during the busiest part of my non-educational related student life. I was even luckier not to substantiate this feeling by switching studies, but to *make* SEPAM fit my interests, being international relations and conflicts – an area of interest I have explored intensively with extracurricular activities. This is why I made the switch from a Transport, Infrastructure and Logistics bachelor programme to a water management kind of Masters programme. If all my choices to come bring about the same increase in motivation and passion for what I am doing, I am going to be a very fortunate man.

Carrying out a Master Thesis project is an instructive process. I am very grateful for the support many people gave me, either because of the importance of this research being carried out, or just because those people are helpful and wonderful persons.

Para algumas pessoas não tem jeito nenhum agradacer em Inglês. Espero que, se um dia dé a opportunidade ler esta tese, eles vão intender a importância do auxilio deles. Pela possibilidade perguntar e apresentar as minhas ideias, quero agradecer Alan, Gustavo, Vandete, Leandro, Hugo, Luciano, Gilberto, Alba, Leonice e Dalio. Pela introdução na vida Brasileira e no jeitinho Brasileiro, valeu Fernando, Janaína, Juliana, Romulo, Dayane e Ricardo (e todos os outras no quarto lá em cima jogando Uno…), Léo e Leo, Claude e Marcao. Pelo desenvolvimento do meu facilidade de brincar na vida, obrigado Jorge, Cristofer, Olavo e Piauí.

Lineu (e Frances)! Obrigadão pelas conversas, a sua hospitalidade, pela conhecer a sua interpretação sobre a vida. Tambem obrigado por deixar conhecer os seus pais, senhor e senhora de Pádua. Thank you for your openness, your help and the possibility of letting me do this research at EMBRAPA Cerrado.

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List of abbreviations

ADASA	Water Sanity Regulatory Agency of the Federal District
ANA	National Water Agency
APA	Environmentally Protected Area
APP	Permanent Preservation Areas
APRORP	Association of farmers in the Preto River Basin
CAESB	Company for Environmental Sanitation of DF
CGIAR	Consultative Group of International Agricultural Research
Codevasf	São Francisco and Parnaíba Valley Development Company
DF	Federal District
DSS	Decision Support System
EIA	Environmental Impact Assessment
EMATER	Institute for Technical Assistance and Rural Extension
EMBRAPA	Brazilian Agriculture and Livestock Research Institute
IBAMA	Brazilian Institute of Environmental Issues and Reusable Natural Resources
IBRAM	Environmental Institute of Brasilia
PoR	Programme of Requirements
PRB	Preto River Basin
RIMA	Report on Environmental Impact
SA	Secretariat of Agriculture
SEDUMA	Secretariat of Urban Development and Environmental Issues
SNUC	National System of Conservation Units
SRP	Small Reservoir Project
TIP-approach	Technical, Institutional, Process-approach
WEAP	Water Evaluation and Planning (model)
UN	United Nations
USUAGUA	Association of water users in the Preto and São Marco river basins

Part 1: Research framework

Part 1 “Research framework” describes the causes and context of this research from an academic perspective. The output of this part is a research framework consisting of a well-defined and well-structured problem formulation and research outline. The theoretical context is an important aspect of the research definition. Subsequent parts of this research will refer to the structure explained in this part.

1. Introduction and structure

This chapter provides background information that forms the foundation of this research. In paragraph 1.1 an introduction to the subject of this research and existing literature regarding this subject is presented. Paragraph 1.2 explains the context of this research. Paragraph 1.3 goes deeper into the structure and arrangement of the research. Consequently, in paragraph 1.4 the research approach used to build up this research is explained shortly. In conclusion, the structure of this report is presented in paragraph 1.5.

1.1. Introduction

Fresh water is becoming increasingly scarce in arid and semi-arid regions in the world, due to interrupted water supply (Jia and Luo 2006), or to inefficient water management practices (Shangguan, Shao et al. 2002). Additionally, demands are growing because of increasing populations and water systems are overburdened because of poor water management (Cai 2003).

Small reservoirs or small dams are hydraulic constructions used in some regions in Brazil, sub-Saharan Africa and West Africa to improve water access in semi-arid bi-seasonal regions. They have been constructed by local governments, communities and on private initiative. Small water dams catch water, usually surface runoff, during the rainy or wet season in order to make water available during the dry season (Liebe 2007). One definition of a small dam, is "one whose maximum height above the lowest point in the original streambed does not exceed 50 feet, and whose volume is not of such magnitude that significant economies can be obtained by utilizing the more precise methods of designs usually reserved for large dams" (United States Department of the Interior Bureau of Reclamation 1974).

"More precise methods" refer to the possibility to control the dams in their water regulative function, e.g. for generation of hydro-power. In other words, a small dam is not intended to be operated for such purposes and the operation centre (if present) is not very sophisticated.

The function of small dams in dry regions is, in short, to have access to water in times of drought. The dams are often referred to as having multiple purposes (or multi-purpose reservoirs), as they deliver water for multiple uses, such as domestic use, livestock watering, and predominantly small-scale irrigation (SRP 2003).

In order to analyze ensembles of small dams within a river basin system, research has been conducted under the Small Reservoirs Project (SRP). This project intends to focus on (1) planning, development and management of small dam ensembles on a watershed/basin level and (2) improvement of livelihoods on the community level. The latter focus is pursued by supporting "properly located, well designed, operated and maintained […] and economically viable" use (SRP 2003).

However, progress reports of the same project show that the research de facto only mapped and analyzed *existing* small dam systems (SRP 2007). Topologies, water allocation issues and – to some extent – institutional frameworks of existing systems of small dams have been researched and described (Lévite, Sally et al. 2003; Balazs 2005), whereas part of the research objectives of the SRP is formulated as planning, development and design of small dams. The latter part has not received much attention in terms of research, although it forms an important part of the objectives formulated as mentioned earlier.

Realizing new small dams is not a big challenge in terms of engineering. In the past, however, realization of small dams has been characterized by institutional chaos, related to responsibility over for example maintenance and downstream effects. Bringing order in the systems of small dam ensembles during the execution of the SRP already reduced this chaos. Hence designing, planning and finding proper locations for new small dams seem to be crucial for prevention of chaotic management in the future.

The Preto River Basin (PRB) in Brazil matches the description of a semi-arid region with fluctuations in water availability (fluctuating water supply) due to a bi-seasonal climate (dry season – rainy season). The basin – a sub basin of the river São Francisco – has also been subject to studies carried out under the SRP. Hydrologic performance (seepage, evaporation, etc.) and institutional format as well as stakes and interests of community members of several communities with regard to existing dams in the PRB were investigated (Balazs 2005; Dekker 2007). This resulted in (among other things) expanded knowledge, insight in the behaviour of the intertwined physical and social system of dams and starting insights in the perceptions of community members and institutional rules about disputes and responsibility issues. Because of institutional chaos, though, conflicts exist related to unequal division of water and poor information by the government concerning the planning and management of new small dams, bringing about resistance of farmers against the process leading to the implementation of those dams.

New small dams are desirable alternatives (Rodrigues 2008) for coping with droughts and a lack of constant water supplies in the PRB. Strategically located and properly designed new small dams can provide access to water for farmers. Irrigation systems in the region can be expanded with new small dams, by means of which (small-scale) farmers can increase their crop yields (Ahrends, Mast et al. 2008).

One of the most basic aspects of the design of new small dams is the location where physical infrastructure must be constructed. Depending on water demand and desired performance of new small dams, sites and dimensions can be determined. However, when singularly used, the perspective of technical performance is too limited to fully comprehend the complexity of realizing new small dams.

Even a narrow interpretation of the goals of the SRP suggests that the realization of new small dams should be researched in a holistic and integrated way. By holistic and integrated is meant that physical, social (Grimble and Wellard 1997; Enserink, Koppenjan et al. 2003; Bryson 2004) as well as institutional (Klijn and Koppenjan 2004; Koppenjan and Groenewegen 2007) dimensions must be taken into account when designing new small dams.

In other words, small dams are part of a socio-technical system (Van Daalen and Thissen 2003; Veeneman 2004; Weijnen and Bouwmans 2006) and new small dams will change the behaviour of the current system in the PRB, if they are going to be built.

As indicated above, the process leading to a location choice for new small dams in the PRB in DF has been characterized by uncertainty concerning responsibility, lack of information and therefore conflicts and resistance regarding those dams. This can be perceived as being problematic, since water scarcity is an increasingly urgent issue and small dams form a favourable and relatively uncomplicated way of coping with this scarcity during the dry season in the PRB in DF.

1.2. Context of this research

This research has been carried out in light of the Master Thesis project, which concludes the two-year master program of Systems Engineering, Policy Analysis and Management, with a specialization in the "water" domain, taught at the faculty of Technology, Policy and

Management at Delft University of Technology. It has been conducted in cooperation with the Brazilian Agriculture and Livestock Research Institute (EMBRAPA), based in Brasilia, Federal District, Brazil.

This research does not stand alone. It is a follow-up of the Small Reservoirs Project (SRP 2003) which is part of the Challenger Program on Water and Food, with cooperation of the Consultative Group of International Agricultural Research (CGIAR).

This research especially addresses the second objective of the SRP, investigating "proper locations" as mentioned in paragraph 1.1.

Part of the research program that is being carried out by Dr. Lineu Rodrigues in the Buriti Vermelho catchment (part of the PRB in the Federal District (DF) in Brazil) has an overlap with this research.

1.3. The research

The *problem* described in 1.1 can be summarized as follows:

In a context of planning locations for new small dams addressing water scarcity during the dry season in the Preto River Basin in the Federal District, Brazil, resistance, uncertainty and conflicts exist amongst stakeholders and institutions with regard to the question what are proper locations for new small dams.

The *objective* of this research is related to the intention to address both the process leading to proper locations of new small dams and the uncertainty and conflicts that currently exist with regard hereto. Therefore, the main objective is:

To shape the minimal requirements for locations of new small dams in such a way, that they coherently contribute to the process leading to a location choice for new small dams in the Preto River Basin in the Federal District.

Accompanying goals are to create decision information for a responsible institute on determining locations for new small dams for irrigation purposes and to give an advice on how to use this information in a socio-technical context.

After all, just listing the least minimal requirements will be of little use for the policy

maker responsible for the implementation of new small dams. This list will therefore go along with an advice on *how to decide* where they should be constructed. Hence the word "coherently," which refers to the coherence of requirements for new locations that must be kept in mind in order to make them useful in the context of a decision-making process leading to an eventual location choice.

The research question posed below translates the goal of this research into an answerable question.

1.3.1. Research question

The research question for this research is formulated in line with the problem statement and research objective. It involves both the formulation of requirements for locations for new small dams and the way in which requirements can improve the process leading to a location choice. It therefore runs as follows:

What are the minimal requirements for locations for new small dams and in what way can these requirements coherently contribute to the process leading to a location choice for new small dams in the Preto River Basin in the Federal District, Brazil?

Although there are two issues addressed in the main research question, namely the composition of a list of requirements and the role of these requirements a decision-making process, the format of a single research question is preferred over the use of two separate research questions. This choice is made based on (1) the strong interrelation between the two and (2) the equal importance of the equivocal role of "minimal requirements" in the research question.

There is much information encountered within this one question.

- First of all, it mentions small dams. What are small dams, what do they do exactly and what performance are they expected to conduct? Why would small dams help?
- Secondly, the question addresses "minimal requirements." What are requirements? How can they *coherently* contribute to a decision-making process leading to a location choice?
- Finally, but less theoretically, the part "Preto River Basin in DF in Brazil" bounds

this research geographically and physically. The concept of a river basin is used here, which might be unclear, as well as the special circumstances and characteristics of the PRB in DF of Brazil.

1.3.2. Sub questions

The sub questions formulated below address the knowledge gaps recognized above. They entail parts 2 (Analysis) and 3 (Modeling and design) of this research. Bulleted points indicate:

- The paragraph of the theoretical framework that is relevant in order to understand the sub question
- The method applied to obtain the answer to the sub question. For a complete overview of methodology applied in this research, please refer to chapter 1.6.1.
- The results of applying this method

The first sub questions will go deeper into the problem situation and context considered in this research. Stakeholders involved expect changes that will be related to new small dams and their locations. These expectations determine the position of stakeholders in the process leading to a location choice for new small dams.

1: Which changes in system behaviour caused by the process leading to (a location choice for) new small dams do stakeholders expect?

- Theory related to this sub question is presented in paragraph 2.1.1, addressing the socio-technical system and system behaviour in it
- Methods used to find answers to this sub question are literature study (conference papers and master theses) and field study (interviews with stakeholders)
- The results of answering this sub question consist of a justification to analyze institutions, stakes and stakeholders and a short list of requirements for the process leading to a location choice of new dams

The answer to this sub question can be found in paragraph 3.3

The word "change" indicates that a situation varies from the current one; therefore the current situation will be part of the contents under sub question 2. This sub question

addresses the history of small dams in the PRB in DF, where "history" means events, roles and functions concerning small dams taking place until the start of this research.

2: What is the case history of small dams in the Preto River Basin in the Federal District?

- The part of the theoretical framework addressing this sub question concerns concepts such as trust and accountability (see paragraphs 2.1.3 and 2.1.4)
- In order to find an answer to this question, journal articles, conference papers and master researches have been studied. Beyond a literature study, interviews were carried out with stakeholders involved in the process leading to (a location choice for) new small dams
- The result of answering this sub question consists of an overview of roles and functions of small dams and small dam ensembles and a justification for the analysis of the physical system and its behaviour

The answer to this sub question can be found partly in paragraph 3.3 and partly in paragraph 3.3

Sub questions 1 and 2 will lead to a better understanding of the context of the main question. Next, insight must be gained in the various building blocks of which a process leading to a location choice might exist. Sub questions 3, 4 and 5 will have an analytical character, but are formulated in such a way that their answers will be useful within the context of the main question. Each analysis sub question provides for the formulation of a list of requirements for locations of new small dams.

The first analysis sub question will address the institutional framework:

3: How does the institutional framework of the Federal District in Brazil influence the process leading to a location choice for new small dams?

- In the theoretical framework this sub question will be addressed in the context of the interplay between technical or physical aspects, the institutional framework and the stakeholders involved. Furthermore, the relation between trust, good governance and the institutional framework in Brazil will be considered in paragraphs 2.1.2, 2.1.3 and 2.1.4

- The answer to this sub question has been sought carrying out a desk study (literature study of existing research, conference papers, laws and policy documents and master thesis reports) and a field study (interviews with stakeholders and people working for institutes involved)
- Results related to the answer to this sub question consist of an overview of laws, rules and guidelines, a list of institutional requirements for locations of new small dams, and knowledge of the formal interactions and relations between institutions and stakeholders

The answer to this sub question can be found in paragraph 4.3

Of course, the institutional framework does not act on its own. The way things are shaped might not always be how they really work. How this discrepancy might hamper or support the process leading a location choice for new small dams is covered by this sub question.

The second analysis sub question will address the role of stakeholders in the PRB in DF and their possible influence on the location choice for new small dams.

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

- Stakeholders and their role in both processes and institutional frameworks are subject to theoretical consideraions about the interplay between physical aspects, the institutional framework and stakeholders involved. In addition, the parts of the theoretical framework regarding trust, governance and accountability specifically address the roles and positions of stakeholders in processes characterized by involvement of governmental institutions. See paragraphs 2.1.2, 2.1.3 and 2.1.4
- The methods used to find an answer to this sub question are: desk study (literature study of existing researches, conference papers, newspaper articles, web pages and master thesis reports) and field study (interviews with stakeholders and people working for institutes involved)
- The search for an answer to this sub question also leads to an overview of stakes and stakeholders and requirements from a stakeholder point of view for locations of new dams.

The answer to this sub questions can be found in paragraph 4.3

The last analysis sub question addresses the physical system, being the DF part of the PRB. Some characteristics of the physical system influence the perceived suitability of a location for a new dam, others are not. Furthermore, the physical system has some characteristics particularly dependent on the disposition of the area. In addition, new small dams will have some impacts on this physical system that are specifically related to their location. That is why sub question 5 focuses on impacts that are connected to the dam location.

5: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be recognized?

- The role of a physical system in decision-making processes is addressed in paragraph 2.1.2.
- Available data have gathered and studied during a combined field and desk study. Data of earlier researches have been collected and processed. summarized and structured requirements and constraints as formulated earlier)
- The results generated are a list of location requirements for new small dams and a collection of well-organized data concerning demands and supplies in the PRB in DF

The answer to this sub question can be found in paragraph 5.5

The next step is to investigate which of these characteristics can be influenced externally in such a way that they become options or variables within the process leading to a location choice for new small dams. This addressed by sub question 6. Where sub question 5 focuses on various system parts, sub question 6 takes system behaviour as a point of departure.

6: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be influenced by policy-makers?

- Theory concerning this sub question is presented in paragraph 2.1.5, which deals with theoretical concepts related to modeling in policy decision-making
- The method used for finding an answer to this sub question is water balance accounting (modeling)

- Results are (1) knowledge about the behaviour of the PRB system in DF when new dams are implemented, (2) knowledge about the use of a water balance accounting model in the process leading to a location choice for new small dams and (3) a list of requirements for locations of new small dams

The answer to this sub question can be found in paragraph 6.3

The separate analyses and the system behaviour study will generate lists of requirements for locations of new small dams. These lists will be integrated into one Programme of Requirements (PoR) in order to serve as input for the process leading to location choices. Integrating the requirements for locations of new dams is addressed in sub question 7.

7: What are requirements for locations of new small dams, based on the institutional framework, the stakeholder situation and the physical system?

- Theory dealing with the PoR is presented in paragraph 2.1.6.
- The only method used for assembling the PoR is a desk study, by means of which requirements generated earlier in this research are moulded into one PoR
- This question results in a PoR concerning (the process leading to) a location choice for new small dams

The answer to this sub question can be found in the interlude starts on page 124 – Interlude.

The main question does not only mention requirements for locations of new dams, but also how these requirements can coherently contribute to the process leading to a location choice. This contribution is latently related to the way the PoR is assembled, formulated and applied. Sub question 8 takes the application of the PoR into account in order to make it useful and contributing in the process leading to the eventual choices for locations of new small dams.

8: Which institutional arrangements must be designed to accompany the decision making process leading to a location choice for new small dams?

- The part of the theoretical framework related to this sub question is presented in paragraph 2.2, which deals with the implications of theoretical considerations for the

process leading to a location choice for new small dams

- Methods used to find the answer to this sub question are design activities
- Results encountered when answering this sub question are (1) a critical reflection of the decision-making process leading to a location choice for new small dams; (2) a set of integrative institutional arrangements that test the translation of requirements of stakeholders, institutions and the physical system into a PoR; and (3) the place of these arrangements in this process.

The answer to this sub question can be found in paragraph 7.3

1.4. Definition and demarcation of this research

Although the research goals and questions already demarcate the area within which this research takes place to some extent, additional aspects related to the subject of small dams or reservoirs fall outside its scope.

A demarcation of the research area has been made partly because of choices regarding emphases and foci of the role of this research in the process leading to a location choice of new small dams, but also partly due to consequences of being involved in this process and flowing along with it while conducting the research. In other words: some demarcations are based on choice and pragmatism, and others on hurdles and "damage-control."

What is involved: definition

The types of research conducted in this project must be consistent with the objectives posed in paragraph 1.3. Minimal requirements for locations of new small dams are formulated and shaped in a useful way regarding the continuation of the process leading to the eventual location choice. To this end, this research entails:

- An assessment of ensembles of new small dams as a large-scale irrigation infrastructure project and its influence on water use, water policy and stakeholder behaviour in the PRB in DF
- An assessment and proposed alteration (enhancement) of the process that consists of the link and interplay between (local) policy, stakeholders, institutions and the water balance in the PRB in DF
- The influence of new small dams on the water balance in the PRB in DF based on water balance accounting

These three points indicate what kind of subjects and areas are explored in such a way that they contribute to finding answers to the main research question. They also define the perspective from which the problems recognized are approached in this research.

Beyond this, these points incorporate a vast amount of subjects that can be potentially researched. In order to prevent superficial investigations of the areas mentioned above and because of time constraints, some subjects must be "sacrificed" for a satisfying progress of this research.

What is not involved: demarcation

The subjects listed below are mentioned because they can easily be expected to be included in this research, while they are not. For each point, a short explanation about why it is not involved in this research is provided, as well as the reason why it does not influence the quality of the research/results to leave out that particular subject.

- A cost-benefit analysis on alternative locations for new small dams will not be carried out. Eventually, a cost-benefit overview of locations, materials and long term water use is crucial, but there are basically two reasons why it is left out of this research. Firstly, there is a significant time constraint. A cost-benefit analysis will only be useful if it is carried out thoroughly and completely, otherwise it will not add any valuable decision information. Secondly, a cost-benefit analysis carried out now will have to be changed significantly in a later stage of the process leading to a location choice for new small dams. This research aims at clarifying partly how the process leading to this choice should run, so alternative locations will not be known directly after this research has been completed. Whenever location alternatives are decided upon and investigated, the cost-benefit analysis will gain relevance
- Water quality is an aspect of the PRB that is likely to be important to various stakeholders. The importance of it will be recognized and elaborated on during this research, but specific influence of small reservoirs on the water quality will not be investigated. The most important reason for not going too deep into water quality or environmental quality is the knowledge framework of both this research and the researcher involved. However, the results of this research do not have to suffer from the absence of in-depth forecasts of water quality parameters, because of two

reasons. Firstly, it can be left out without damaging the credibility of results of any other (technical) aspect (e.g. water balances[1]). Secondly, the recognition of water quality being important can already lead to the right kind of requirements for the current stage of the decision-making process concerning locations for new small dams

- Multi-dimensional flow models or boundary conditions for those models are considered to be falling outside the scope of this research, because of the scale at which this kind of models contributes to generating relevant information. As indicated in the definition-part of this paragraph, the PRB in the DF is the geographical basis of this research. Implications of new small reservoirs affect a large system, in which the interplay of technical, institutional and stakeholder aspects is the point of departure for analyses carried out in this research. Behaviour of river reaches at a small scale are important when conducting a specific study to the construction of one small dam, which will have to take place after this study has been completed
- Irrigation, modernization and water use efficiency are also concepts that are not addressed in this research, although they could be relevant research subjects. The reason for not involving them fully is related to the reasons for leaving out a cost-benefit analysis: investigating irrigation, modernization and water use efficiency would be very useful, but at another stage of the decision-making process regarding agricultural development of the PRB in DF. Nevertheless, the subjects mentioned have impacts on the way results of this research must be interpreted; especially results regarding behaviour of the physical system. Intense knowledge of these subjects might change the analysis approach of physical system behaviour, but is likely to do so at a smaller scale (i.e. not on the PRB in DF scale, but at a river-reach or community scale)

1.5. Results of this research

This research provides for the absolute minimum of requirements, which a process architecture leading towards the implementation of new small reservoirs in the PRB should

[1] The other way around (water balances' influence on water quality) would probably be more problematic, but this can be researched separately and at a later stage.

meet. For this purpose, there will be drafted

- A clear institutional overview that gives policy makers the opportunity to understand where, when and how to act when drafting a process architecture leading to the implementation of new small dams in the PRB in DF
- An overview/model of the water balances of the PRB within DF, allowing for policy makers to see what happens to the system when small dams are implemented and to communicate about stakeholders' preferences
- A combination of the two: a set of institutional arrangements for the institute responsible for the implementation choices concerning (locations of) new small dams, regarding physical, institutional and stakeholder requirements and constraints.
- Another usable end product of this project consists of recommendations about the complete set of requirements that are prerequisite for a successful process leading to useful new small dams that address the problem of water scarcity during the dry season limiting the possibility to extend irrigation in the PRB in DF of Brazil.

1.6. Research approach and methods

A structured approach helps when finding answers to the sub questions – and so does a structured way of presenting this. The structure of this research is based on two factors. Firstly, a research framework helps shaping the analyses and other research activities into a mould that also fits this particular research (see paragraph 1.6.).

Secondly, the sub questions indicate what kind of research has to be carried out, and how these various parts of the research are structured in such a way that they result in one cohesive end-product. This structure is also drafted in paragraph 1.6.

Both research and presentation are structured by four parts that are also displayed in Figure 1.2:

Part 1: A research framework to get familiar with theoretical concepts and backgrounds of this project

Part 2: An analysis part for institutional and stakeholder analyses and for gathering data about the physical system

Part 3: Modeling technical information such as water balances to generate decision information; and

Design of a set of institutional arrangements that tests if the Programme of Requirements lists all the minimal/relevant requirements

Part 4: Interpretation of results and conclusions on the research and research processes

1.6.1. Methods used in this research

There are two levels of research that must be approached systematically. The first level is the overall research that divides the research in researchable parts, and at the second level there are the separate parts of this research, each of which a specific method must be applied for.

Bandaragoda (2000) provides an interesting framework for institutional analysis in a water resources management context. As already mentioned in paragraph 1.3, this research focuses on the interplay between technical, institutional and stakeholder aspects of the problem that is recognized in the PRB in DF. Moreover, these three aspects are going to be analyzed separately and integrated afterwards. The framework mentioned before supports this approach and indicates more specifically what kind of factors usually is important in a water resources management context. A critical note can be made regarding the initial focus of the framework on institutional analysis and eventual design of institutional arrangements. However, the definition of institutions provided by Bandaragoda (2000) (and cited in paragraph 2.1.2) as well as the indicated application of his framework makes it both useful and relevant in the context of this research.

His framework has been modified nevertheless. First of all, a case specific literature study has been added under the physical system study component. Second of all, the intended output of the framework has been changed from "Developing Effective Institutions" into "Design of arrangements," which has to do with both the scale of this research and the actual case characteristics. After all, the goal of this project is not to design new institutions.

Thirdly, the structure of the framework has been changed; a chronological element has been incorporated. The new structure fits the approach of phases within this study: first analysis, then modeling and design. Output of the analysis is the transition between these phases that is formulated as "performance".

The eventual framework is presented in Figure 1.1. The subsequent paragraphs describe

the specific methods of the separate building blocks.

Physical system and case study

The physical system within which this research takes place is the PRB in DF. Characteristics of this system that are relevant for this research are water resources, system infrastructure (rivers), topology and case characteristics related to one of these issues. A literature study helps to understand concepts that are relevant in this research. Such a literature study is executed partly before the practical studies are initiated (desk study), and partly during the practical process (complementary desk study). After all, some factors are only recognized as being relevant after some experience with the case in the field.

A field study in this case means gathering data on the local institutional framework, by means of conversations, interviews, analysis of projects and formal processes. A stakeholder analysis approach complements this. If gathering technical information is possible as well (for example in order to reduce time needed for modeling activities), this should be considered part of the field study as well. The case study approach has been loosely based on Yin (1994).

Institutional framework analysis

The basis of the institutional analysis in practice is information collection by means of interviews and conversations, verified (or complemented) by institutional literature study. Methods of Bandaragoda (2000) will be complemented with the work of Ostrom, Gardner et al. (1994) Plans, laws and systems exist that are the roots of institutions with executing power, right of initiative or monitoring functions. Because of cultural differences between Brazil and the Netherlands, this research is very dependent on the information transferred in official and informal meetings. Documentation a posteriori is to provide structure for this approach.

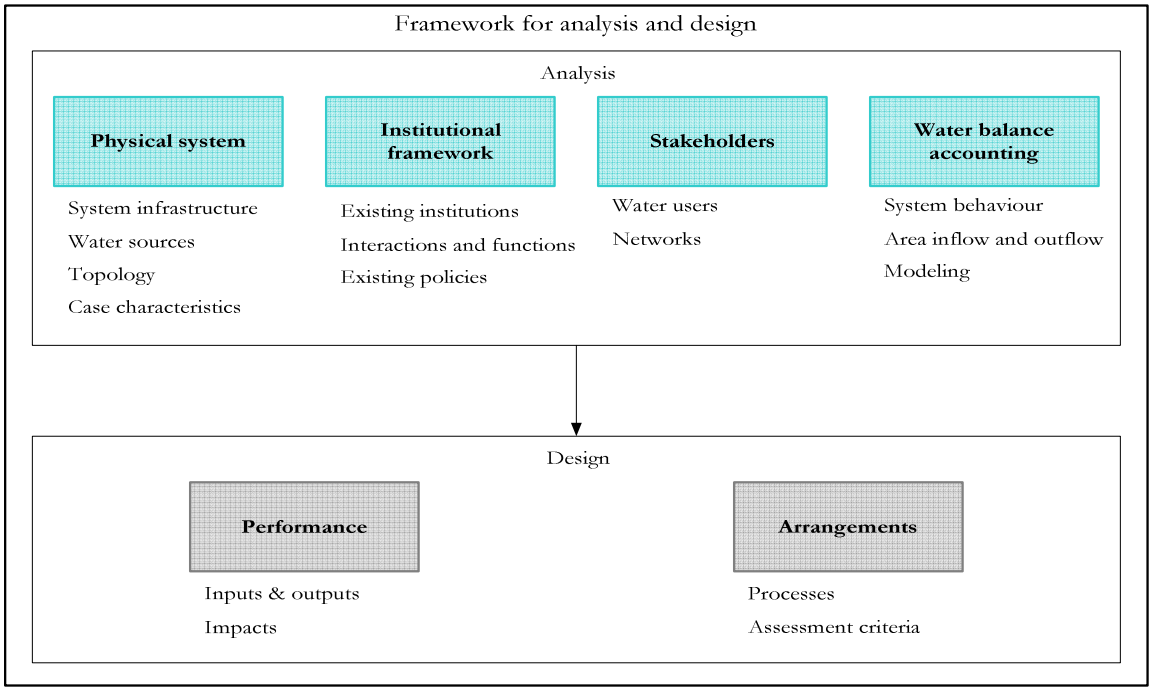

Figure 1.1 Framework for analysis and design in a water resources context. Adapted from: Bandaragoda (2000).

Stakeholder analysis

An historical overview and summary of earlier activities executed in both the Small Reservoirs Project and new small reservoirs in the PRB provides for a good starting point for collecting knowledge of parties involved, sensitivities in processes and stakes represented. This part of the study leads to an inventory of water users and their networks, stakes and goals.

Subsequent methods used are interviews with parties involved in the existing process, field visits and informal talks.

All this information must be mapped in a structured way; the tools of Enserink, Koppenjan et al. (2003) to structure stakeholders' interests and perceived problems are useful here, as well as the tools that are summarized conveniently arranged by Hermans (2005).

Water balance accounting

Water balance accounting needs a method on its own: computer modeling. This part of the research contributes to interpretation of technical data (water balance) as well as

preparation for the design of an end product.

Water balance accounting means that system inflows and outflows in a water resources model on a basin level are regarded. The concept of water balance means that from a physical point of view, outflows must equal inflows and vice versa. In water balance accounting models, the water balance point of view provides for a starting point when calculating how much water is available for human activities to be carried out (Molden 1997; Yates, Sieber et al. 2005; Becu, Neef et al. 2008).

Design: Performance and arrangements

The methods for this phase consist of a synthesis of all the building blocks for this entire research. The design of an end-product depends on the requirements found and the analyses that have been conducted in advance. Consequently the actual method that is underlying is again the adapted framework of Bandaragoda (2000).

1.6.2. Structure of this report

Before continue reading this report, it is useful to consider the underlying structure: what kind of information can be found in which part of this report? The overall structure is divided into the four parts indicated in the previous paragraph.

In this introduction the problem and the research goal and –question are presented. After reading this part, the relevance of this Master Thesis project can be taken into account while reading the next parts. In addition, it is described what type of method/theoretical approach is used in the research.

Furthermore, part 1 "Research framework" explains theory related to the problem formulated as well as methods in chapter 2. In order to understand the steps taken in this research, one must comprehend the language of the field in which it is conducted. In other words, one must understand terminology, the general way of thinking, and *develop* an antenna for the kind of conclusions drawn from the information assessed. In addition, the consequent steps of the research are guiding for the quality of results obtained. Therefore, chapter 2 describes the most important theoretical concepts challenged and applied in further parts of this research.

Part 2 "Analysis" continues where the introduction stopped: chapter 3 explains what

happened in (recent) history in the project concerning small dams in the PRB. Moreover, this chapter reveals the focus of this research in terms of interests of organizations and stakeholders. Chapter 4 maps the arena bound by these dimensions, in terms of stakeholders and institutions involved. Part 2 is characterized by analysis-activities. The intention is to take the closest look possible into the "the way how to get things done" in decision-making processes in DF. Of equal importance is the analysis of water availability in the PRB that is presented in chapter 5.

Part 3 "Modeling and design" starts with chapter 6, in which a water balance accounting model is used to model the impact of new small dams on the PRB in DF.

One of the results of chapters 3 to 6 is an initial Program of Requirements (PoR): a list of aspects, which define the explicit requisites and conditions of locations to be chosen for new small dams. This list is purely based on the institutional and stakeholder research. Therefore, a short moment of integration between the areas of institutions, stakeholders and physical behaviour is reserved. This interlude encounters the interdependent relation between these separate approaches. Conclusions resulting from institutional analysis might be useful in regarding some technical problems. After all, it is the researcher who cuts reality into little pieces, so at a certain point, these pieces must be related to each other once more. In chapter 7, the design of a set of integrative institutional arrangements based on inter alia the PoR is realized.

Part 4 – interpretation – presents a reflection, conclusion and recommendations based on this research. Chapter 8 incorporates the reflection on among other things the theories used, expectations and outcomes of this research and limitations related to the role of the researcher. Presenting the reflection on this Master Thesis project before presenting conclusions is deliberate choice. With the reflection fresh in mind, the conclusions of this research can be interpreted in line with the reserves addressed in that reflection. Part 4 concludes with recommendations for further research and for continuation of the process leading to a location choice for new small dams.

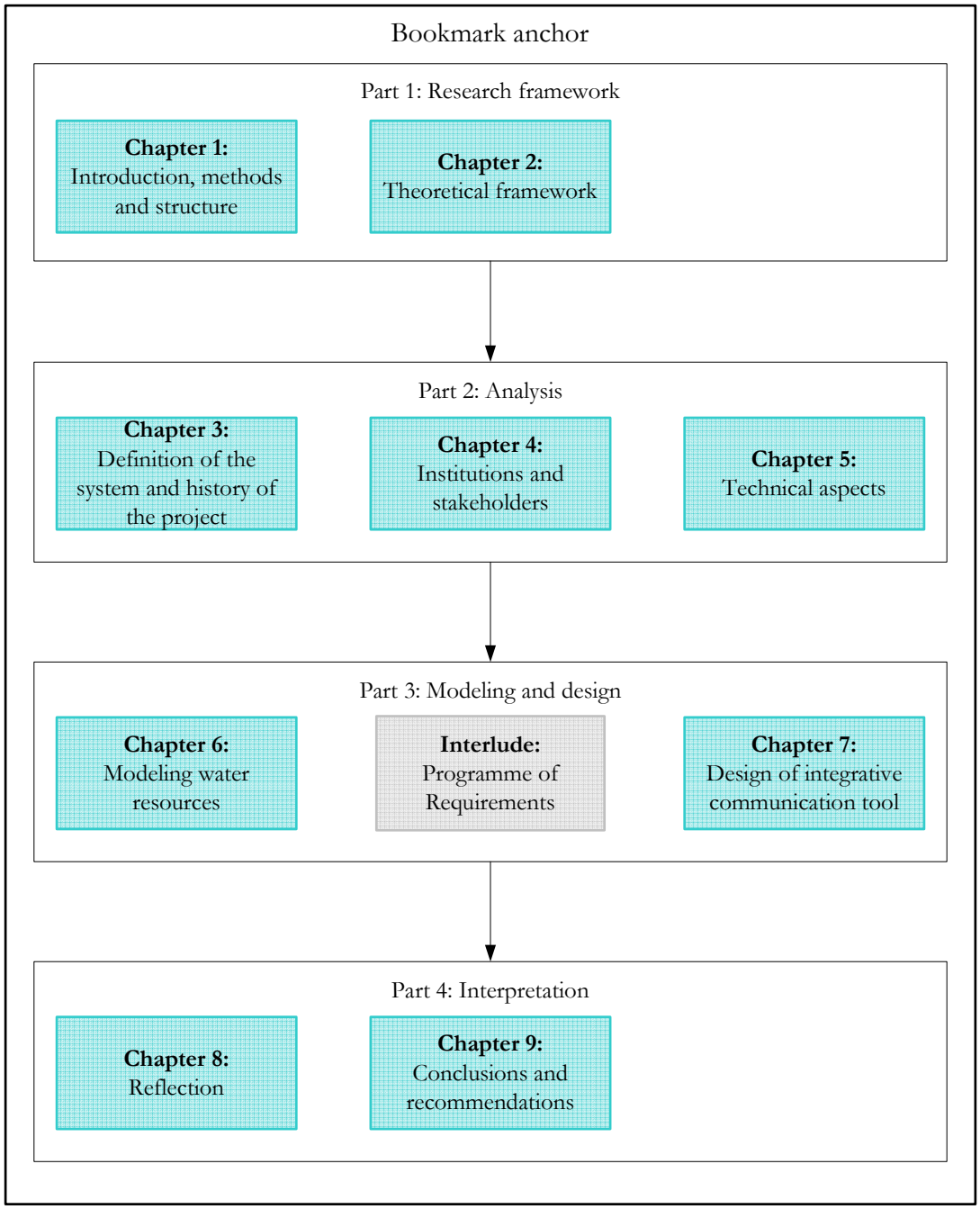

Figure 1.2 Bookmark anchor for this report

2. Theoretical framework

This chapter does not answer a sub question, but clarifies the concepts mentioned under each sub question. However, since the goal of this research is related to a choice of proper locations, this theoretical analysis also aims at describing the aspects that should be incorporated in making such a choice.

This project is practical in nature. Still, it is formulated and defined as a scientific project. This means that it bears the possibility of applying some current theory (at least), or questioning one (at best).

Therefore, this chapter is based on several theoretical pillars related to institutional theory, network and stakeholder theory, and the use of computer models in a decision making process.

Separating the theoretical framework rigorously from the analyses and design activities performed later is beneficial for two reasons.

1. It limits the confusion that is likely to exist between theory and practice when doing the analysis. Obviously, the theoretical framework will return in the 'practical' chapters, but mentioning the theory separated from the practical investigations first makes it possible for the reader to recognize what is theory, and what is experienced during the practical parts of the research
2. When interpreting results, the parts of the theory described can possibly be improved/change (based on practical experiences) stand out more clearly

In the introduction of this thesis, many theoretical concepts have already been touched upon. The concepts that capture the basis of the sub questions are elaborated explicitly in this chapter.

An attentive reader might be wondering why some concepts used in the practical part of this research are *not* involved in the theoretical framework. Much literature can be found about irrigation efficiency and modernization or on integrated river basin management, see for example Faci, Bensaci et al. (2000); also see Causapé, Quílez et al. (2005).

This research, though, has been demarcated. This means that theory falling outside its scope is not applied in the practical problem that is investigated. Irrigation efficiency is just one example of concepts that fall out of its academic scope. Integrated river basin

management is another example of a topic that involves virtually every subject, because of which it does not contribute to the focus of this subject.

Theoretical concepts will be listed and elaborated in section 2.1. Conclusions and useful contributions to this research will be addressed in section 2.2.

2.1. Relevant theoretical concepts

The concepts listed in this section are part of the theoretical framework, either because they were already recognized as being important or because they were run into during this research. Moreover, knowledge gaps revealed by the main research question in paragraph 1.3.1 can partly be filled with insights in the theoretical framework related to the process leading to a location choice for new small dams in the PRB in DF. Either way, each concept addressed will be referred to during the practical analyses as well.

Each part of this paragraph explains the theoretical framework behind a (set of) sub question(s). Therefore, each sub question addressed in the following theoretical considerations is repeated. This indicates the relevance of the theories addressed, while it should not mislead the reader, because the sub question(s) mentioned will not be answered in this chapter.

2.1.1. Socio-technical system

This paragraph mentions system behaviour, which refers to the system within which new small dams are going to be constructed. It is necessary to understand what a system is, what kind of system is observed in this research and which components can be recognized. The sub question addressed in this paragraph is:

1: Which changes in system behaviour caused by the process leading to (a location choice for) new small dams do stakeholders expect?

A water system such as a river basin can relevantly be observed as a socio-technical system (Van Daalen and Thissen 2003; Veeneman 2004; Weijnen and Bouwmans 2006). A socio-technical system as formulated by Weijnen and Bouwmans (2006) is an integrated system, whereby integrated refers to a combination of physical and stakeholder networks, each bringing about a certain amount of complexity. The socio-technical concept has been

examined thoroughly by Trist (1980), who described the slow process of seeing social systems as complementary and finally part of technical systems. He also described how this paradigm shift influences strategic decision-making. Theoretically, he regarded the concept on three levels:

1. Primary work systems: Small groups or a number of groups that has clear tasks, goals, resources and equipment.
2. Whole organization systems: Everything between self-standing workplaces and corporations or public agencies that "persist by maintaining a steady state with their environment."
3. Macrosocial systems: An example of a macrosocial system is formed by "media." The media are no organizations per se, but they are socio-technical phenomena.

Trist (1980) furthermore warns for the temptation to regard all (complex) systems to be socio-technical ones. Because of the socio-economical aspect of system users on the one hand, and the hydrological and hydraulic performance of the river and –branches on the other, a river basin fits the above definition of a socio-technical system. Still, adopting the socio-technical point of view has serious implications for how to analyze a situation, system or problem. When analyzing a system, a consistent approach is necessary to address various aspects and boundaries of it. Such an approach is provided for in paragraph 2.1.2.

Lessons learned

The most important lessons we can learn from theory concerning socio-technical systems, also summarized in Table 2-1 are:

- That there are various levels, which a system can be observed at, and that we must be consistent in the chosen level of observation. In other words, the right scale has to be chosen.
- That it is important to resist the temptation to simply regard every system as a socio-technical one
- It is suspected that it is also important to be flexible as to when a system must be regarded as a socio-technical one. Perhaps, it is useful to leave out either the technical or the social aspects at certain points in the process.

Table 2-1 The socio-technical concept in this research

Paragraph	Concept	Relevance for practical research
3.1.1	Socio-technical system	▪ Regard a river basin as a socio-technical system, but be flexible in doing so ▪ Consider the system at the right scale ▪ Do not involve every aspect the whole time

2.1.2. The TIP-approach

The previous paragraph showed how a socio-technical system needs an approach that respects the various components of such a system, but that also provides for a way to interpret the system behaviour in an integrated way. This research addresses three distinct components of the socio-technical system that the PRB in DF forms, captured in three sub questions:

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

5: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be recognized?

These three components – institutional framework, stakeholders and the physical system – are placed in the theoretical framework in this paragraph. The next question mentions design of institutional arrangements. Although this paragraph does not mention design, an idea of what institutional arrangements are and their significance in the context of this research is also drafted.

8: Which institutional arrangements must be designed to accompany the decision making process for locations of new small dams?

This research is divided into an analysis phase and a design phase. The analysis should lead to the discovery of information with which design alternatives can be drafted. Since a design is created for a specific situation, the analysis should discover "special characteristics"

of this situation. In other words, the analysis phase of this research is carried out to find out what are the characteristics of the situation in the PRB: What makes the situation special?

Adopting the perspective of reality as a socio-technical system has various implications for the approach of this research. As a frame of reference, three basic dimensions are recognized.

1. An institutional dimension: organizations and rules (Klijn and Koppenjan 2004)
2. A stakeholder dimension: interests of and interactions between stakeholders (Bruijn, Heuvelhof et al. 2002; Hermans 2005)
3. A technical dimension: physical system (Bandaragoda 2000)

These concepts are clarified further below. Observing these three dimensions of a socio-technical system can be called the TIP (technical, institutional, process) approach, where the P of TIP refers to stakeholders and their networks.

The reason for carrying out the research with a TIP-approach has not been clarified yet, however. Analysis from a TIP-perspective is carried out with a purpose: a list of requirements for the design of a product that lies within the solution space for a problem. To understand the concepts of "problem" and "solution space," reference can be made to much literature (Dym and Little 2004; Herder and Stikkelman 2004). A quick understanding can be obtained, however, by considering the classical (and highly simplistic) example of two parties that need oranges for their operations (Fisher, Ury et al. 1991). Suppose there is only one orange available. A problem exists for both of the parties, as both of them need the orange. Both companies perceive the situation as problematic: the expected outcome of the situation might be disadvantageous compared to the ideal outcome. The solution space in this case is shaped by a division of the orange.

This is where the TIP approach comes in: To divide the orange, information about the size and shape is necessary (technical analysis). Furthermore, since the companies have a perception of the situation as it is, their interests, wishes and position must be specified (stakeholder/network analysis). Additionally, the division must be "fair" in a verifiable way (institutional analysis). This means that a format must be found in which both companies agree with the outcome in advance, even though this outcome may be disadvantageous for

one of them (think of contracts, an appointed judge, or a form of cooperation).

In the orange example, both companies needed another part of the orange. One company turned out to want the peel, whereas the other company desired the flesh of the fruit. This was the result of the respective goals of the companies: making perfume and respectively production of orange juice.

The TIP approach is a rather complete one in decision-making procedures. An additional example exemplifies the TIP framework: a married couple picking a new couch.

- Technical dimensions: various aspects such as durability, intended time of use and size can be recognized
- Institutional dimension: the couch is going to be family property (property transfer, contract).
- Process dimension: How to decide which couch is suitable? Are there pets in the house, is the couch going to be used for children, or does it fulfil an ornamental function?

As we can see, a certain overlap exists between the three dimensions. Intended use might be perceived as a technical dimension. As we will see later, positioning decision information under one of the three dimensions can have strategic implications.

Institutions

One confusing part about institutions is the variability of definitions. There are basically two different kinds of definition, the first of which can be summarized by "the rules of the game" and alike. The second one has a less abstract significance. In this case, institutions are organizations with public responsibility.

Social interactions are framed by rules. Institutions are often referred to as "rules of the game," whereby "the game" is a history of (a set of) interactions between different parties. To avoid substitution of "institution" by "rule," this definition has been extended. North (1990) defined institutions as "the rules of the game in a society, or more formally, the humanly devised constraints that shape human action." Still, this definition is consistent with the variety of instances of institutions. The function of institutions, which devolve out of habits or situations lacking clarity, depends on the actual situation in which the institution is established.

Merrey (1993) adopted an evolutionary approach, by regarding institutions as rules that survive because "they are patterns of norms and behaviours which persist because they are valued and useful." Rules are not shaped by people or society, but evolve and sometimes sustain. When they are valued useful, they stand a chance of becoming a part of society indeed.

Bandaragoda (2000) distinguishes between organizations and institutions and notices the danger of mixing up the two concepts. He also lists forms of institutions, without excluding the possibility for some variation:

- policies and objectives
- laws, rules and regulations
- organizations, their bylaws and core values
- operational plans and procedures
- incentive mechanisms
- accountability mechanisms
- norms, traditions, practices and customs

The various definitions of institutions listed show how there is a distinction between abstract forms of institutions (rules, norms, objectives) and "tangible" ones (organizations, institutes). For this research it must be sorted out which type of institutes is most influential.

Now that the concept of institutions has been clarified, their meaning in the context of the TIP-approach deserves some attention. One could regard the objective of this research as to find a way to decide upon locations for new small reservoirs. The institutional analysis results in two main knowledge extensions:

- Knowledge of how things work in DF, or how to "get things done"
- Criteria and constraints for a successful process (not hampered by institutional failure)

The first point refers to both the rules in place in DF (the Douglas/Merrey/etc. definition) and the organizations with responsibilities over these rules (Bandaragoda-definition).

The second point appears to be soft or abstract, but it is not. In traffic, for example, the rules clearly contribute to successful transport. More importantly, almost every situation of failure can be appointed to a sequence of actions inconsistent with the rules: a traffic

accident happens because at least one of the participants did not obey one or more rules.

Stakeholders

Stakeholders can be specified sometimes, but often "it is not clear how to accommodate various interests." "Shaping of a project depends simultaneously on task complexity and the degree of development of institutional arrangements." (Miller and Olleros 2000).
A definition of stakeholders as groups provided by Miller and Floricel (2000) describes how "Stakeholders are interest groups that can affect the performance of corporate objectives and are, in turn, affected by the achievement of objectives and by cospecialized parties, upon which sponsors depend for continued survival." Stakeholders are active in processes, such as decision-making processes or policy processes, because of the stakes they want to see represented in future developments. "A process approach maps which parties have an interest in the decision making and what their resources are." These parties are called stakeholders (Bruijn, Heuvelhof et al. 2002).

However, according to these authors, it is both very hard and very important to involve the right stakeholders in a process, because "it may (…) be unclear what stakeholders are necessary to enrich the decision making." The analyst can be wrong, but stakeholders can also refuse to expose themselves because of their unwillingness to cooperate.

That the influence or importance of stakeholders may vary has been clarified by Grimble and Wellard (1997). The importance of a stakeholder analysis is important, and these authors list a number of complicating characteristics in which this importance in particularly significant, one of which is a context of "natural resources."

After listing many incomplete and context-dependent definitions of stakeholders, according to Bryson (2004), "[s]takeholder analyses are now arguably more important than ever because of the increasingly interconnected nature of the world."

Technical aspects

The technical analysis (part of the TIP-approach) explores the quantitative characteristics of the defined problem. Boldly stated, the technical analysis incorporates everything that is calculable and measurable.

In terms of Bandaragoda (2000) the technical analysis could be defined as a combination

between the description of the physical system and water balance accounting activities.

Of course, the results of calculations, models and technical analyses must be interpreted and placed in the context of a problem.

Lessons learned

Some important lessons for the practical part of this research are summarized in Table 2-2. The most important one is related to the added value of temporarily cutting up a system into pieces. Furthermore, the system regarded in this research does not only fit the definition of a socio-technical system, but the existing problem can also be approached from a TIP point of view. One major pitfall is of course that during the analysis part of this research, the idea evokes that the TIP-approach is "sacred." For the sake of credibility, this pitfall will be surpassed during the analysis part of this research and only honestly referred to in chapter 8. Another pitfall rises from the separate approach of various parts of the system. Reality, however, is a holistic concept. Results regarding these separate parts can only be considered valuable when the separate parts are integrated into a shape concedes to the holistic nature of the recognized problem.

Table 2-2 The TIP concept in this research

Paragraph	Concept	Relevance for practical research
3.1.2	TIP-approach	▪ Use TIP approach as a point of departure for analysis ▪ Keep in mind that it is not sacred ▪ Do not forget to integrate afterwards

2.1.3. Trust and governance

Sub question 2 addresses the history of the process leading to the implementation of new small dams in the PRB in DF. This sub question is supposed to reveal (among other things) the interface between the institutional framework in DF and stakeholders involved in the small dam project (respectively incorporated in sub questions 3 and 4).

2: What is the history case history of small dams in the Preto River Basin in the Federal District?

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

Why should we be interested in relations between government and citizens expressed in trust? Various reasons can be listed. First of all, the relation between trust and citizens' compliance with governmental initiatives is made evident by Levi (1996). Figure 2.1 shows how governmental commitments to a project and fair execution of procedures contribute to the likeliness of people to comply with the government. What stands out directly is the amount of characteristics owned by the government that determine the probability of citizens to comply. As the author has eloquently put it herself: "[a] basis of trustworthiness is the encapsulated interest of the government stakeholder to honour his or her agreements or to act according to a certain standard." This point of view is conceptualized as follows: governmental behaviour can be expressed in terms of commitment and the plausibility of existing procedures. This behaviour affects the trustworthiness of the government, which is also influenced by the amount of information concerning rules and procedures that is publicly available for parties involved in a relationship with the government. The trustworthiness of the government is closely related to citizens' compliance. A result of this compliance is the ethical reciprocity rate: non-compliance of citizens despite a high trustworthiness of the government leaves room for the government to adapt its behaviour. Ethical reciprocity is also influenced by information concerning rules and procedures that is publicly available: it will be difficult for citizens to comply with rules that they are unaware of. Lastly, ethical reciprocity also affects compliance directly. A non-reciprocal citizen will not comply with governmental interference, even if this government has proven itself to be helpful in the past.

A second reason to focus on trust between parties with different responsibilities and accountabilities is provided for by Goodin (2003), who addresses how trust and trustworthiness become especially relevant in the situation where two parties do not *have* to cooperate. Goodin mentions this relevance in a context of accountability of institutions such as a government. This accountability can be related to the afore mentioned "interest of the government stakeholder to honour his or her agreements;" it expresses more or less the same.

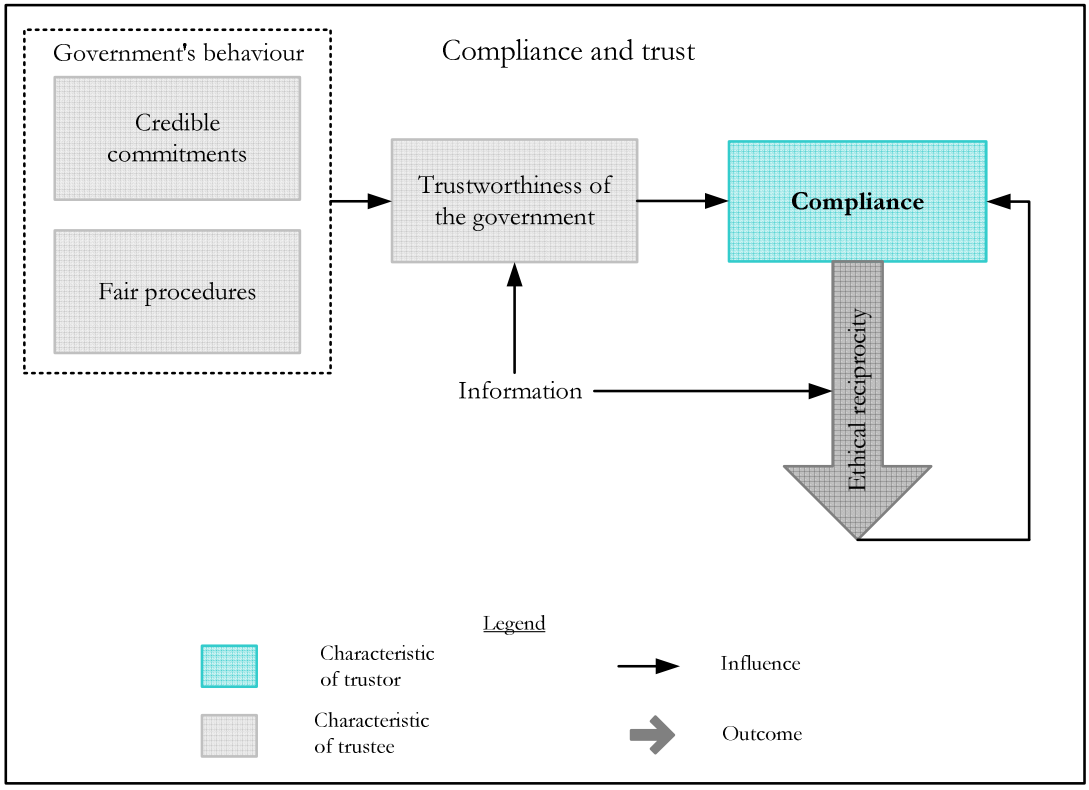

Figure 2.1 Compliance and trust. Adapted from: Levi (1996)

Thirdly, lack of other contracting structures leave *risk* to be a part of the trust relationship between two parties (Mayer, Davis et al. 2006). The existence of trust in a relationship does not only explain risk taking, it also justifies risk taking in this (professional) relationship. So trust can be a reason to take risk, but lack of trust is an equally logical explanation for risk-aversive behaviour in a relationship. This mechanism is explained in Figure 2.2. On the one hand, there is a party that trusts another party to a certain extent: the trustor. This trustor has a tendency of trusting other parties (trustor's propensity). The trustor is looking for a way to determine the amount of risk he is willing to take in a relationship, which will be dependent on the risk the trustor *perceives* to be present. The perceived risk, on its turn, is dependent on the trust that exists between the trustor and the trustee (the other party in the relationship). The existing amount of trust is dependent on the trustworthiness of the trustee, which consists of three characteristics owned by the trustee:

1. Ability: What are the competences within specific domains of the trustee that make him trustworthy?

2. Benevolence: The non-egoistic (non-economic?) thrives of the trustee to let others reap the benefits of his/her actions.
3. Integrity: A more abstract characteristic of the trustee, which is, however, not to be determined by the trustor, but rather by the trustee's track record (justice, etc.).

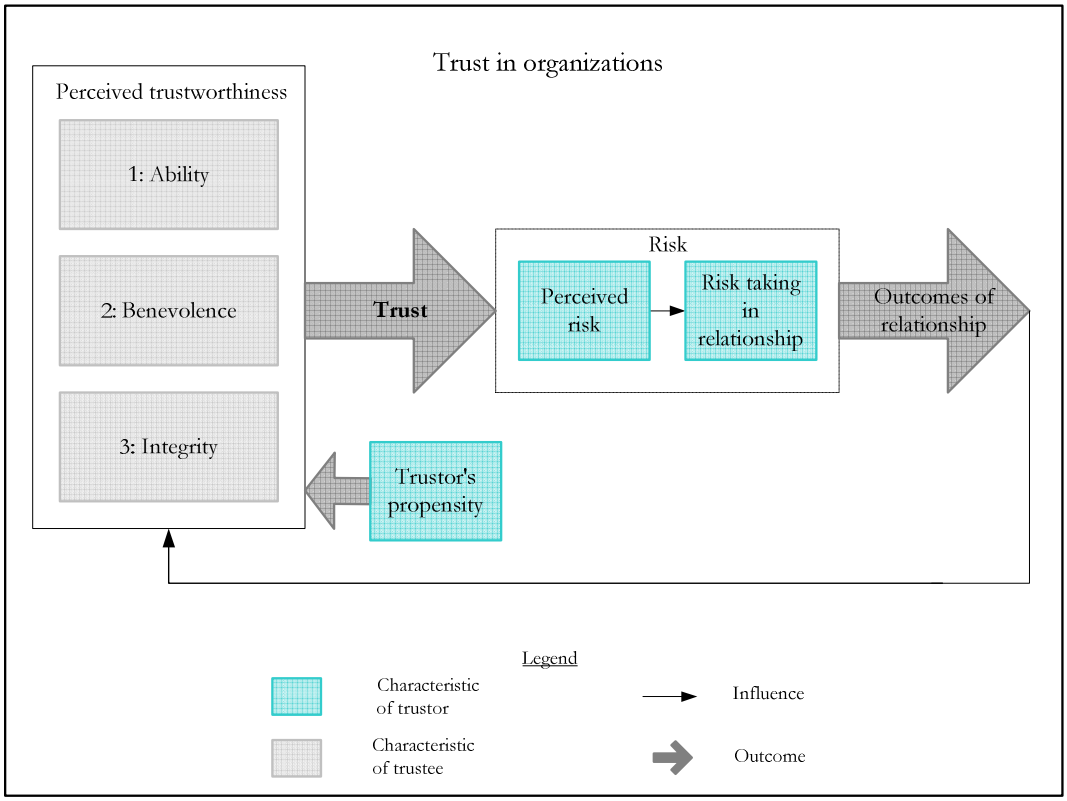

Figure 2.2 Integrative model of trust in organizations, adapted from: Mayer, Davis et al. (2006)

In the end, the outcome of a relationship also influences the trustworthiness of the trustee. If the trustee lied, this will be to the detriment of his trustworthiness and to the trust that exists between the trustor and the trustee.

Klijn and Koppenjan (2004) define trust as "a (stable) perception about the intentions of other stakeholders. The trust of a stakeholder concerns the expectation that other stakeholders will refrain from opportunistic behaviour even when there is occasion for such behaviour." This definition clearly confirms that the concept of trust knows two directions:

- A forward direction (expectance): stakeholder x expects stakeholder y to behave in a

certain way

- A backward direction: stakeholder y has displayed behaviour that influences the perception and expectance of stakeholder x. Therefore: stakeholder x looks back at the record of stakeholder y. Did y display honesty/resist opportunistic behaviour?

As we can observe here, trust is not just a matter of earlier behaviour of the trustee. The level of trust is (equally) dependent on the impetus of the trustor to trust the trustee.

In this respect, trusting the government is a matter of expectation combined with the government's record of behaviour. As we will see in few lines and as recognized by Levi, the government has an active role in managing its trustworthiness.

Governance

Berger, Birner et al. (2006) recognize the problems of water uses and –users complexity in large-scale infrastructures, due to hydrological and socio-economic complexity. These authors pose the next questions regarding large-scale infrastructures in water resources:

"1. What is the capacity of local user organizations to manage interactions with higher-level organizations and with government agencies? And during the planning process, what is the impact of information asymmetries on the concentration of assets such as land resources?

2. How can competition between various water uses (here: hydropower, irrigation, and recreation/tourism) be reconciled in terms of quantity, timing, and quality? What are likely externalities for upstream and downstream water users?

3. What are the likely distributional effects of private concessions in terms of access to water and poverty alleviation? Will new infrastructure projects improve the security of water supply for current holders of water rights versus newly assigned water rights?"

Especially the first and last questions reveal which information is crucial to know before even starting to plan the development of new large water managing infrastructures. The first question evaluates accessibility and transparency of the government. The third question poses a fundamental question: will current water users not be damaged by new infrastructures? Will every stakeholder reap the benefits of large-scale irrigation projects?

These questions are not just a matter of well functioning infrastructure, but also of a well-functioning government. The authors presuppose information asymmetries, which can be justified by the fact that new large infrastructural project involves money, new rules and

intended results (constructed to address a problem).

The amount of literature on corruption in irrigation projects is small. It is a common phenomenon in engineering projects (Tanzi and Davoodi 1997), where it usually can be expressed as a percentage of the total project costs. Corruption is a sensitive term, and it covers a vast amount of definitions. For the sake of clarity (and openness), use an inverse approach of defining the theoretical concept of corruption (government malfunction) is used: the concept of good governance.

Good governance has been defined by the United Nations (Seng 2008) based on the next "performance indicators."

- Consensus (amongst various stakeholders)
- Participation (public participation, stakeholder participation)
- rule of law (and independent legal power)
- effectiveness and efficiency (as conscious objectives of governments)
- equity and inclusiveness (equal treatment and pro-active approach to include stakeholders)
- responsiveness (possibility to react and get a reaction of governments)
- transparency (openness of actions, procedures and processes)
- accountability (see paragraph 2.1.4)

All of these concepts are related to each other and have some redundancies in their significance, but a poor representation of one of these concepts already leads to diminished quality of governance. One could reason that the intended (on purpose) absence of one of the above principles corresponds to a corrupt governing style.

So now we have seen both the potential problems in large infra-structural projects in a context of natural resources as indicated by Berger, Birner et al. (2006), ánd the principles that are necessary to govern such a project successfully. Connecting the two reveals which principles should be represented in which problem:

- Interactions with higher level organizations (transparency and participation)
- Impact information asymmetries (accountability and equity)
- Effects of increased access to water and poverty alleviation (effectiveness and efficiency)
- Results of water rights allocation (consensus and transparency)

Although various UN definitions were placed at the distinguished parts of questions

posed by Berger, Birner et al. (2006) the most important part of good governance is participation, at least in this case. Participation is either a prerequisite for or a result of all the other aspects of good governance. That is, in water resources management issues.

Some hard numbers on trust in governmental institutions are provided for by the elaborate research of Moisés and Carneiro (2008). According to these authors, distrust in the government could mean that citizens expected an institution to have another function than originally intended by the institution itself. Figure 2.3 shows the actual trust of Brazilian people in their governments (middle line), the extent to which they prefer democracy as type of governance (top line) and their satisfaction with democracy (bottom line).

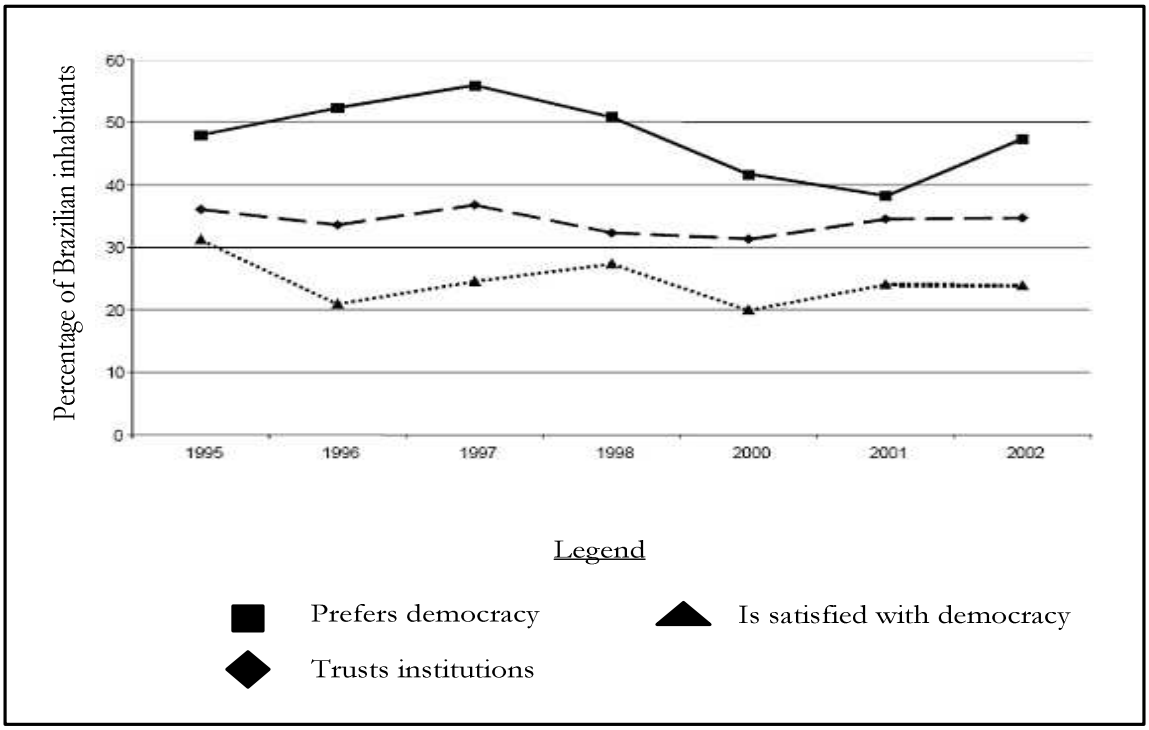

Figure 2.3 Development of democracy as a preferred alternative, satisfaction with the regime and confidence in politics in Brazil, 1995-2002. Adapted from: Moisés and Carneiro (2008)

Lessons learned

In the interface between the institutional framework and stakeholders, the trust relationship between government and non-governmental stakeholders is an indicator for the willingness of the latter to participate in the decision-making process. This trust relationship can be actively managed by the government. By showing "good behaviour" governmental

parties can safeguard a well-managed trust relationship. This can be expressed in terms of good governance and by making sure that stakeholders in a process are well-informed about the existing institutional framework and the procedures part of it.

Implications of these observations for the analysis part of this research are related to the current relationship between governmental parties in DF and stakeholders in the process leading to a location choice for new small dams in the PRB in DF. Also when analyzing physical aspects of locations for new small dams, interpreting the results of this analysis must be done while keeping the trust relationship between the government and other stakeholders in mind. The observations made in this paragraph useful fur the practical part of this research are listed in Table 2-3.

Table 2-3 Trust and governance in this research

Paragraph	Concept	Relevance for practical research
3.1.3	Trust and governance	▪ Trust can be actively managed from the government side ▪ Trust leads to acceptance of parties to take risks regarding governmental interference, e.g. stakeholder participation in a large infra-structural project ▪ Use good governance principles leading to trust in governance as requirements for institutional design of locations for new dams ▪ Analyze the relation between public institutes and other stakeholders ▪ Analyze from the perspective of both government and other stakeholders ▪ Keep trust and governance in mind while interpreting results of analyses carried out

2.1.4. Accountability in river basin management

In terms of the relation between the institutional framework and stakeholders in a decision making process, one issue that repeatedly evokes is the top-down vs. bottom-up structure of the institutional framework. This subject is represented in the next sub

questions:

2: What is the history case history of small dams in the Preto River Basin in the Federal District?

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

River basin management, and especially integrated river basin management, is a concept that is as popular as it is voluminous. This paragraph focuses on the aspects of river basin management related to governance and policy-making.

Accountability is a concept that can be interpreted in many ways. It can for example refer to individual responsibility for actions of public servants, or it can be used to measure democratic standards in governmental behaviour. In this context, however, "'accountability' is linked with the extent to which governments pursue the wishes or needs of their citizens (accountability as 'responsiveness') regardless of whether they are induced to do so through processes of authoritative exchange and control" (Mulgan 2000).

Brazil has known a federal form of state governance ever since the renewed 1988 constitution implementation (Presidência da República 1988). Democratic principles strut the way Brazil has been governed ever since. However, examples show how decision procedures have a highly top-down character (Branco, Suassuna et al. 2005; Moisés and Carneiro 2008). Top-down means that decisions are taken at high level governmental institutes and subsequently imposed on the lower levels of society and can be defined as "large-scale, short-term, technical solutions, mostly palliative in nature" (Branco, Suassuna et al. 2005). These authors would like to see a shift (particularly in drought management) towards bottom-up management, in which "small-scale, long-term measures which address the needs of the most destitute" will be strived for.

Not every author shares the opinion of this straightforward relation between bottom-up decision making and addressing the needs of the most destitute.

Wester, Merrey et al. (2003) for example, recognize how "most analysts recommend managing water based on river basins and increasing stakeholder participation in water management," but also that "[t]oo often, the participation discourse draws attention away

from the very real social and economic differences between people and the need for the redistribution of resources, entitlements, and opportunities," an example of which would be the fact that water can be a politically contested resource.

The answer to this difficulty is – obviously – that the success of participation depends on context and the specific characteristics of the river basin. In short (as stated by Wester, Merrey et al. (2003)):

"Although few would disagree that the institutions for managing river basins should be broadly democratic, where the boundaries of consent for river basin management are drawn is a political choice, and should be treated as such in current water reforms."

According to Abers and Keck (2006) the difficulty of current water management lies in the formulation of this shift from top-down to the more participative bottom-up structure. Tensions arising due to changes in power had a solution, which "was to build enough ambiguity into the legislation so that all sides could claim victory, leaving clarifications for the future."

Lessons learned

Accountability is one of the good governance indicators mentioned in the previous paragraph. It is one of the indicators that should be analyzed after all others are, because it is not a very straightforward one. More downward accountability does not lead to more content stakeholders.

In other words, the positive connotation of bottom-up structures that is often given by literature is in fact quite dependent on the perception of stakeholders involved in that structure.

Therefore, the attitude of stakeholders towards downward accountability and bottom up structures must be analyzed in the continuation of this research. See Table 2-4 for a summary of relevant aspects to take into account during the practical parts of this research.

Table 2-4 Accountability in this research

Paragraph	Concept	Relevance for practical research
3.1.4	Accountability	▪ If good governance principles are taken into account: analyze bottom-up vs. top-down issues

		▪ The positive connotation of bottom-up governance structures is only paradigmatic ▪ The attitude of stakeholders towards downward accountability must be analyzed

2.1.5. Modeling in policy decision making

Sub question 6 addresses the impacts of small dams on the physical system that are dependent on their location choice and that can be influenced by policy makers. A computer model is intended to support finding an answer to this sub question.

6: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be influenced by policy-makers?

Computer models can be of great help when large numbers of data need to be combined or processed. The interpretation of model outputs remains a matter of understanding the problem that has been modeled, though. In other words, models do not give answers themselves. In this paragraph the role of the output of a computer model in the decision making process is discussed.

Some computer models can be used specifically in the context of river basin management. One role a model can have in this context is addressed by Zagona, Fulp et al. (2001), who state that "[c]omputer modeling is necessary to efficiently manage the complex interactions between the numerous constraints and objectives over an entire basin."

These authors furthermore state how models can "improve efficiency by allowing more accurate, rapid and comprehensive evaluations of management alternatives. They can also improve communication and promote trust in adversarial situations when water managers and stakeholders have identical versions of a model to use in performing analysis for discussion purposes."

Thus, the threefold use of models in (water) policy decision making according to Zagona, Fulp et al. (2001) can be summarized as:

- Mapping relations, objectives and constraints
- Evaluation of management alternatives
- Communication between stakeholders with different interests

Daalen, Dresen et al. (2002) recognize the variety of models that exists. The differences between models "affect how models can be used)." Variety exists because an existing situation demands a certain approach (modeling ex post) or because a model builder expects a certain applicability of the model (modeling ex ante).

As for the functions or significance of computer models, Daalen, Dresen et al. (2002) notice that a computer model is not presenting "the" truth, and can be applied as catalyst for social processes (i.e. involving stakeholders). The place of a computer model in the "policy lifecycle" (a sequence of steps in policy making) depends on the actual role the model is supposed to fulfil, potentially and respectively being: Eye-opening, challenging and visualizing alternative futures, consensus creating, or assessing effects of concrete policies.

Lessons learned

Apparently, a crucial aspect of computer modeling in decision-making processes is a clear definition of the *role* and the *timing* of model use. The role of the model can be determined by either context or the client, but the timing has less flexibility with regard to the perceived usefulness and its function. Creating consensus by means of binding all available information in one model is considerably less useful during a policy implementation phase than during the policy implementation phase.

Both aspects, though, are highly dependent on context and process development. The model is an instrument that serves whatever predetermined purpose, but does not always fit the situation it has been designed for.

Expectations and actual role of the model used in this research are interesting to focus on after having used it, because the relation between role and intended function of a model in the decision-making process does not need to be straightforward.

The conclusions that are useful for the practical phase of this research are summarized in Table 2-5.

Table 2-5 The PoR in this research

Paragraph	Concept	Relevance for practical research
3.1.6	Computer models in policy decision- making	▪ Define which role the water balance accounting computer model has in this research ▪ Let the role fit the scale and stage of this research

2.1.6. The Programme of Requirements (PoR)

The main research question addresses minimal requirements for proper locations for new small reservoirs. Furthermore, these requirements must be shaped in a way that they are coherently contributing to the process leading to a location choice for new small dams. The word "coherently" refers to the distinct parts of the socio-technical system (being the physical system, the institutional framework and the stakeholders involved) that need to be integrated after analyses have been carried out.

However, the role of requirements and how to shape them is something that should be backed up by a theoretical framework, because requirements can have various meanings, roles and functions. The sub question that addresses requirements is sub question 7:

> ***7: What are requirements for locations of new small dams, based on the institutional framework, the stakeholder situation and the physical system?***

The word "requirement" in design literature is often related to concepts such as "functions" (Cross 1997). The word is intentionally avoided by Dym and Little (2004), who probably do not want to confuse the reader with related words such as goals and objectives, constraints, functions and implementations. With these words, however, these authors describe quite clearly which definitions "requirements" might cover.

Requirements are formulated within a problem situation, for which a product or an artefact is a desired solution. This means that there is a problem owner who wants to formulate his requirements for this solution. According to Darke and Shanks (1996) there are two distinct phases in defining requirements: requirement *acquisition* and requirements *modeling*. The former relates to elicitation and formulation of the requirements, the latter to the way the requirements represent the actual needs of a problem owner. Both of these activities are crucial for the final result: the solution to the actual problem.

Creating a framework of requirements for a specific situation enables the same set of requirements to be used in comparable situations (Michalsky 2004). So framing requirements makes it possible to save a lot of time, for example in a situation where many comparable units have to be designed in slightly different situations (such as small dams in a small region).

One remark must be made her. All the authors mentioned and more (Sage and Armstrong 2000; Herder and Stikkelman 2004) address requirements, the PoR or objective lists (whatever the synonym) as a crucial step in the *beginning* of a design process.

Lessons learned

Taking a short look ahead into the case of small dams in the PRB, it will be interesting to investigate the role of the framework of requirements for a location when the end-product (a small dam) has already been defined. Possible implications are a shift from product definition to product testing, from exploration of functions to function refinements, or from design of a product to product comparisons. The conclusions useful for the practical part of this research are summarized in Table 2-6.

Table 2-6 The PoR in this research

Paragraph	Concept	Relevance for practical research
3.1.5	Programme of Requirements (PoR)	▪ Let the PoR fit the scale of the research ▪ A framework of requirements for later use can save time ▪ Take into account that it is rather unique to define the PoR *after* knowing the eventual artefact (testing, comparison and refinement function)

2.2. Conclusions and connection to analyses

The next chapters will dive into the PRB and the practical problems that can be analysed there. What observations and conclusions of this theoretical analysis can contribute to defining how to make a choice about locations for new small dams? Table 2-7 summarizes the main points that can be derived from the theoretical analysis.

The River Basin can be regarded as a socio-technical system. It is very important to understand at which scale this system must be regarded in the context of the research that is going to be carried out. Some flexibility is therefore needed. During the first analyses, it is

possible to find out at what level problems substantiate.

Flexibility is also advisable with regard to the classification of the PRB as a socio-technical concept. Although it is important to be consistent in choosing an approach, the temptation to see everything as part of this concept must be resisted to maintain grip on reality. Perhaps, at some points in time, it may be wise to let go of the socio-technical concept. So sometimes it may be helpful to address separate parts of the system. Later, these parts can be combined. The TIP approach is a helpful instrument when studying the different aspects of the PRB from a socio-technical point of view. The need to recognize separate aspects of one system is backboned by this approach, which therefore is a starting point for analysis. However, integration of the different analyses and findings must take place before the problem in the PRB can be comprehended completely. As for a way to address the problems recognized, the same line of thought holds: integration of different components studied throughout analyses of the problem is fundamental for the credibility of recommendations concerning any kind of solution.

The proposed way to integrate information in the continuation of this research is based on a Programme of Requirements. When formulating requirements, it must be kept in mind that the eventual PoR joins to the scale of this research. Some of these requirements can be derived from literature, such as requirements related to good governance principles. These principles can obtain that status due to the relation between trust and compliance that has been recognized in this chapter. In an institutional analysis, interactions between public institutes (governmental stakeholders) and other stakeholders are important to understand because of the role of the concept of trust in a socio-technical environment. One aspect of good governance deserving additional attention during analyses is accountability. The positive connotation of this concept is very much context dependent: not every culture accredits the same aspects of accountability to be positive.

Finally, the use of a computer model completing the knowledge framework of system behaviour can be valuable for this research, as long as the role of both the model and its results is carefully considered.

Table 2-7 Concepts applied in this research

Paragraph	Concept	Relevance for practical research
3.1.1.	Socio-technical system	▪ Regard a river basin as a socio-technical system, but be flexible in doing so ▪ Consider the system at the right scale ▪ Do not involve every aspect the whole time
3.1.2.	TIP-approach	▪ Use TIP approach as a point of departure for analysis ▪ Keep in mind that it is not sacred ▪ Do not forget to integrate
3.1.3.	Trust and governance	▪ Use good governance principles leading to trust in governance as requirements for institutional design of locations for new dams ▪ Analyze the relation between public institutes and other stakeholders ▪ Analyze from the perspective of both government and other stakeholders
3.1.4.	Accountability	▪ If good governance principles are taken into account: analyze bottom-up vs. top-down issues ▪ The positive connotation of bottom-up governance structures is only paradigmatic ▪ The attitude of stakeholders towards downward accountability must be analyzed
3.1.5.	Programme of Requirements (PoR)	▪ Let the PoR fit the scale of the research ▪ Take into account that it is rather unique to define the PoR *after* knowing the eventual artefact
3.1.6.	Computer models in policy decision-making	▪ Define which role the water balance accounting computer model has in this research ▪ Let this role fit the scale of this research

Part 2: Analysis

The intended output of this analysis phase is a thorough understanding of the concept of new small dams and the dynamics of parties around them. Furthermore, the analysis output serves as an input for the formulation of requirements for the location of new dams as well as rough data input for a water balance model.

Before diving into the real analysis of the system components of this research, the contextual components such as the physical system and the prologue of the project will be explored in depth.

3. Definition of the physical system and history of the project

Physical system

System infrastructure
Water sources
Topology
Case characteristics

The physical system within which this research has been conducted will be introduced shortly in section 3.1. The *analysis* of the physical system and its technical aspects will be addressed later, in chapter 5.

Section 3.1 will address the following sub question by defining the boundaries of the physical system within which this research has taken place, and by observing current functions of small dams in the physical system.

The history of the project from the point of view of some very diverse parties (section 3.2) will provide for the justification and set-up of the stakeholders and institutional analyses. The same section will address sub questions 1 and 2.

1: Which changes in system behaviour caused by the process leading to (a location choice for) new small dams do stakeholders expect?

2: What is the history case history of small dams in the Preto River Basin in the Federal District?

Section 3.2 will also give the justification for the analysis answering sub questions 3 and 4.

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

In section 3.3 conclusions from the observations made in this chapter will be listed and the answers to the sub questions that have been found will be presented.

3.1. Definition of the physical system

Brazil has 26 states and one Federal District. The size of this Federal District (DF) is about 5800 km^2, and the population is growing to 2.4 million inhabitants.

This research has been carried out in DF of Brazil. It has also been carried out in the PRB, which is part of the São Francisco river basin. Figure 3.1 shows what the action radius of this research actually is: the part of the PRB that is located within DF. The grey picture in

the upper left corner is a map of Brazil. The first enlargement is the São Francisco river basin, and the second enlargement (in the lower right corner) is the PRB. The blue strong line indicates the part of the PRB lying within DF.

The Preto river has a length of 378 kilometers, and the basin's area is approximately 10500 km^2, 1500 km^2 of which lies within DF (CBH-Paracatu 2005). Other parts are located in the states of Minas Gerais and Goiás. About 80 percent of all agricultural activity in DF is carried out in this river basin. Within the PRB, over 99 percent of all water used is used for irrigation purposes (Carneiro, Maldaner et al. 2007). Especially during the dry season, the availability of water for irrigation purposes is uncertain.

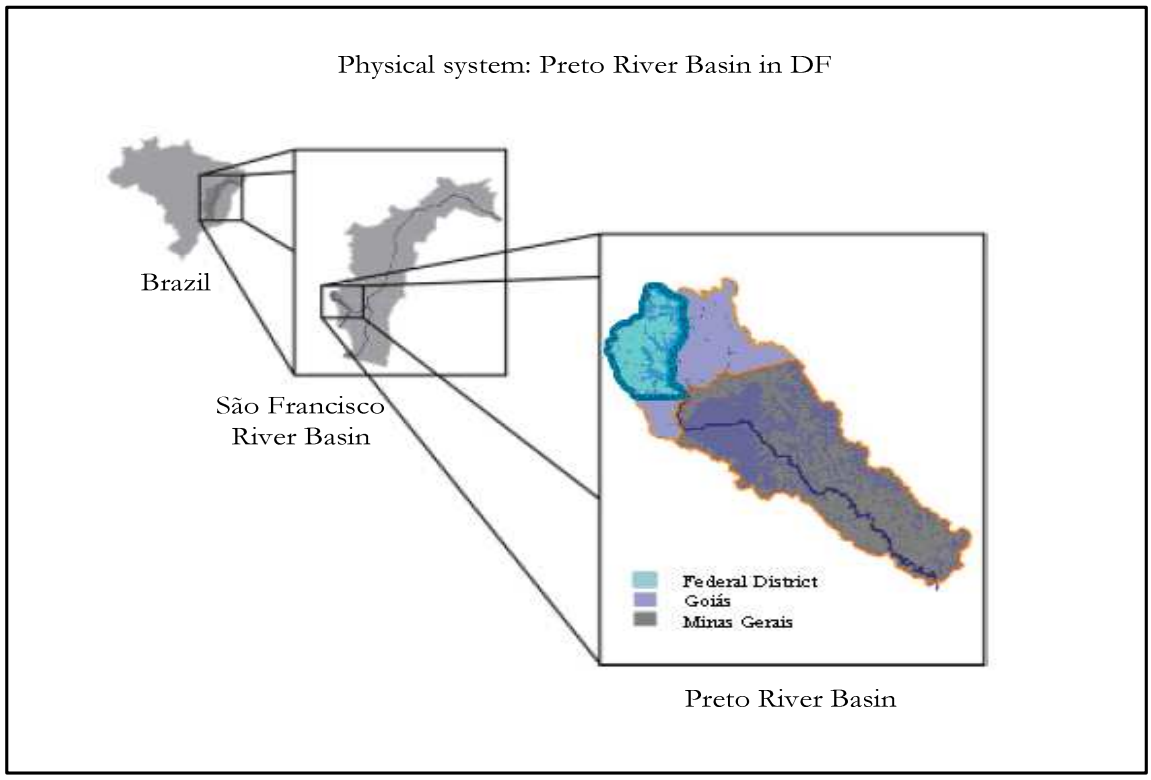

Figure 3.1The Preto River Basin in DF. Adapted from Rodrigues at al (2007).

Storing water is the only way to make sure that a minimum need is met during this dry period. The most used form of water storage is the small reservoir: a small dam made out of earth blocking the course of the water until a reservoir is filled. According to research carried out by Rodrigues, Sano et al. (2008) dimensions of small reservoirs in the PRB in DF vary from 9991 m^3 to 261668 m^3 storage capacity with surfaces varying from 1.08 ha to 34.95 ha.

The same authors have estimated the total number of small dams in the PRB to be 262, based on satellite images. Some of these reservoirs are more then 30 years old, and knowledge of their construction and age is only limited. According to the same study, there is only little awareness about the interconnection of small dams in a hydrological system, and there has been no central institution that was available for the construction of these dams. Some have been established privately, others publicly, and the rest in a public private partnership.

As already mentioned, irrigation is an important instrument for farmers to manage their yearly yields. Yet, almost 57 percent of the farmers in the PRB do not irrigate. Also, only in 38.5 percent of the existing small reservoirs, the reservoirs are only used for irrigation purposes. This is remarkable, taking the earlier observation of Carneiro, Maldaner et al. (2007) about the amount of water used for irrigation in the PRB into account. Alternative uses have not been listed, but probably come down to livestock maintenance, private water use or a combination of irrigation and livestock.

Most of the projects carried out by the government are said to have a conflict reducing purpose, according to Maldaner (2003). However, this can only be conflict between farmers and small farmer villages, since cities are absent in the PRB part of DF. In other words, conflicts are likely to exist over water availability rather than over different types of water use.

3.2. History of the project

The Secretariat of Agriculture of DF initiated a project called "Projeto de Aproveitamento Hidroagrícola da bacia do rio Preto" in 2001 (GDF 2001). The intended result was a significant increase in irrigation capacity during the dry season, by constructing a series of new small reservoirs. This project was never completed, but had a sense of malign governance activities: about 5.3 million Reais[2] had a destiny that could not be explained by the Secretariat of Agriculture (SA) (Queiroz 2005). This section provides for background information about some of the parties involved in the project.

Although some understanding of the stakeholder network is necessary to completely understand the storylines presented below, these storylines are presented before the in-depth stakeholder- and network analyses. Reading the storylines first will improve the sense for this project's delicacy.

3.2.1. Storylines

The storylines presented below are provided for by two types of institutions, situated at the extremes of interests. Please keep in mind while reading that these are only storylines; reports of conversations with people who might be heavily biased.
Nevertheless, for these people, it is the truth. This is why it is very interesting to see how the institutions presented in section 4.1 are involved in the process that was supposed to lead to new dams.

Storyline 1 (representative of farmer/water user organizations)

For a reason (assumed and not confirmed) of enhancement of chances for reelection, by means of Emenda Parlementar[3] the Secretary of Agriculture of DF decided to start and execute a project within which new reservoirs would be constructed in the PRB part inside DF. An initial study was carried out to investigate this project. An audiencia publica was organized[4], according to the standard procedure of infrastructural projects. However, the institutes necessary to be present were either absent or poorly represented (e.g. there was one

[2] Brazilian currency. This is approximately €1.9 million
[3] Congress meeting about allocation of finances
[4] Public participation meeting

person present to represent various governmental organizations).

The Secretariat of Agriculture (SA) held its research silently away from the farmers involved. The group of water users was, in fact, carefully excluded from the research. The actual goal of the project seemed to be the construction of 30 new reservoirs. These reservoirs would catch water that would be transported to big producers (who were supporting the Secretary).

There was one problem: the land used for the storage of water belonged to two farmers, who would not benefit from this project to any proportion, for two reasons. The first was that the government was not going to pay for the land of the two farmers. The second one was that these farmers only receive an insignificant share of the water stored on their land.

They found out about that the project moved to the phase of construction when the contractor started the first activities on the land of the farmers.

Normally, a public information meeting is organized to hear the people, institutions and water users and their stakes. In this case, as already stated, it was only marginally organized so.

The farmers consequently took steps and went to the Association of Producers of the River Preto (APRORP). They went to the media, in order to get the attention needed to be treated fairly justly.

The first reaction of the government was a threat to withdraw licenses/permits to use land, a result of which would be keeping the farmers from executing agriculture activities. The secretary refused to negotiate about his plans. Furthermore, the water regulatory agency of DF called ADASA (responsible for the division of water rights for rivers in DF) started to divide water rights arbitrarily, even to those who did not bid for one. The intended result (according to the interviewee) was conflict between farmers and prevention of colliding of a strong group of farmers.

The farmers responded by going to the Public Prosecutor (and to the ministry of Integration), which resulted in the discovery of a corruption scandal.

After the scandal, ADASA started an in-depth study to the allocation of water resources (water supplies, demands). Furthermore, a water users organization was initiated (USUAGUA).

The government organized a so-called Governo Rural, a publicity meeting intended to inform the public and elaborate on the events that took place. However, the institutions

present did not want the president of APRORP to speak in public about the actual events (according to interviewee). Despite a direct comment of one of the government's representatives, she did, herewith exposing the corruption scandal to the public.

Within the Rio Preto basin, there are 368 producers. 20% of these producers are big landowners (holding more than 1000 hectares of land). The majority of the land owners do not actually own their land, but farm it from the government. At their turn, they could use the same construction to lease their land to other farmers willing to pay.

The farming of land was arranged by contracts between the SA and the farmers. An old contract which lasted for 15 years, terminated and a new one (also for 15 years) was signed. The farmers were happy to find the next contract sealing an agreement for 50 years.

However, every contract signed by the SA was annulled. The formal reason for this was the fact that much land in DF had been sold illegally. People tended to move to DF shortly after its commence, cultivate the land and sell it afterwards (although it had never been purchased from the government). This left the farmers in the uncomfortable situation (which currently still exists) of using land without truly owning it, nor having certainty about future possession.

The implications for investments to be made in infrastructures are severe. A sense of ownership is fundamental for the willingness to maintain and improve a system. The pressure on the agrarian sector is increasing as urbanization is taking place. Unlike the European situation, farmers in Brazil receive no subsidy. This makes the production of food a very expensive practice. As the current irrigation system in the PRB lacks proper maintenance, investments in new infrastructure bare high risks.

So how are new small dams possible? Which resistance or natural aversion has nested itself in the agrarians? Apparently, not much. As long as this time the decision-making process shows the characteristics of a bottom-up process, resistance can be limited.

USUAGUA and APRORP (water users of the Rio Preto basin) suggests that the water users within the PRB should internally settle their conflicts over water use. The plan for new water reservoirs looks as follows:

Instead of the relatively small (but in reality quite large) reservoirs, farmers should construct smaller reservoirs in the form of a public private partnership. People losing land that are not compensated sufficiently by the extra water yields should be compensated for the remainder of losses by the community of farmers.

Little resistance is furthermore expected according to interviewee 1 (countering the argument of competition-disadvantages), due to a twofold argumentation:

- Small reservoirs are only interesting for those farmers who already irrigate
- The competition disadvantage in case of unequal access amongst irrigating farmers asking for more water and irrigating farmers that do not is relatively small, because the DF appoints a limit of land use by one farmer. This means that small farmers can grow, but farmers operating at the limit cannot.

This presupposes a situation in which no none-irrigating farmer is planning to start irrigating.

Next to a proposed institutional structure of public-private partnership being a criterion of the water users, there are some technical criteria formulated. The most important one is that the new reservoirs are going to be very small, almost at farm level. A second one is their function: recuperate headwater and catch rainwater.

Water rights distribution is a question quite complicated in this case. Both ADASA and ANA (National Water Agency) are responsible for water rights in the PRB. On paper, the division is comprehensive: ANA is responsible for the river Preto, ADASA for its tributaries. ADASA divides water rights when the water concerned originates within DF and does not cross borders with another state, whereas ANA divides water rights when the water concerned is captured from a river originating from or flowing to another state. The practical complexity, however, rises because of the presence of two poor-communicating water regulative bodies in one small Federal District. The PRB complicates the division of water rights, because rivers arms in it are both inter- and intra-state. And, once again, there is no communicative connection between ADASA and ANA of any form.

The process of new small reservoirs can only be initialized after water rights are obtained by the users (whenever applicable (see the exception rules)). Land ownership is another big problem, because the relation between farmers and the government is fragile.

The user-organization should solve conflicts about the location of new small reservoirs within their own community. If farmers are heavily against new reservoirs, they can go to court.

Storyline 2 (employee at the Secretariat of Agriculture (SA)

The Secretary of Agriculture of DF had a goal in mind. This goal was simply to build

new small dams. The underlying reasons and intended effects of these dams seemed to be absent. For example, no research had been carried out to existing demands of farmers, irrigation plans and specific aspects of development plans.

Normally, there is a fixed way of processing an idea such as this one. A basin committee should evaluate a plan, it should be in concurrence with the water council's objective and with the law. This evaluation process could follow the path of federal institutions or that of state institutions.

As the plan for new dams only concerned land and water within DF, the Secretary could avoid the federal procedures. Also, because the projects were (individually) relatively small, the processes of public audiences and alike could be limited to a minimum. As a matter of fact, the secretary presented his plan more or less directly to IBAMA, the institute responsible for granting environmental licenses.

It was here, that it was found out that the area subject to the plans of the secretary was in fact a protected area; a reserve of the type APA (Area de Proteção Ambiental or environmentally protected area). This made the area to be a federal protected area, meaning that all federal procedures were applicable after all. Therefore, when IBAMA was involved, EIA/RIMA's (Environmental Impact Assessment procedures) carried out for state influence were irrelevant: the plan staggered over its own feet.

No relevance could be proved in terms of necessity for these dams, either from irrigation perspectives or for community benefits. Although some dams were run through an EIA/RIMA procedure (dams 5.2 and 8.3), the construction of these dams was never realized. The project as a whole ceased to exist apart from a few documents in boxes in a closet.

The mistake made by the higher level of the secretariat of agriculture was covered for by a lower level employee. Currently, the observation of the secretariat is that the resistance likely to exist with farmers who loose their land will evaporate when a proper plan is presented. The next step is therefore to start the project all over, this time taking more aspects into account than just the will to build new dams.

The people counting on new dams will have to wait and see what happens, according to interviewee 2 at the SA. When all steps will be carried out properly this time, no one is going to be against the construction of new small dams.

Storyline 3 (a mediate-rich landowner)

Brazil has a history of unequal division, due to exploitation of assets and agriculture on the one hand and a sudden withdrawal of the colonists – leaving poor people and chaos behind – on the other. The historical inequity is present in current policy, but especially in the nature of all politicians. Maximize your own benefit, use your power.

According to the interviewee, that is the rationale of decision-makers, also in DF of Brazil. He and his uncle own a nice piece of land, as one of the 10 percent private land-owners in the PRB in DF. They use it to grow several irrigated crops. The uncle of interviewee 2 applied the centre pivot for irrigation, he constructed two of them.

As far as the interviewee knows, the need for new reservoirs never existed. That was the whole problem: the government called new dams "small dams", but the ones the interviewee knows of weren't supposed to be small at all.

Moreover, in all the main river branches he never heard a farmer complain about water shortages. The smaller streams do suffer from droughts indeed, but for the streams big reservoirs would only lead to droughts directly downstream.

Farmers are very concerned about the environmental quality at and around the farmlands. Like many inhabitants of the region, he is proud of the cerrado, the savannah like type of vegetation and climate. The cerrado hosts 33 percent of Brazil's biodiversity, despite its hostile and dry environment during the dry season. The direct impacts of a dam on his own farmland would be severe; several interesting species live around the area where the reservoir was planned. Furthermore, the impacts of a dam for the wildlife of plants and animals downstream could be disastrous. Anyway, if a dam will be built, the Environmental Impact Assessment must be carried out meticulously.

The problem is that no one wants new dams. Everyone who is irrigating his land now manages to succeed, and new small farmers who want to start irrigating their land hardly exist. They believe in the will of God (related to the availability of water), not knowing that an upstream farmer with a new pump will use more water than before, only because the capacity of his pump increased. The majority is analphabetic, so even trying to trigger their interest is hard. Small, uneducated farmers are very hard to involve into a project.

Especially when it comes to governmental projects. The government gives no subsidies at all, plus her interventions lack consistency with the wishes of farmers. And no lines of communication between government and farmers existed, until USUAGUA and APRORP

were established (by farmers themselves).

So there are chances for consistent development of the region. USUAGUA and APRORP approach the government proactively, and manage water use infrastructure. Furthermore, a "line of knowledge" has finally been established, which offers education possibilities for small farmers.

As for the future, the government can best involve farmers with knowledge about the land, the water use and the water availability. And hopefully, the government will change slowly into a well functioning institute.

3.2.2. Observations based on storylines

These storylines do not tell us the actual and exact history of what happened in the PRB, nor do they provide for a direct connecting factor for policy. What they show, are the opposing interests of various parties, the actual conflict as a point of departure for future policy. Interviewee 1 (storyline 1) and interviewee 2 (storyline 2) share some points of view that are directly conflicting, which makes it seem difficult to negotiate about values or interests. Interviewee 3 even doubts the necessity of new small dams. This is why these storylines are useful: they indicate what to analyze in the following (stakeholder and institutional) analyses.

Mutual trust or conflict?

One of the most important things to be "measured out" is related to an information dilemma. Water users, stakeholders and institutions determine the requirements that new small reservoirs should meet. They provide information about what their objectives, wishes and expectations are.

The storylines show that this information is biased though. The challenge of translating the requirements of biased stakeholders into comparable criteria lies with the researcher, who has to apply unbiased methods to make a final comparison. Even then, the results have to be judged by the parties involved, not by the researcher.

However, in this situation, the information provided for by stakeholders is characterized by a high rate of un-likeliness. The SA employee expressed his expectations about a new sound plan for small reservoirs in the PRB: "If the plan is sound, no one is going to be

against," he said.

The remarkable thing is that farmers organizations expected that whenever the "few demands" of the organization she represents were met, no farmer would oppose the plans for new small reservoirs. In other words: these organizations agree with what is stated by the SA employee.

The likeliness of this being true is at least questionable. As indicated in paragraph 3.1, many conflicts between water users in the PRB already exist. Furthermore, history has proven that farmers are not willing to give up their land easily, if they perceive the change connected to this land-loss as unprofitable. This observation can be confirmed by the comment of interviewee 3 (storyline 3). He primarily added the perspective of the environment, thereby proving that the interests of one farmer may vary from the other. Furthermore, he literally stated that no farmer wants new reservoirs (although he admitted later that this statement was especially related to the old plans of the SA).

The striking part is that two parties at the opposite ends of the interest-spectrum are equally naïve in their expectations. Especially considering the recent history of confrontation between these two parties.

So, simply copying the demands of various parties into a PoR cannot lead to an implementable decision about the locations for new reservoirs, since history would repeat itself. This is not a shocking conclusion. What is more interesting, though, is the observation that parties might agree in a relatively early stage of the process (on paper), because they actually think that they can agree on the eventual result.

Thus, some kind of protection mechanism must be built into the institutional arrangements accompanying the PoR, which translates the demands of various parties in such a way, that other parties understand the implications for themselves on the long run.

For this reason, the institutional and stakeholder analyses must lead to understanding of the viewpoints of the parties involved, but also to understanding of the way these parties understand each other. If this level of understanding cannot be reached, the PoR will be useless.

Other observations

In storyline 1 various types of participation possibilities were mentioned (Emenda Parlementar, Audiencia Publica, Governo Rural), but what stood out was the lack of real

influence interviewee 1 had during the old project despite participating in these participation possibilities.

An Environmental Impact Assessment exists, but in the old project, interviewee 3 felt damaged because of the lack of concern about the environment. Different farmers have different stakes.

There is a large group of potential stakeholders that is not interested in participation now, but might be after improved education.

Each interviewed person indicates that a sense of ownership of new small reservoirs is necessary for the successful implementation of new dams.

3.3. Conclusions on the history of the project

Answers to the sub questions that were found are presented in this paragraph. In addition, other relevant conclusions and the set-up for further analysis are listed. Table 3-1 lists the requirements that can be formulated based on the observations made in this chapter.

1: Which changes in system behaviour caused by the process leading to (a location choice for) new small dams do stakeholders expect?

When observing the changes caused by the process leading to (a location choice for) new small dams expected by stakeholders in the PRB in DF, it becomes clear that these expectations lead to a problem situation.

Firstly, reduction of conflict is expected because of increased water availability during a season that is normally characterized by water scarcity. On the other hand, increase in conflicts is expected because of disproportional privileges among water users.

The same kind of contradiction exists with regard to water use versus land use. On the one hand, more water is expected to be available, but on the other, land and environmental quality are expected to be lost.

The contested contributions of small dams are also present in the institutional context. On the one hand, agro-economic stability is expected to be a result of the implementation of new small dams. On the other hand, loss of autonomy is an expectation of some stakeholders, because the government decides about the locations and dimensions of these new small dams.

2: What is the case history of small dams in the Preto River Basin in the Federal District?

The case history of the small dam project consists of a process, roles and functions that small dams are supposed to fulfil.

- Small dams used to be small-scale solutions for individual farmers. They have a significant impact on the hydrology at a larger scale
- Small reservoirs lead to conflicts, but when designed properly and on carefully picked locations they can also contribute in conflict resolution
- Diversity in responsibility fragmentizes stakeholders
- Small dams have an impact on the environmental flows, habitat and quality of the cerrado

The functions small dams have are:

- Allowing for water availability during the dry season
- Irrigation and livestock maintenance

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

These questions are not answered in this chapter. However, the relevance of the stakeholder and institutional analyses that follow in chapter 4 has been clarified and justified. It has become clear how stakeholders expect contradictory results of the implementation of new small dams. What justifies a thorough analysis of both the institutional framework and the role of stakeholders in the process leading to a location choice for new small dams is the apparent lack of knowledge amongst stakeholders about each other and mismatch of expectations regarding the institutional framework and the actual form and function of the institutional framework. Even before researching these subjects, stakeholders have indicated that knowledge about responsibility over small dams and acceptance of the shape of process leading to their implementation is vague and contested. Therefore:

- Stakeholders must understand institutions and each other.
- There must be some kind of protection mechanism in institutional arrangements that accompany the overview of requirements for locations of new dams. This mechanism must make sure that stakeholders understand their own stakes and are able to compare them to the implications of new policy/decisions.

Conclusions relevant for further research

Responsibility: Farmers expect the government to take decisions. They also expect to be damaged by these decisions, but the responsibility for the project is not their own problem. This has implications for the likeliness of farmers to comply with decision made by the government. These implications must be researched in the institutional and stakeholder analyses and will be related to the type of relation that formally and informally exists between farmers and governmental stakeholders.

Hydrological impact: Although small dams are solutions that were implemented on a small scale, they have impacts on a large system. The high level impact can be linked to high level responsibility. This must be involved in an analysis of the influence of policy decision-making on the PRB (e.g. the impact of a location choice for new small dams on water availability).

Participation: Public participation was characterized by low accessibility tot the decision-making process leading to the implementation of new small dams, hence the complaints of farmers' organizations about the results. The earlier project ended with a revealed questionable quality of governance, so participation should be encouraged in order to increase transparency of actions of the government. This does not have to be in contrast with the expected responsibility over the small reservoirs project of the government.

Education and new entrants: Many farmers do not use irrigation system, at least not yet. However, education may lead to new entrants and new stakeholders involved in the decision-making process leading to a location choice for new small dams.

All of these aspects must be part of the institutional analysis and stakeholder analysis carried out below. At a later stage, the above observations can be starting point for developing the requirements that the locations of new small dams must meet.

Table 3-1 Location requirements and measure

#	**Location requirement**	**Measure**
1	Location must allow for the small dam to fulfil its distributive function	Q (m^3/s) per period
2	The location may not be contested by stakeholders	Information rate (%)
3	Stakeholders involved must know who other stakeholders and what other institutions involved are	-

4. Institutions and stakeholders

The previous chapter has revealed to us why it is relevant to analyze the roles of institutions, how stakeholders perceive them, and how stakeholders see each other. This chapter addresses the institutional framework of DF (4.1) before it presents the stakes, stakeholders and relations (4.2).

Institutional framework

Existing institutions
Interactions and functions
Existing policies

Stakeholders

Water users
Networks

The analysis outcomes will provide answers to sub questions 3 and 4, about (respectively) the influence and role of the institutional framework and stakeholders in the process leading to a location choice for new small dams. Before roles and influence can be investigated, the actual institutional framework and stakeholder situation are analyzed.

3: How does the institutional framework influence the process leading to a location choice for new small dams?

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

In the research framework drafted in chapter 1, working from laws and regulations towards existing organizations is preferred over addressing organizations first. This is done predominantly because the Brazilian water law has been imposed to renew the entire water framework instantly. It is very important to understand the goals and meaning of Brazilian water law and regulations. Without it, the goals of institutions (also newly created) will be harder to understand. Furthermore, the errors and possible malfunctioning of these institutes can be related to the structure and rules laid down in the laws.

However, knowledge of the formal institutional framework will not be sufficient for a complete understanding of the functions of this framework in the context of this research. As already observed in chapter 3, formal institutions are limitedly influential with regard to the decision-making process concerning new small dams. Apparently, a discrepancy exists between processes shaped by institutions and processes carried out in practice. This discrepancy might lead to a decreased functionality of this institutions (to some extent), unless the institutional framework consists of more than just the formal institutions. To understand this rather complex framework, the formal institutions will be analyzed firstly nevertheless. When comparing formal institutions, processes and procedures with

stakeholder relations, processes and networks, a conclusion can be drawn regarding the extent of formal functionality of the institutional framework in the DF related to the small dam process.

4.1. Institutional analysis

This paragraph investigates the institutional framework related to the small dams question in the PRB within DF, Brazil. Furthermore, the overview presented in this chapter gives information on the tasks and goals these institutions are *supposed* to have, according to their own mission statements or according to the laws that are their raison d'être.

The actual influences and powers they have and the way these parties are pursuing the achievement of their tasks and goals is addressed in section 4.2, because that chapter describes the influence of parties on each other. Please keep this in mind while reading this paragraph.

As for the types of institutions mentioned in chapter 2, the wide interpretation of the concept of institutions is applied in this analysis. This means that institutions can be both formal agreements and institutes.

This section will be structured as follows:

- Firstly, an overview of the water and environmental framework in Brazil is presented. We have seen how the old project leading to new small reservoirs suffered from lack of transparency, how it inaccurately ran through the environmental rules of the game, and how parties involved mentioned responsibility problems. In the analysis of laws and regulations, we will see what rules and procedures are and what responsible parties should be (according to the law and policies). Referring to the literature study (chapter 2), this is the "rules of the game" institutional analysis
- This framework will be completed with institutional parties involved (with a distinction made between parties inside the water framework and parties outside the water framework). This analysis shows what their intended functions are (based on the perspective of these organizations themselves, not based on law and high policy). This is what was referred to in chapter 2 as "organizations as institutions."
- This paragraph will conclude with observations made during the institutional analysis, and some preliminary conclusions that can be drawn.

Only most relevant laws, policies and institutes in the new small dams – PRB in DF –

context are presented. An in-depth analysis of each law, policy document or institute mentioned in this chapter can be found in appendices C and D.

4.1.1. Overview of the water framework in Brazil

The water resources framework in Brazil has been laid down completely in law 9433/97 (República 1997), called the National Water Resources Policy. This comprehensive law encapsulates water resources in various contexts, such as water resources management practices, water resources plans, water pricing and water rights, and water resources information systems, water regulative bodies, agencies and councils, and so on. The instruments and other parts most relevant for the small dam project are explained in this paragraph. In Appendix B, a more complete overview is presented.

There are basically three important concepts that play a high level role in Brazilian water management.

1. The National Water Resources Management System: This "System" lays down the basis for sustainable and integrated water management in Brazil. Human and animal needs prevail over other water purposes, though. Management should be based on the hydrographical characteristics of a river basin as well as decentralized and participatory management.

2. The National Water Resources Plan (República Federativa do Brasil 2006): The plan was drafted to backbone the system, but was only completed in 2006. On a federal level, the plan has three main goals: Improvement of availability of water, reduction of water conflicts and the introduction of the socio-environmental water conservation perspective.

Table 4-1 Concepts in the Brazilian water framework

Concept	Meaning
SINGREH	National Water Resources Management System
PNRH	National Water Resources Plan
Constituição do Brasil	Brazilian Constitution
Outorga	Water Rights
Cobrança	Water pricing

The National Water Resources Plan is a policy document. It divides Brazil into 13 hydrological regions and into 56 hydrological units (República Federativa do Brasil, Ministério do Meio Ambiente et al. 2007).

For each region, a lower level plan is supposed to be drafted for the long run. These lower level plans can be worked out per unit. The idea is to truly implement the integrated river basin management approach: rivers running through different states must be managed by river basin committees, not by states.

3. Federal rivers and state rivers. Some rivers cross the borders of states. The laws applicable to those rivers are federal law. Rivers with head and tale within the same state are subject to state law, unless defined otherwise due to special circumstances.

The river Preto is such a river. Therefore, it is subject to federal law. Furthermore, it is part of the hydrological region of the river São Francisco. So when an institute such as the Secretariat of Agriculture decides to implement new small reservoirs, this decision has to fit in with the policy carried out by the São Francisco river basin and to comply with federal law.

4.1.2. Institutional organizations in the PRB in DF

Within the National Water Resources System and the National Water Resources Plan, various institutions are appointed to hold responsibility over a certain area. Figure 4.1 provides an overview of institutions involved in the Brazilian water framework. Appendix B gives a thorough description of every institution that is more or less related to the water framework in DF and in Brazil, but in this chapter only the most important ones will be elaborated on.

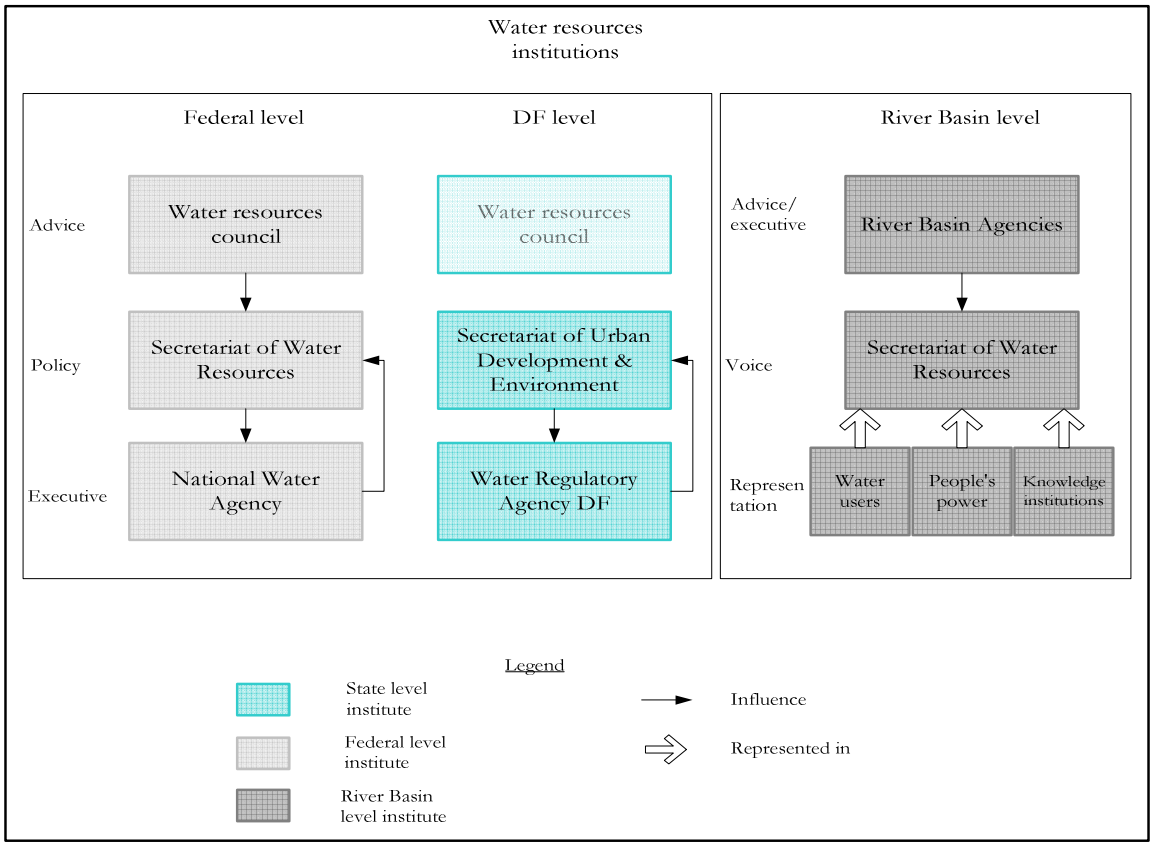

Figure 4.1 Parties in the Brazilian Water Framework

The most important parties with regard to this research are:

National Water Agency (ANA) Agência Nacional de Águas or the National Water Agency operates at the federal level. It has three main functions, the appointment of individual and indistinctive water rights of which is the most important one. Inspection of water use and water pricing are two consequent tasks of the agency. All the research needed to take decisions in the areas mentioned is carried out by ANA as well.

ANA was created only in 2000 in order to safeguard the implementation of the National Water Resources Management System. It is an institution acting on federal level, meaning that it is entitled to take decisions on federal problems, and to delegate this decision making to lower (state-level) organs.

Water Sanity Regulatory Agency of DF On paper, the Water Sanity Regulatory Agency of DF (ADASA) – existing since 2004 – has adopted as its main goals the regulation, control and inspection of water quality and quantity within the water bodies of either DF, or the domains

delegated by the ANA or by other states. Furthermore, it bears the responsibility for the public services of water provision and the sewage system of DF.

In reality, ADASA is mainly responsible for the water rights division in DF. In the PRB, Adasa claims that it has carried out the most profound researches into water availability and –conflicts in the region.

Secretariat of Urban Development and Environmental Issues Now it gets a little complicated already. This is an institution situated in the DF that would normally fall outside of the water framework. Nevertheless, it is part of it now.

According to the National Water Resources Plan, there has to be a State Organ for Water Resources Management (Orgão Estadual Gestor de Recursos Hidricos). This organ must be appointed by the River Basin Committee of – in this case – the river São Francisco. A commonly used format for this responsible organ would be a Secretariat of Water Resources. In DF, this does not exist. Instead, the responsibilities of what would normally be a State Organ for Water Resources Management have been appointed to the Secretariat of Urban Development and Environmental Issues in DF (SEDUMA).

The tasks of SEDUMA are related to those of River Basin Committees and entail water pricing and water rights division in the context of policy decision-making.

4.1.3. Instruments

The most important instruments to carry out water management activities are water rights – outorgas in Portuguese – and water pricing mechanisms – called cobrança.

Water Rights (Outorgas) Water users have to apply for water rights when they use more than 1 m^3 per second for their activities. Both ANA and ADASA have the authority to grant water rights to water users. ANA acts on a federal level and ADASA only has authority in DF. Since the river Preto is a federal river, ANA would be the first responsible institute to address water rights requests. ANA delegated this task to ADASA, though.

The river Preto is an affluent of the river Paracatu, which is an important contributor to the river São Francisco. Therefore, it is important for ANA and ADASA to communicate about the water rights that have been granted. After all, it is hard for ANA to determine how much water still is available if it does not know how much water has already been allocated.

According to representatives of both ANA and ADASA, this communication is poor or even absent (Azzi 2008; Lopez 2008).

Water Pricing (Cobrança) In the Brazilian water resources management system, water-pricing activities must be linked to water rights division. The basic principle of water as an economic good and the implications of adopting this principle are incorporated in the concept of water pricing.

Furthermore, according to the law that forms the Brazilian water resource management system, yields of water pricing must be invested in the region within which the money has been collected.

So in short, water pricing must be linked to water rights, and the collected money should be invested in water resources management projects in the same region.

4.1.4. Institutions and their instruments outside the water framework

Up to this point, we have observed two types of institutions: Laws and policy on the one hand, and representative organizations on the other. A third important group of institutions consists of organizations and policies involved in water resources issues, but without direct influence on water policy. The construction and location choices for new small dams fall outside the scope of just the water framework in DF. In this paragraph, the other institutions involved in decision-making concerning the location choice for new small dams are presented. The same distinction between policy and law institutions on the one hand and organizations as institutions on the other as applied in paragraph 4.1.3 has been made here.

Policiy and aw

Especially environmental law is relevant in the context of determining locations for new small dams. Environmental impacts of both the behaviour of the dam and the location of the reservoir make new small dams subject to environmental law and procedures (Rodrigues, Ramos et al. 2008).

- In the National System of Conservation Units (SNUC) concepts such as Permanent Preservation Areas (APP) and Environmental Preservation Areas (APA) are defined

(O Vice-Presidente da República do Brasil 2000). When a river runs through such an area, there are well defined constraints for structures such as small dams in terms of impacts on the environment.

- Forestry law lays down comparable constraints (Rodrigues, Ramos et al. 2008).

Processes

In order to determine the environmental impact of a small dam, several procedures have to be run through before getting licences for planning, constructing or operating new infrastructures such as dams. A schematic overview of these procedures is displayed in Figure 4.2. In Appendix D the whole process of the EIA is described in detail. The most important factors to take into account when implementing new small dams and determining locations for them, are the separate licenses that must be obtained and the studies that must be carried out before they can be obtained.

In the Terms of Reference, a planning of each phase made by the responsible organization for a project, an exact planning of how the intended phase should be implemented must be handed over.

The environmental impact studies run parallel with the applications for licenses to enter a new phase with the infrastructural project.

Furthermore, the first license granting the beginning of the infrastructural project can only be obtained after having organized a public meeting in which stakeholders involved are informed and given the opportunity to respond to the planned project. For two new small dams, the EIA has already been carried out completely (Ministério do Meio Ambiente and IBAMA 2002; NCA 2002).

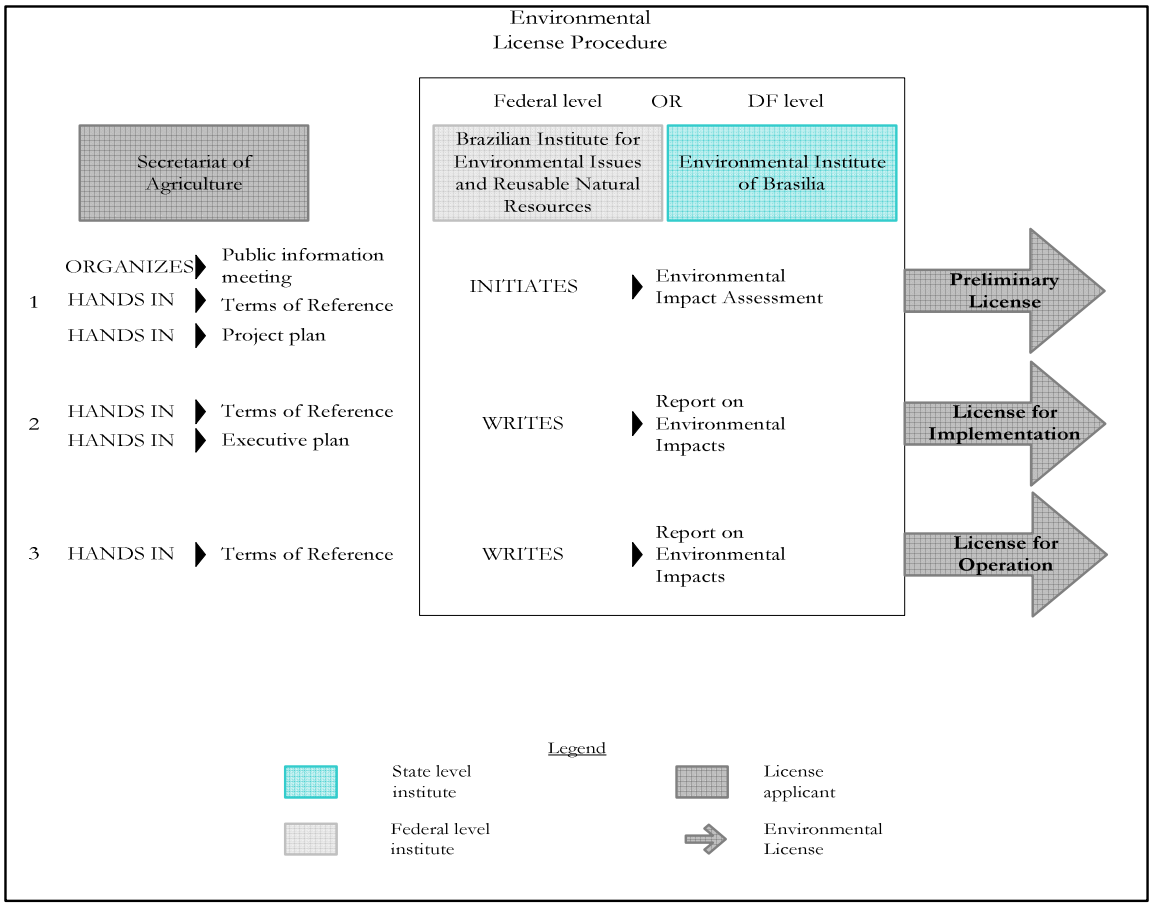

Figure 4.2 Environmental license procedure

Organizations

Institutes involved in the small dam project are:

- *Secretariat of Agriculture.* The institute that was responsible for the original project of new small dams was the Secretariat of Agriculture (SA), fully called Secretaría de Estado de Agricultura, Pecuaria e Abastecimento (Secretariat of State of Agriculture, Livestock and Resources). SA aims at development and rehabilitation of rural areas and communities in DF (GDF, 2000) and the project of new small dams fits within this objective.
- *IBAMA.* The Brazilian Institute of Environmental Issues and Reusable Natural Resources (IBAMA) is responsible for the environmental impact studies and procedures mentioned before on a federal level. This institute judges the reports and terms of reference handed in by the organizations applying for licenses, when the project affects federal territories such as protected areas or federal rivers.

- *IBRAM*. Fulfilling the same tasks within DF, the Environmental Institute of Brasilia (IBRAM) can be delegated by IBAMA to carry out regional projects.
- *Public Prosecutor*. If governmental decisions harm citizens in their quality of life or in any basic right, these citizens can summon the responsible governmental institute. The Ministerio Publico (public prosecutor) has already been involved in the project carried out earlier: complaining parties managed to stop this project by exercising this possibility.

4.1.5. Observations institutional analysis

Although the above presentation of institution is rather short, a thorough understanding about their functions has been accomplished in this research, based on both literature and interviews with employees of the organizations being part of the institutional framework. In appendices C and D the interviews held can be found, as well as the more detailed description of the institutions mentioned in this chapter.

Which flaws that appeared when investigating the institutional structure relevant for the process leading to new small reservoirs in the PRB can already be appointed? Before actually mentioning the shortcomings, it is useful to present them in categories.

- Conceptual problems: How might the institutional format hamper decision making about locations for new small dams?
- Inter-institutional problems: Which problems can be accredited to the relationship between several institutions?
- Intra-institutional problems: What kind of problems was recognized to be caused by internal functioning of the institution?

Conceptual problems

Levels. The government is divided in levels of institutions, but not in "levels of analysis" as described by (Ostrom, Gardner et al. 1994). There is a conceptual difference formulated between the several levels of institutions, but they are highly intertwined. It is therefore quite hard to understand where responsibility lies.

Example: existing responsibilities of SEDUMA about water rights are transferred to ADASA (via ANA (Q.E.D.)) without changing the status of SEDUMA. So whether ADASA imposes operational rules that were part of SEDUMA's set of rules or not has not been defined properly.

Institutional novelty. There is a water resources plan, which prescribes the functionality of the water resources system. However, differential approaches for different areas within this system were not encountered. The National Water Resources Plan is very young, and should be incorporated in all the actions and legislation relevant in the process-design for new small reservoirs. But it is a new plan, so changes are likely to occur, due to flaws or other mismatches between theory and practice.
The system was supposed to be imposed as planned. When this did not happen, an additional institution was created to see to its implementation, namely ANA. So instead of making the system flexible, the new and hardly functioning system was made even more fixed. Because of this, functional problems have been fixed as well. Interference of other problems has magnified this initial cause of resistance.
On DF level, ADASA is a very young organization and yet bears great responsibility concerning an issue that is characterized by conflicts. Their power of control is therefore questionable.

Many institutes on a high level, few on lower levels. Many institutional changes were made in the past few years to open up the possibility for stakeholders to participate in water management decisions. However, possibility to contribute to decision-making processes or to be informed about decisions made remains limited. This is partly due to the small amount of institutes that operate close to stakeholders (farmers and water users). Typical is the example of the old project: farmers could only stop it by using the Public Prosecutor.

Temporal Scale. The requirements for dam construction are quite clear. Processes such as the EIA/RIMA and constraints such as the minimal distance to a head are formulated unambiguously. Also, in terms of technical behaviour of a small dam, the downstream impacts must be researched carefully before constructing a small dam. After construction, though, responsibility over the dam is not addressed. In the various phases of the EIA it is

presumed that responsibility over the operation of new infrastructure is an issue that can be sorted out right before the relevant license-application. For example, in the Report of a dam planned in the old project, farmers are appointed to be responsible for the operation and maintenance of the new reservoir. To this end, organizations have yet to be formed (NCA 2002). In the context of this research, it is interesting to notice that this has not happened yet, as the EIA/RIMA has been carried out for two small dams.

Inter-institutional problems

Lack of communication between institutions. Assigned tasks are carried out, but feedback remains absent. The most striking example is that of ANA and ADASA. During the first interview with Lopez (2008) and during the first interview with Azzi (2008), the interviewees were remarkably frank about the lack of communication between the institutes. They acknowledged the need for a linkage. Moreover, both of these employees recognized how strange it was that they did not have a clue about the mutual interests, while the overall goal their organizations are pursuing are based on the same interests.

Water rights division. Responsibilities over water rights division are vaguely distributed. The only clear definition is based on status of the river basin/area. The actions of the Secretariat of Agriculture pointed out, that distinction between federal and state authority is quite vague.

The distinction between state and federal rivers furthermore seems to be artificial, because there is almost always more than one state involved, when you look to the system more closely and incorporating downstream effects.

Too high an overlap in initial interests. As the situation currently is, it is hard to define the true goals of the institutions involved in the project of new small dams, as they do not differentiate. Farmers, the Secretariat of Agriculture and the advisory institutes want the same: development of rural activities. They highlight their own activities, without indicating what they truly expect from the new dams project. However, they already have agreed to cooperate on this project without definition of the content.

The river basin level. River Basin Committees and agencies are invisible in the PRB. Carneiro et al. (2008) show how policy makers in the PRB cautiously try to look for an

institutional middle. In the context of suggesting the establishment of a River Basin Committee for the river Preto, these authors wonder out loud if "the application of another mechanism like in this case a user organization that interacts with the São Francisco Basin Committee" would make sense, and at what level this organization could interact.

Intra-institutional problems

Confusion of interests. IBRAM operates under the flag of SEDUMA, which cooperates with the Secretariat of Agriculture. Yet, a project of the SA must be checked by IBRAM. The independency of IBRAM is either hard to persist or hard to present to stakeholders and institutions involved.

Lack of agenda setting. The Secretariat of Agriculture does not formulate an agenda with regard to the small reservoirs project. It may be the sensitivity of the subject that hampers the willingness to do so, but because of a lack of agenda setting, various institutes (and stakeholders) are being limited in their possibilities to communicate.

Information. Many problems evoke when the public meeting is attended badly in a contested subject. This was the case in the old project. Intentionally or not, keeping out stakeholders only postpones the representations of stakes in the project, as can be demonstrated by the course of events of this small dam project.

Quality of procedures. The EIA/RIMA procedure leading to the Preliminary License was initiated by the Secretariat of Agriculture (with some partners). It was only after completion that mistakes were recognized about the nature of the areas affected by the new small dam. The essence of this procedure is to make the impacts on the environment explicit, so the environment had to be defined properly.

4.2. Stakeholders and networks

This section is closely related to the previous one. In terms of the framework of Bandaragoda mentioned in section 2, this section focuses on water users and their networks. In addition to organizations that are active in the Brazilian water framework or in the project

of new small dams addressed in section 4.1, there are (organizations of) water users or other stakeholders involved in that project.

This stakeholder analysis continues to analyze the organizations that were already recognized to be involved in the institutional framework as described in the previous section. However, emphasis of the stakeholder analysis is on the relations between these parties. It focuses on:

- Stakes and interests of these parties
- Institutionalization of procedures
- Chances and threats for new small dams

It is quite useful to know who has stakes related to new small dams. Knowing who has something to win or lose (practically the same thing) helps in deciding which parties should be involved in a process leading to new small dams. Looking ahead to the question who is to bear the management and maintenance of new small reservoirs, it will be interesting to find out whether or not organizations of farmers/water users are willing to do exactly what the SA expected them to.

Moreover, it is useful to know which stakes these are exactly, so that various parties can understand the varying interests.

Most institutions mentioned in the previous chapter are institutes, or organizations. The formal relations between them have already been investigated. As we observed in the previous section, these relations are either confusingly or poorly defined (e.g. responsibility issues). Therefore it is interesting to examine how informal relations are shaped among institutes and among institutes and other parties.

Consequently, this network/stakeholder analysis adds information to the earlier institutional analyses rather than applying another paradigm.

4.2.1. Overview of stakeholders and their interests

Getting a grip on the exact interest of stakeholders within the project of constructing new small dams is key to potential support of these stakeholders. To this end, and based on the analysis techniques of Enserink, Koppenjan et al. (2003) and the techniques summarized by Hermans (2005) as well as the methodology of this research (see paragraph 1.6.1), a stakeholder analysis has been carried out. The complete results of this analysis can be found

under Appendix D.

As the need for new small dams in the PRB in DF has been recognized and confirmed by conducted researches, there is a need for support of the construction of new small reservoirs by stakeholders involved. In the current situation, there is a plan to build these reservoirs, but there is too much vagueness of parties involved/affected to realize these dams.

Secretariat of Agriculture

The SA wants new small dams to (GDF 2001)

- Increase revenues of rural products
- Extended offer of products throughout the year with stable revenues
- Stabilize discharge of water (supply)
- Preserve the environment
- Conserve a minimal flow within the river

Despite the failed former project, the SA remains a problem owner. Taking the functions of small reservoirs into account, both institutional responsibility and interests of the SA make the implementation of new small dams to be a project of the SA. The SA has to deal with distrust of farmers and other institutes that are sceptic with regard to intentions and profoundness of researched environmental impacts.

EMBRAPA

The Brazilian Agriculture and Livestock Research Institute (EMBRAPA) is one of the few organizations that enjoy confidence and trust of Brazilian farmers and citizens, despite being a public (governmental) institute. A possible explanation for this is related to its focus. EMBRAPA focuses on products instead of organizations, so farmers do not have a feeling that the institute interferes with their business.

Still, EMBRAPA is involved in the small dam project. As a research institute, it can be valuable ally of the SA. For EMBRAPA, the small dams project is interesting because of the intended effects of the dams: increased irrigation capacity. EMBRAPA is involved in research in on irrigation efficiency, in the behaviour of many irrigated crops, and in soil types.

EMATER

EMATER (Institute for Technical Assistance and Rural Extension) is the institute that supports rural development and the role of technology in it. Therefore, the interests of EMATER concern good rural development in DF. Small reservoirs should add to the rural extension, and this is as far as EMATER's interests go. In a way, the interests of EMATER and EMBRAPA cross over here. This mutual interest in small reservoirs makes the two institutes, which both enjoy public support, excellent monitors of the decision-making process leading to new small reservoirs.

APRORP

The main activities of the Association of Producers of the River Preto (APRORP) are aimed at the people related to the producers of the Rio Preto, and consist of integrating families and the community of farmers, usually by means of sending newsletters and organizing events.

Hereby APRORP protects the values and interests of water users in the PRB. This rather innocent description of the mission statement of APRORP did not prevent them from blowing the whistle firmly, when two farmers were harmed in their interests by the construction of a new small dam on their land.

Although very sceptical about any kind of governmental interference in agriculture, the farmers supporting APRORP are open to "well defined plans" of the SA.

Farmers

The group of farmers in the PRB in DF can be divided into three distinct groups in light of this research.

- Land owning irrigating farmers
- Land farming irrigating farmers
- Non-irrigating farmers

The farmers that own their own land (about ten percent (Maldaner 2008)) and that irrigate have more influence over the Secretariat of Agriculture than the farmers that do not own their own land, but farm it from the government. Both parties have land to lose and – if the dams are constructed badly – little to gain, but the government has more power over farmers using land from the government than over farmers having their own land. This has

to do with licenses for land use and complicated land-ownership issues in the past.

Non-irrigating farmers are only involved in this project if they are triggered to start irrigating, either because of education or simply because there is more water available.

CAESB

The Company for Environmental Sanitation of DF (CAESB) is an institute that provides for tap water and sewage services in DF, and preserves environmental water quality. CAESB is currently active in the area where new small dams are planned. At some points in the river Preto, the institute takes in water for the purposes mentioned above.

In terms of quantity of water to be extracted from the PRB, CAESB is not a big player in the current process, but in terms of environmental quality it is. That is why it is an interesting partner to involve in the process for the SA.

ADASA

Working together with farmers to determine the amount of water that can be divided and to address existing water use conflicts, ADASA has information about physical behaviour of the river Preto and about existing sensitivities amongst farmers. Furthermore, ADASA has a great amount of formal power due to the authority to assess water rights applications.

Among other institutes, the novelty of ADASA and the profoundness of presented researches undermine this position of power. Nevertheless, it is an important party for both farmers and SA in the future.

Codevasf

The public organization for the development of the São Francisco and Paranaíba river basins fills in the gaps that river basin committees leave. Where the river basin committee should be responsible or acting, Codevasf actively invests, monitors and interferes with river basin development.

This organization has knowledge, money and expertise in situations such as the small dams project. Still, this organization operates at a very high level, so its involvement in the small dam project should be proactively pursued – if desired.

4.2.2. Stakeholders in a network

We can already recognize some key institutions, which can be separated from what the institutions that can be shared under "process-institutions." Process-institutions are those institutions that will inevitably be part of the process leading to the implementation of new small dams, either if they care or not. IBRAM, for example, must be part of the process at some point in time because of the environmental impact assessment that must be carried out. In the stakeholder analysis carried out in this section, these institutions return as critical stakeholders.

In **Error! Reference source not found.** the stakeholders are placed on two axes, according to how dedicated they are in the process leading to new small reservoirs and according to how critical they are, so how much depends on them for the process to succeed.

APRORP is a non-governmental party that represents stakes of professional or private water users.

EMBRAPA has specific interests in the realization of new small dams, because of the purpose of those dams: irrigation. EMATER is the institute that supports rural development and the role of technology in it. Therefore, the interests of EMATER concern good rural development in DF. Small dams should add to the rural extension, and this is as far as EMATERs interests go. In a way, the interests of EMATER and EMBRAPA cross over here. This mutual interest makes the two institutes, that enjoy public support, excellent monitors of the decision-making process leading to new small dams.

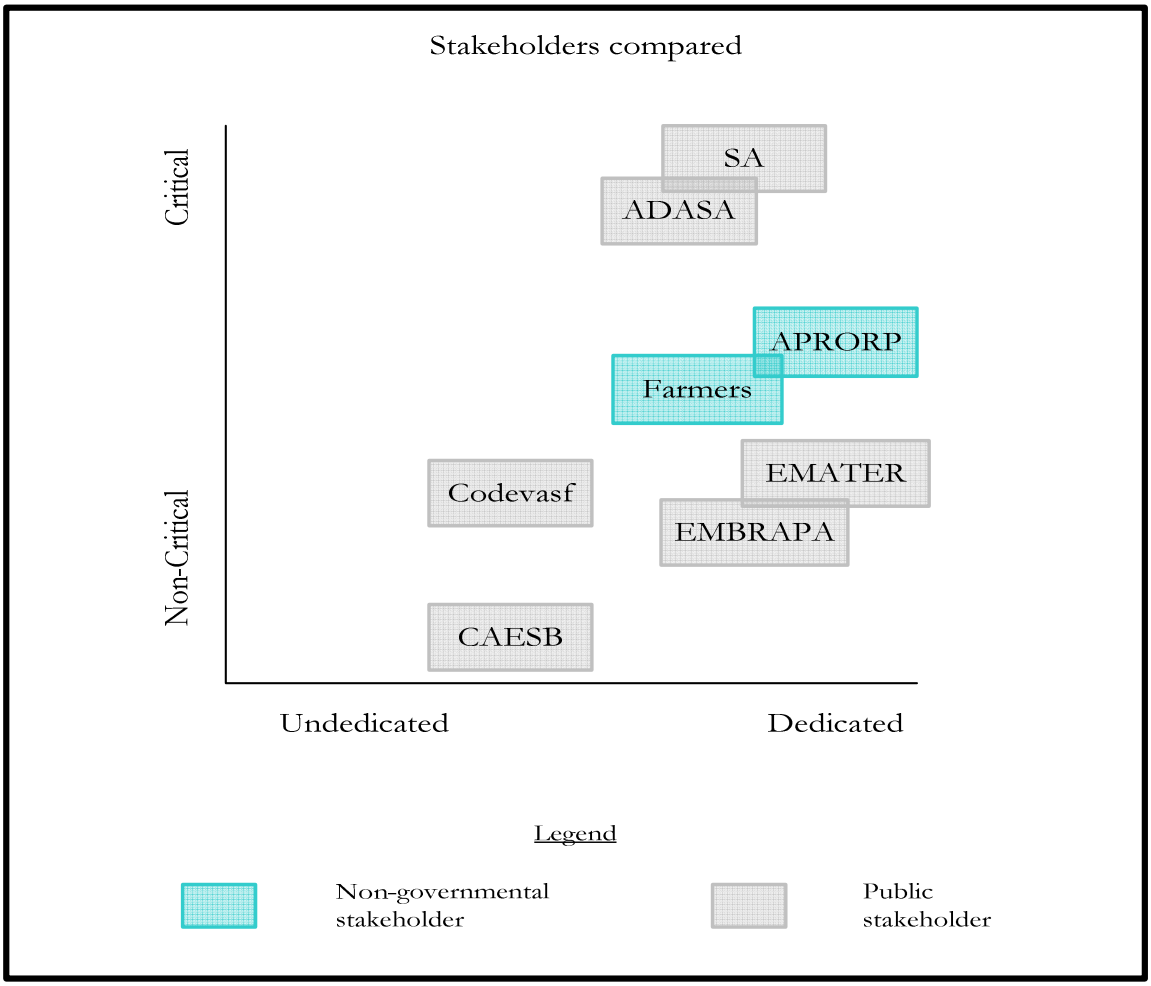

Figure 4.3 Stakeholders compared

Every stakeholder has some form of power or resources available. These resources also indicate how stakeholders in DF relate to each other. Table 4-2 shows stakeholders with their most important resources in the decision-making process leading to new small reservoirs.

Table 4-2: Stakeholders and important resources

Stakeholder	Important resources
Secretariat of Agriculture	Decision power, large group of adherents, liaison with farmers
Farmers	Money, independency (therefore no incentive to cooperate)
CAESB	High influence on environmental quality standards
IBAMA	Authority in nature, legislative environmental power (EIA

Stakeholder	Important resources
	RIMA procedure, environmental licensing procedure)
ADASA	Distribute water rights on state level
ANA	Legislative powers and authority, distribute water rights on federal level
IBRAM	Authority in nature, legislative environmental power (EIA RIMA procedure, environmental licensing procedure) within DF
APRORP	Knows about corruption, has strong support of adherents
Codevasf	Money for the project, institutional knowledge
EMATER	Technical knowledge, farmer support
EMBRAPA	Research and technical knowledge, farmer support

4.2.3. Observations stakeholder analysis

We are confronted here with an interesting problem. Process management literature often points to the importance of keeping stakeholders involved in the process to minimize the chance of opponents blocking it. In designing institutional arrangements for the determination of locations of new reservoirs, the designer normally has some degrees of freedom. Still, being educated in a course that emphasizes the importance of multiple criteria and possible future interdependencies, it is tempting to recognize situations that fit this frame of reference.

However… We are facing a dilemma about keeping the stakeholders involved. The stakeholders and institutions involved in this problem accept and even expect a high extent of command and control in making a decision on new small reservoirs, hence the remark of one of the fiercest opponents (conversation with farmers' representative).

While collecting decision-information, all stakeholders should be closely involved. The project plan might be drafted on a higher level (in a next phase), although involvement of the stakeholders remains advisable to prevent later resistance. Radical change in an ongoing project such as this one is unlikely. This means that institutions are not expected to diminish their influence.

The main point is this one: it is not the question *that* part of the project planning should be carried out by high level institutions, but rather the question *when*.

4.3. Conclusions on institutional and network analysis

Two sub questions were posed in this chapter, the first of which being:

3: How does the institutional framework influence the process leading to a location choice for new small dams?

This question has been answered by first framing the institutions that are relevant for the continuation of the process leading to a location choice for new small dams. These institutions are listed in Table 4-3

Table 4-3 Institutions related to small dams

	Water framework	**Environmental framework**
Federal Level	The National Water Resources Management System The National Water Resources Plan ANA	SNUC Forestry law IBAMA (Public Prosecutor)
DF level	ADASA Secretariat of Urban Development and Environmental Issues	Secretariat of Agriculture Secretariat of Urban Development and Environmental Issues IBRAM

The influence of these institutions on the process leading to a location choice for new small dams turned out to be a complex matter. As already referred to in the introduction of this chapter, a formal institutional framework coexists with a non-formal one. Nevertheless, many organizations acting in the institutional framework are also stakeholders in the process leading to new small dams. Therefore, the influence of the institutional framework on that process is observed simultaneously with the role of stakeholders involved:

4: What is the role of stakeholders in the process leading to a location choice for new small dams?

The stakeholders related to small dams in the PRB are presented in Table 4-4.

The remainder of this paragraph presents conclusions affecting both the influence of the institutional framework and the role of stakeholders in the process leading to a location choice for new small dams, which can be justified by two arguments:

Table 4-4 Stakeholders

	Public stakeholders	Non-public stakeholders
Federal Level	EMBRAPA Codevasf	
DF level	Secretariat of Agriculture EMATER CAESB ADASA	Farmers APRORP

- A narrow playing field. The majority of parties in the stakeholder network is related to agriculture. Actually, all communities in DF involved in this water management subject are "nucleos rurais" or rural communities – farming communities.
- High overlap. What is striking is the observation that almost all stakeholders are institutions – or organizational institutions – exercising some kind of power. Only the communities and the farmers represent "groups of individuals" that are not institutionally organized.

Independent initiative. The only body of voice successful enough to stop one governmental initiative was APRORP. This organization has nothing to do with any governmental reform, change or initiative. "Government" has a negative connotation in this regard. In the initial plans for institutional reform, bodies of voice were mentioned. In reality, these bodies of voice only exist on paper. During this research, no party or person has been encountered that specifically mentioned the existence of such a body existing based on a government initiative.

For example, if farmers are damaged by the decision to place a reservoir on part of their fields, they will take neither the basin committee nor the DF government seriously, let alone the chance that they will cooperate with set schedules and fixed water prices.

So the **role** of stakeholders in this regard is related to communication, cooperation and compliance. Only if they show an initiative to cooperate themselves, the negative connotation of governmental interference can be overcome.

Lack of formal and informal relations. However, the **influence** of the institutional framework leaves little space for communication between stakeholders and institutions. The formal

relation between farmers and policy-makers is a means of last resort (the public prosecutor).

Lack of margins. Therefore, there exists only limited facility to resolve conflicts between farmers and government. Going to the Public Prosecutor is the first step farmers can take to stop governmental decisions from being carried out.

Exclusion of future players. Field interviews revealed that the Secretariat of Agriculture has no plans to grant access to new irrigating farmers. Small farmers are often highly religious, analphabetic and traditional (Maldaner 2008) in their practices. They do not irrigate and leave their fate in the hands of statistics (the weather), or in the hands of God as they prefer to see it.

Subsequently, the distinction between groups of farmers/water users is very important. They are represented by one institute now, but their internal stakes are different. Land ownership is a key concept here. This might blur the **role** stakeholders have now, and lead to misplaced **influence** of the institutional framework.

Trust. EMBRAPA and EMATER are the only governmental parties that enjoy the unconditional support of farmers. If policy-makers want to **influence** the **role** stakeholders have in the decision-making process leading to a location choice for new small dams, these two parties can facilitate – both formally and informally – communication between farmers and governmental parties. In this way, the role of the National Water Resources Policy can be shaped into a format that is consistent with goals of both farmers and the Secretariat of Agriculture.

Especially since governmental abuse of power seems to be embedded in this culture. If it is not present, most people assume it to be. Trust in the institutional system – or lack of it – makes people involved in any kind of capital intensive project sceptical about the governing persons/institutes. In my experience, virtually everybody accepts the phenomenon of fraud. Fraud in itself is condemned, but the phenomenon exists. Worsely, some people see themselves as potentially corrupt when confronted with the opportunity. A corrupt government is problematic, but assumed corruption *a priori* might be even worse. That is also an **influence** of the current institutional format.

It could even be called downward imaginary corruption transfer. When exposed to the

possibility to abuse power, someone gaining power due to downward accountability/decentralization might see him/herself tempted to abuse it.

That is why the good governance principles mentioned in paragraph 2.1.3 are crucial. They must be incorporated in a decision-making process leading to new small dams.

EMBRAPA and EMATER must play a dominant role in connecting farmers to the government.

In short, the **influence** of the institutional framework on the process leading to a location choice for new small dams is related to **trust** stakeholders have in the institutions involved in that process. That is why there are chances to improve both the relations between stakeholders and the decision-making process.

Requirements

The observations and conclusions mentioned in this chapter can be translated into requirements which locations for new small dams should meet. These requirements are presented in Table 4-5.

Table 4-5 Stakeholder and institutional requirements and measure

#	Location requirement	Measure
1	The decision-making process leading to location choices must be transparent and participatory in nature	% of farmers informed
2	APRORP must be involved in the decision-making process	Yes/no
3	Farmers must be informed about the existence of plans for new small dams	Amount of farmers up to date > 90 percent
4	Location options must be communicated by the responsible institute to farmers/-organizations	Information meeting attendance > 70 percent
5	Location criteria must be discussed by the responsible institute and farmers/-organizations	Information meeting attendance > 70 percent

#	Location requirement	Measure
6	The EIA must run parallel with the environmental licensing procedure concerning locations for new dams	Time difference in reporting < 1 month
7	Each dam must be subject to a unique EIA procedure	-
8	EMBRAPA and EMATER must monitor the decision-making process leading to new small dams	Yes/no
9	The distance dam-river head must be at least 50 meters	m
10	Interference with current land use must be minimized	M^2
11	Farmers' opportunity costs must be minimized	R$
12	Current water rights division may not suffer from newly constructed small dams	M^3/day/water user

5. Technical aspects

Physical system

System infrastructure
Water sources
Topology
Case characteristics

In terms of the research framework drafted in chapter 1, this part addresses the *physical system* within which the research problem has been defined. As described in section 1.3 this study has been carried out in light of the Small Reservoirs Project, which in its turn was part of the Challenge Program on Water and Food of the Consultative Group of International Agricultural Research (CGIAR 2003). In the end, the problem examined in this researched is all about needed or expected availability of water. This chapter looks at the technical aspects of water *balances*, whereas the previous chapters have taken into account the perception-related aspects of water *scarcity*. The word "technical" actually addresses the water balance/water resources situation in the PRB. This balance consists of a simplified demand and supply side. Chapter 6 also addresses the water balance, but focuses more on system behaviour than on this chapter. This chapter and chapter 6 are related to each other in such a way, that the distinct factors affecting the water balance in the PRB in DF are recognized and appointed in the former (analysis), and the actual influence these factors have is explored in the latter (modeling). The sub question answered in this chapter is:

5: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be recognized?

The answer to this sub question will be complementary to the answers to the other analysis chapters. Part of the expected answer will consist of the data and information needed for a model that studies the impact of small dams in the PRB, based on water balance accounting.

Hence, this chapter is subdivided into the following sections:

- Functions and characteristics of small dams
- User demands of the biggest water users in the PRB
- Water resources and supplies
- Earlier considerations about locations planned in history
- Observations and conclusions

The analyses carried out in this chapter are based on earlier studies. The most important one is a study that has been carried out to realize the construction of 38 new small dams in

the PRB in DF, by the Secretariat of Agriculture. This is the same study referred to in section 3.2. In order to remember the geographical boundaries of this research, Figure 5.1 shows the physical system of the PRB in DF once again.

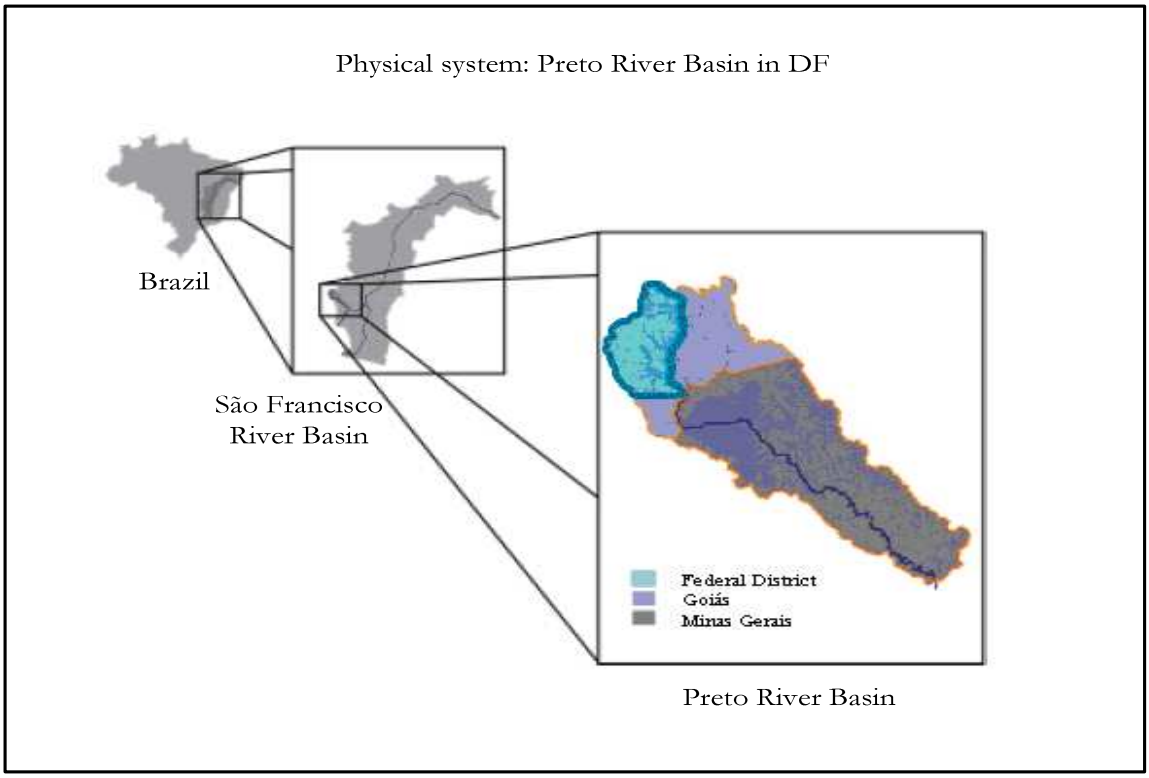

Figure 5.1 Physical system revisited

5.1. Functions and characteristics of small dams

This section discusses the intended functions of small dams as they are planned by the SA, as well as dimensions and characteristics of typical small dams in the PRB in DF.

5.1.1. Functions

From a technical perspective, the most important intended behaviour of a (small) dam is to regulate the river discharge, in order to guarantee a continuous flow even during the dry period of the year (which lasts from May until September in DF) (SEAPA 2000). An important difference with large reservoirs used for other purposes (e.g. generation of hydro-electric power) is that small dams have no sophisticated operational functions. A small dam is – so to speak – just a dam, and in the PRB made out of earth, which makes its functions

comparable to weir functions.

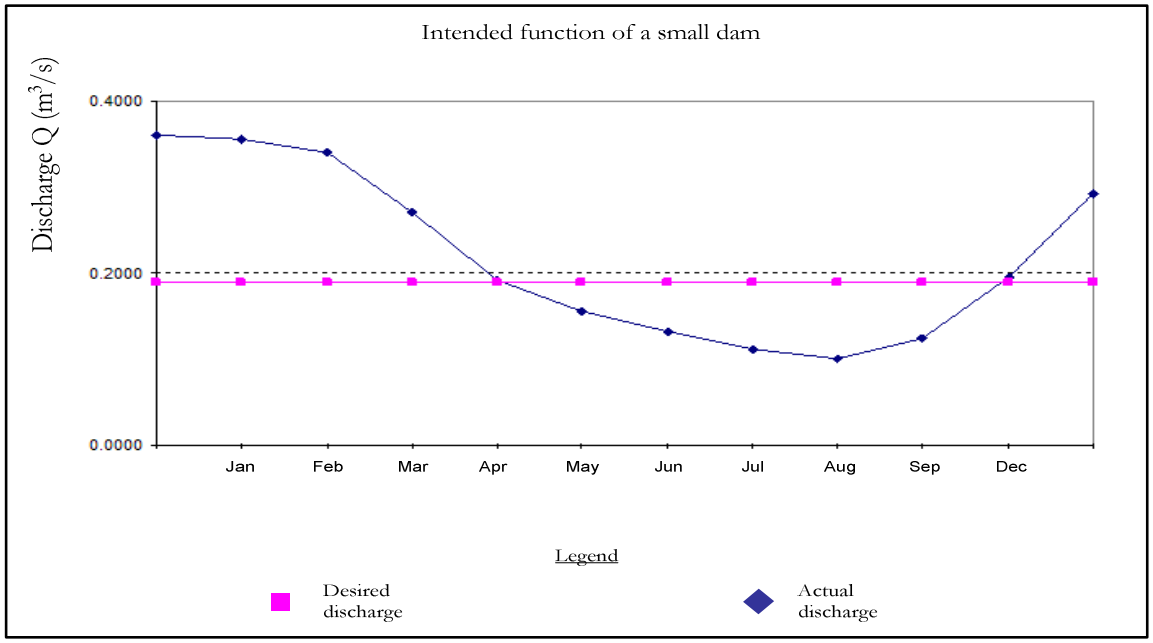

Figure 5.2 Intended regulative function of a small dam. adapted from: SEAPA (2000)

The intended regulative function of a small dam is presented in Figure 5.2. On the Y-axis, the river discharge is presented. The X-axis displays the time period of one year. What the figure shows, is that a small dam results in a constant (but somewhat lower than average) discharge throughout the year. It also indicates the minimal net capacity of the reservoir. If the reservoir would be designed without margins, point of departure is the month November. This is the point where the net content of the reservoir (so correcting for dead storage and losses within the chosen timeframe) may reach 0 due to an outflow, which is higher than the inflow. Right afterwards, the inflow will surpass the outflow, guaranteeing the constant water supply. Right before this point, the inflow plus current reservoir storage per time step must be at least equal to the expected constant outflow.

Thus, the dimensions of the small dam must be chosen in such a way, that the reservoir stores enough water to guarantee the constant supply until the natural supply exceeds the regulated outflow (reservoir is filling up again).

Contrarily, the dimensions of the small dam must be chosen in such a way, that the reservoir is able to store the water that exceeds the regulated outflow until the natural supply fails to reach the regulated outflow (reservoir drains again).

5.1.2. Important dimensions/characteristics

A location choice is highly interconnected with other characteristics of a small dam. The characteristics of a location where a new dam is planned determine the physical behaviour of it to a high extent. Characteristics having influence on the dam behaviour are:

- Intended regulated outflow: How much water should flow out?
- Reservoir capacity: How much water must be buffered?
- Water level-volume ratio: What is the shape of the landscape determining how much the water level rises when a variable amount of water will be stored?
- Discharge without intervention: How much water flows in the river at the point where a new reservoir is planned?
- Seepage: What are the water losses due to soil characteristics and leaking water?
- Evaporation: What are water losses due to (potential) evaporation?

All of the above factors influence the choices for dimensioning a new small reservoir. Let us take a look at the extent to which these characteristics are determined by location characteristics by examining one example: The intended regulated outflow seems to be dependent on dam dimensions and hydraulic structure. Still, being able to meet the intended regulated discharge is dependent on the eventual location choice, because the intended regulated outflow will be dependent on the river discharge without intervention.

The conclusion about the characteristics listed above is therefore not that all are directly dependent on the location choice, but that they are all (directly or indirectly) related to location characteristics. So, for each location the above characteristics should be taken into account in order to be able to decide whether or not it meets technical requirements for a new dam.

5.2. User demands and water supplies

This section lists the type of water use in the PRB in DF and explains in detail how water rights are distributed in DF.

5.2.1. Types of use

As described in chapter 4, ADASA is the main organ that distributes water rights in DF in Brazil. This institute has mapped the demands of farmers in the PRB, and is currently still

updating this information.

In a study into water use carried out by ADASA (2004) an overview of user demands expressed in divided water rights is presented. The entire PRB that is part of the DF has been divided into subunits. These subunits are presented in Figure 5.3. For any subunit recognized, the water users exercising their water rights have been listed, as well as ongoing research to new water use. The various types of water use listed are:

- Irrigation water use
- Livestock water use
- At some points: drinking water intake
- Fishery water use

For a detailed description of how these data have been collected and organized, please refer to Appendix E.

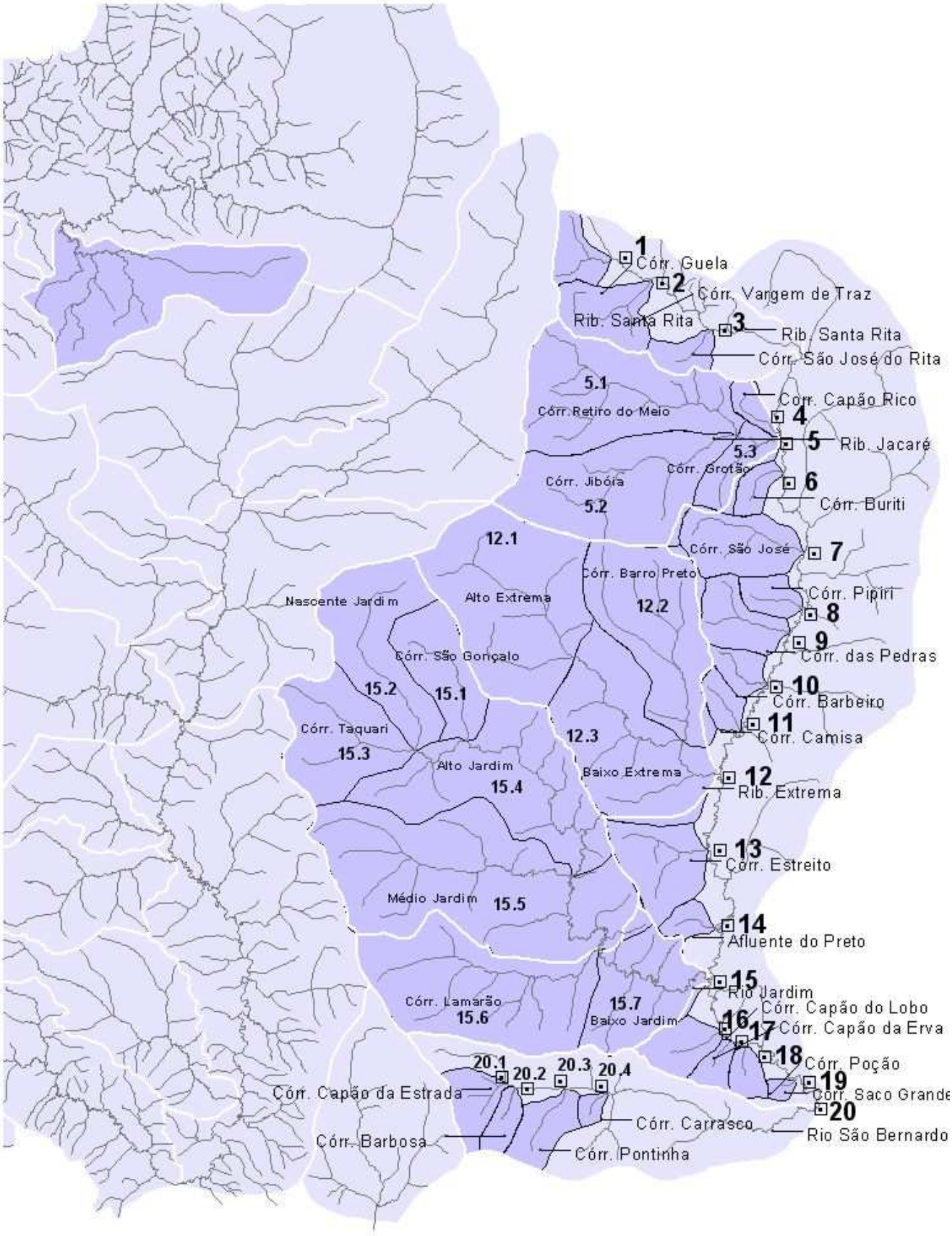

Figure 5.3 Division in subunits by ADASA

Table 5-1 Subunits in the PRB

#	Subunit	Sub basin
1	Córrego Guela	Ribeirão Santa Rita
2	Córrego Vargem de Traz	Ribeirão Santa Rita
3	Córrego São José do Rita	Ribeirão Santa Rita
4	Capão Rico	Alto Rio Preto
5.1	Córrego Retiro do Meio	Ribeirão Jacaré
5.2	Córrego Jibóia	Ribeirão Jacaré
5.3	Córrego Grotão	Ribeirão Jacaré
6	Córrego Buriti	Alto Rio Preto
7	Córrego São José do Preto	Alto Rio Preto
8	Córrego Pipiri	Alto Rio Preto
9	Córrego das Pedras	Alto Rio Preto
10	Córrego Barbeiro	Alto Rio Preto
11	Córrego Camisa	Alto Rio Preto
12.1	Alto Extrema	Ribeirão Extrema
12.2	Córrego Barro Preto	Ribeirão Extrema
12.3	Baixo Extrema	Ribeirão Extrema
13	Córrego Estreito	Alto Rio Preto
14	Afluente do Preto	Alto Rio Preto
15.1	Córrego São Gonçalo	Rio Jardim
15.2	Nascente do Jardim	Rio Jardim
15.3	Córrego Taquari	Rio Jardim
15.4	Alto Jardim	Rio Jardim
15.5	Médio Jardim	Rio Jardim
15.6	Ribeirão Lamarão	Rio Jardim
15.7	Baixo Jardim	Rio Jardim
16	Córrego Capão do Lobo	Alto Rio Preto
17	Córrego Capão da Erva	Alto Rio Preto
18	Córrego Poção	Alto Rio Preto
19	Córrego Saco Grande	Alto Rio Preto
20.1	Córrego Capão da Estrada	Ribeirão São Bernardo
20.2	Córrego Barbosa	Ribeirão São Bernardo
20.3	Córrego Pontinha	Ribeirão São Bernardo
20.4	Córrego Carrasco	Ribeirão São Bernardo

5.2.2. Granting water rights

ADASA works as follows when distributing water rights: For each subunit, the distributable water rights are determined, independent of the actual demand and based on minimal discharge data. Later the actual demand is compared with the distributable water rights, and if the latter is higher than the former, the water rights are granted.

The water users themselves indicate the actual demand. Water users applying for water rights go through a mainly bureaucratic procedure in order to indicate their expected demand; and to apply for their water rights. The comparison ADASA makes between available water and requested water demands is presented in Figure 5.4. This figure shows in which period of the year which amount of water can be provided for according to water availability.

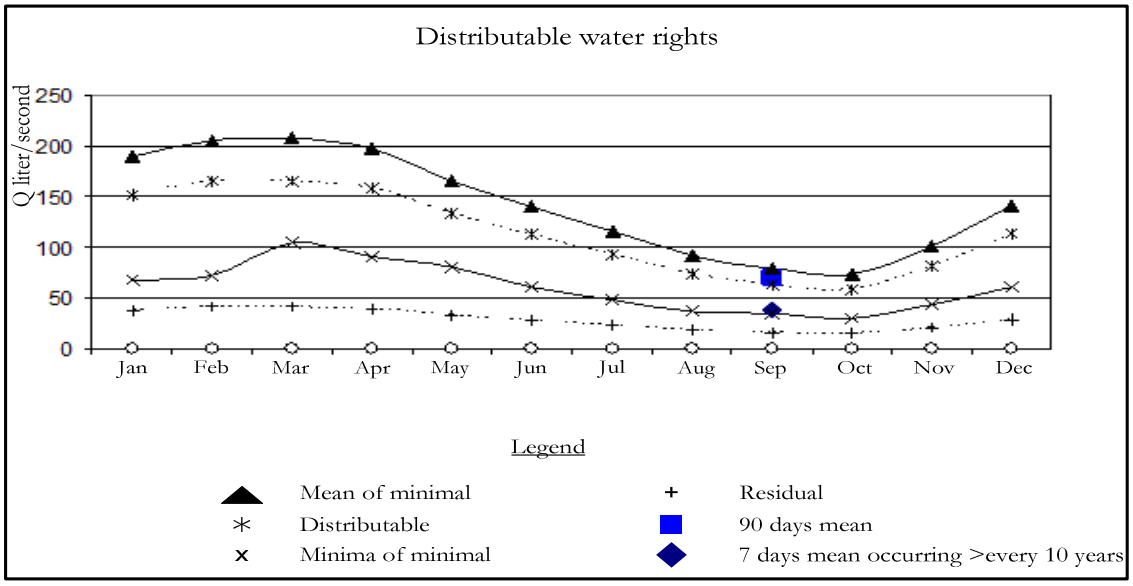

Figure 5.4 Water rights distribution by ADASA

Important data for determining a suitable location for new a small reservoir that can be derived in this context are:

- the area of the subunits or region in which water rights are granted
- the demand of users
- the division of water demand throughout a year
- river discharge data

- the number of users

The type of use is not a relevant factor in this regard, because 99 percent of all water used in the PRB is related to irrigation or agricultural activities (see paragraph 3.1).

5.3. Water resources and supplies

River and stream discharges have been researched by ADASA in the same study that addressed the water rights distribution. In addition, the Secretariat of Agriculture has carried out a study into the construction of 38 new small reservoirs in the PRB. In both studies river discharges are provided for, but the SA study focuses particularly on the construction of new small dams. Therefore, the discharge data are related to the suitability of a location for new dams. In other words: SA picked locations for new small dam and studied the characteristics of those locations. Although this may be in the wrong order from a stakeholder point of view, this approach shows which location factors are important when planning the construction of new small dams. For this reason the SA study is preferred over the study carried out by ADASA when gathering data for a water balance accounting model.

The type of data relevant for the location of new small reservoirs is listed below:

- River head flows
- Monthly average flows at planned locations
- Yearly average flows at planned locations

The advantage of having two sources available lays both in back up and double-checks of information. If the SA information turns out to be incomplete, ADASA data can compensate for this. In addition, if SA information is complete, a plausibility check can be carried out based on ADASA data.

5.4. Remarks on data quality

The data provided for by the studies of the SA are detailed and elaborate. The source of all these data is provided for in the documents concerned. However, expert's knowledge and inside information at the SA in DF have indicated that the profoundness of the performed researches is questionable.

According to Rodrigues (2008), there has not yet been done much research into the actual hydrology of the PRB in practice. During a meeting with all institutions involved at

the Secretariat of Agriculture, addressing amongst others this project on 08-08-2008, this view was confirmed by other parties.

As for the data that was provided for by ADASA: during a presentation of ADASA, in which the data used in this research were presented, all other parties with running investigations related to hydrology or water resources in DF commented on the level of detail that is hard to reach within the amount of time ADASA has carried out its researches.

The information of ADASA sometimes heavily deviates from reality (Azzi 2008). Farmers simply do not know how much water they extract from a source, because of which they ask for less than actually used.

For this reason, the data on water demands are available yet need to be used with some reserves. The data were collected with the best intentions and keeping a long term relationship between ADASA and the water users, hence the long term relationship that ADASA tries to build up with the water users despite erroneous information.

Despite the reserves that need to be taken into account when using the available data, the data collected by the SA and the data collected by ADASA about the water supply are in the same range. So although the quality of data is questionable, it is usable to investigate water availability, test this with practice and research the behaviour and impact of small dams on the water system in the PRB.

5.5. Observations, conclusions and considerations

The question that has been answered in this chapter addresses the characteristics of the physical system related to the impacts on water availability in the PRB:

5: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be recognized?

This chapter started addressing the functions of small dams. The intended function of a small dam is a reservoir function: small dams store water to make it available during the dry periods. Whether this is exactly how small dams work in practice will be researched in chapter 6.

Furthermore, location characteristics that are related to the functioning and requirements

of locations for new small dams were recognized. These characteristics serve as a basis for understanding the impacts of new small dams on the PRB system behaviour.

- Water use rates
- Water demands
- Intended regulated outflow
- Reservoir capacity
- Water level-volume ratio
- Discharge without intervention
- Seepage
- Evaporation
- River head flows
- Monthly average flows at planned locations
- Yearly average flows at planned locations

Other conclusions

The technical analysis carried out in this chapter comes down to the ultimate step preceding a water balance accounting model explaining the PRB in DF behaviour and the impacts of new small dams on that system. Modeling is necessary because of the large amount of data that has to be processed. The type of data necessary to calculate water demands and supplies and the role of small dams in this context are explicit now.

Also, the most important considerations regarding the continuation of this project can be made based on the analysis of technical data. The most important considerations and trade-offs to be made are:

Quality of data: For the water balance accounting model and the modeled behaviour of small dams, it is possible to improve the quality of data about river discharge. A short study into a statistical spreadsheet model called the RAINRU (rainfall-run-off) model (Savenije 1997; Lieuw 2005) has been carried out. See Appendix H for the application of this model. On the other hand, it can be assumed that the available data suffices for the creation of a "toy model," which shows which mechanisms or impacts occur when small dams are applied. The choice to be made is one between researching mechanisms in the river basin, or enhancing data quality (with for example the RAINRU model).

How to model dam behaviour: In a computer model, the choice has to be either to build in the intended regulated outflow or to represent the dimensions of the dam. The latter option provides for an inspection of the reservoir behaviour: does it meet the predefined requirements? Will this dam give the intended regulated outflow?

User distribution: In the water balance accounting model, a choice must be made regarding the water use and water users. Based on the available data, the water use will be easier to model in total than the water use per user. If the users are combined, the model will not serve the function of optimizing water allocation from a water user perspective, but merely from a water use perspective.

Lower boundary of water use: Farmers using less than one cubic meter per second of water are not modeled, because ADASA has not registered them. This makes it an automatic lower boundary of modeled water use.

Seepage and evaporation: These data are neither available from the studies carried out by ADASA nor by the Secretariat of Agriculture

Given the doubts on the quality of data on both demand and supply side, it is better to make a "toy model," a model that shows what mechanisms evoke when new small dams are implemented. The detailed data do not have to be of very high quality, and the data gathered for this research suffice in detail for the construction of this toy model. The data have been collected in a highly official environment and had with the intention of giving serious and suitable information on water resources in the PRB.

Part 3: Modeling and design

From this point forward, integration of information generated in earlier parts of the research becomes increasingly important. The analyses carried out have revealed what small dams are, what they are intended to do and in what kind of context the decision-making process leading to a location choice for new small dams is taking place. In other words: distinct parts of the PRB system have been recognized. Many requirements for this process and for locations of new dams have been formulated. The intended output of part 3 "Modeling and design" is a clear overview of how that process can be influenced and how system behaviour in the PRB in DF can be influenced. Beyond this overview, part 3 results in a set of institutional arrangements for the continuation of the process leading to a location choice for new small dams.

6. Modeling water resources[5]

Water balance accounting

System behaviour
Area inflow and outflow
Modeling

Data about physical behaviour in the PRB have been collected and examined in the previous chapter. The idea is for this chapter to turn these data into information; to give additional meaning to the numbers and figures examined in chapter 5. This will be done using a computer model.

The sub question addressed in this chapter is:

6: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be influenced by policy-makers?

In paragraph 2.1.5 an overview of uses of computer models in socio-technical problems has already been presented. In this chapter, however, a specific computer model must help the designer to decide which locations for new small dams are more appropriate than others. The chosen model must therefore contribute to clarifying which criteria exist in determining locations for new reservoirs. Two fundamental questions about a model are, in short:

1. How does the model contribute to generating decision information about the locations of new small reservoirs
2. How can it be determined whether or not this is the right model (see paragraph 6.1.3)?

An additional result of this chapter is an answer to the question which role mentioned in paragraph 2.1.5 the model fulfils in this research.

Paragraph 6.1 addresses the Water Evaluation and Planning (WEAP) model within the context of water balance accounting, whereas paragraph 6.2 places WEAP within the context of this research.

6.1. The Water Evaluation and Planning model

This section introduces the Water Evaluation and Planning (WEAP) model and connects

[5] If interested in the water balance accounting model made to investigate the impacts of new small dams on water availability in the PRB in DF or the WEAP software used in the context of this research, additional information can be obtained via email: maxlinsen@gmail.com.

the context in which this model is normally used to the context of this research. After introducing water balance modeling, earlier applications of WEAP, a comparison with other water balance accounting models and a confirmation by experts of the usability of WEAP in the context of this research, the actual program will be introduced. Therefore, if specifically interested in the functions of WEAP, please refer to paragraph 6.1.5.

6.1.1. Water balance modeling

Data concerning water supply and water demand are very hard to interpret directly. These data are elaborate and complex. Therefore, computational support is necessary for a rough interpretation of the available data.

To choose the right computer program for data evaluation, several aspects can be taken into account:

- Type of data available
- Problem context/type and scale of questions that need to be answered
- The type of research following this first one

Based on the type of data available and the scale of the problem and questions asked, the WEAP model offers the right features to evaluate the available data. Paragraph 6.1.2 on earlier application of the program supports this statement. In the subsequent paragraph, the exact role of WEAP within this research is exemplified. This entails a feedback to the relevant research questions as well as an introduction to the main elements and jargon of WEAP. Hereafter, the practical aspects of the program such as data, models and results are presented. This chapter ends with a paragraph on the interpretation of the results as provided for by WEAP.

6.1.2. Earlier applications

In showing the utility of the WEAP model, earlier applications contribute to a justification. A general introduction to the basic practical and academic goals of developing WEAP has been provided for by Yates, Sieber et al. (2005). Furthermore, the relevant hydrological and mathematical underlying equations and principles that distinguish WEAP from comparable models are presented. Lévite, Sally et al. (2003) assess the advantages and

disadvantages of using WEAP in a context in which stakeholders and decision makers must have information about water balances on different levels in a South-African river basin. Their main conclusions on WEAP are twofold. First of all, there exist limitations with respect to the hydrological quality of the model. Secondly, WEAP is "potentially a useful tool for a rapid assessment of water allocation decisions in a river basin, in particular to locate graphically where the problems are likely to occur." This statement endorses observations made earlier about the suitability of WEAP for the problem in the PRB, and is consistent with the competencies of the researcher in this research.

In the studies of Sorisi (2006) and Olusheyi (2006), WEAP is also connected to decision making processes regarding institutional optimization of water resources management and sustainable development of water resources respectively.

6.1.3. Compared to what

A comparison of WEAP with other models has been carried out by Yates, Sieber et al. (2005) in their introductive paper about the program. The special characteristic (or unique selling point) of this type of program is the proclaimed integrative approach, which refers to the integration of institutional and stakeholder-related factors with the water balance accounting function of the program. Other models are:

- US Department of Agriculture's Soil Water Assessment Tool (SWAT) (Gassman, Reyes et al. 2007)
- The RiverWare™ DSS (Zagona, Fulp et al. 2001)
- The US Geological Survey's Modular Modeling System (U.S. Geological Survey 2006)
- HEC-ResSim (Hydrologic Engineering Center of the U.S. Army Corps of Engineers 2008)
- MODSIM DSS (Colorado State University 2008)
- MULINO DSS (Giupponi, Mysiak et al. 2004)
- WaterWare (Services 2008)

The most repetitive comment on the above models comes down to difficulties with truly integrating various aspects of water management and maintaining a comprehensive yet easy

to use interface. Furthermore, many models are dependent on other models' output, for example when a hydrologic model must contribute to completing the input-information (RiverWare), or when boundary flows must be prescribed separately from the model (MODSIM).

Apparently, a gap exists between water management aspects and watershed hydrology. WEAP21 is the program designed to (attempt to) bridge this gap. It should be able to model a river basin or watershed from head to tail independently.

Although Lévite, Sally et al. (2003) mentioned that the hydrological performance of WEAP was limited, WEAP is independent of high quality hydrological data. The model can be extended with other (hydrological or geomorphologic) models to improve the quality of input, which will of course improve the representation of flows and hydrologic behaviour. Nevertheless, the independency of WEAP with regard to complete data is advantageous in a situation as existing in the PRB.

6.1.4. Expert advice

Literature has provided for some reasons to choose WEAP for modeling water balance accounting in this research, but two experts also supported the use of this program, being Dr. Lineu Rodrigues (of EMBRAPA Cerrados) and professor Dr. Ir. Nick van de Giesen (of Delft University of Technology, faculty of Civil Engineering and Geosciences), based on their involvement in the Small Reservoirs Project. This project is the same project for which this research serves as a follow-up.

For a deeper study into the earlier applications of WEAP, please refer to the WEAP21 website, where a complete variety of research with the program has been listed.[6]

6.1.5. Short introduction to the program

WEAP is a program that represents the balance between a demand-side and a supply side of a water system. The demand-side consists of parameters such as agricultural use, industrial use or personal water use. Even pollution and pricing mechanisms can be shared under the definition of demand. The supply side can be defined as rivers, creeks,

[6] http://www.weap21.org/indexnld.asp?doc=16

groundwater and reservoirs. A close-up of WEAP components as visible in the WEAP interface is presented in Figure 6.1.

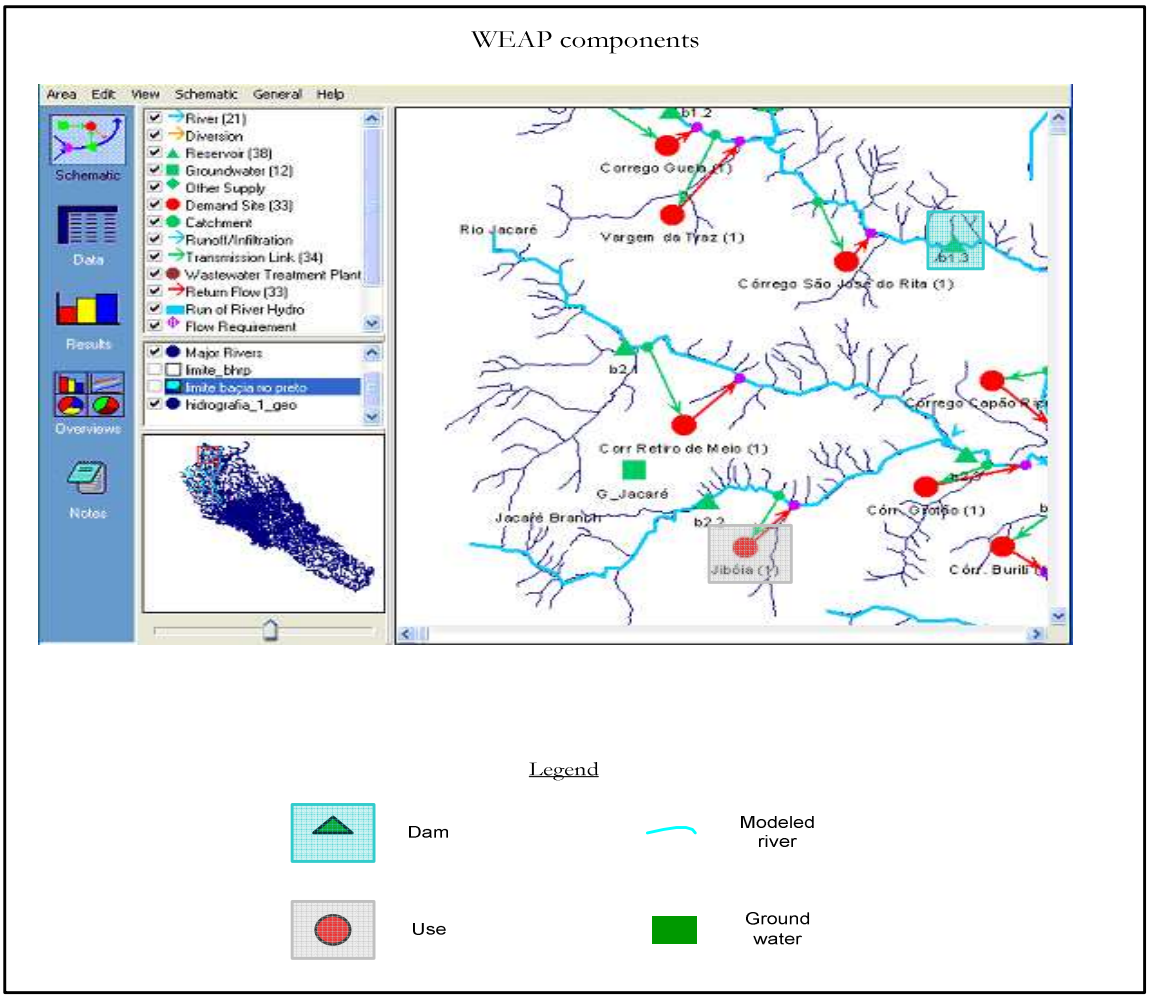

Figure 6.1 Close-up of WEAP components

In order to mark the area within which research is being conducted, a GIS layer can be added (see Figure 6.2). In this case, a GIS layer of the entire PRB was made available by EMBRAPA. It is a helpful tool in discovering where the rivers flow. The locations of water users – available in the (ADASA 2004) report – can also be verified, as this GIS layer displays all the centre pivots[7] (Omary, Camp et al. 1997) used in the region.

[7] A widely used irrigation process in the region. Centre pivot irrigation is a subject which has been studied in a vast number of researches. In this research, however, the presence of centre pivots has been used as an indicator to check the exact location of water use patterns.

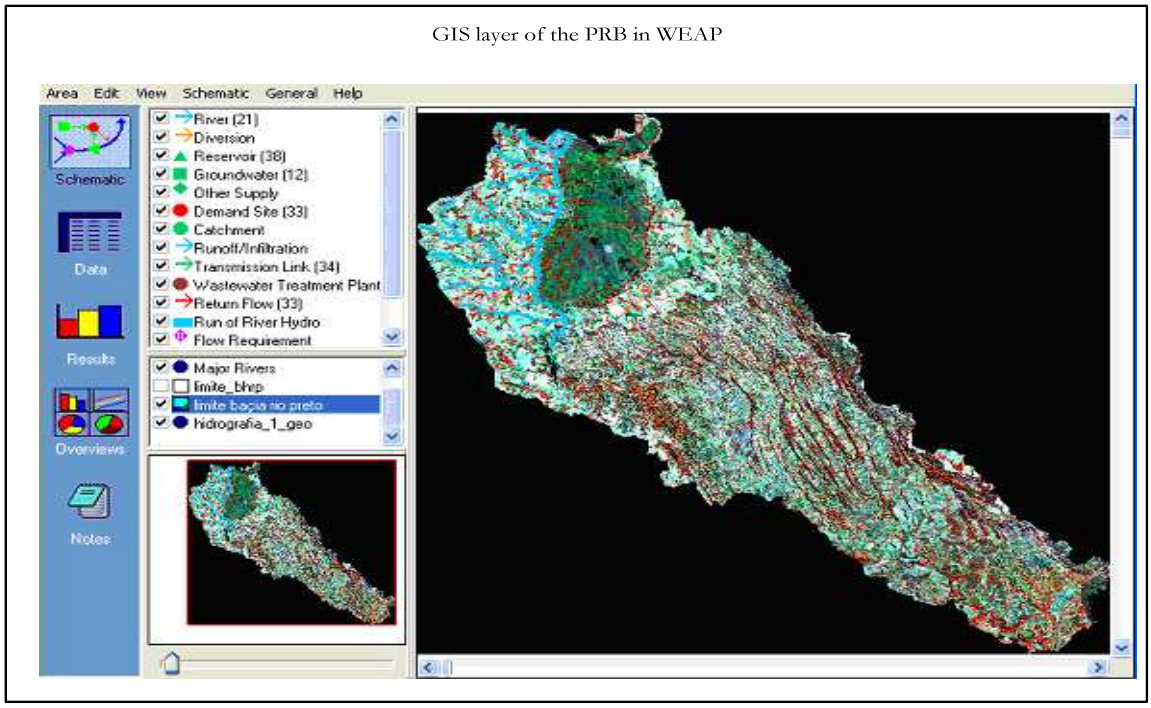

Figure 6.2 GIS layer of Preto River Basin in WEAP

Rivers

Only the rivers that have data readily available are useful to model. WEAP does not calculate complicated hydrologic behaviour if not clearly entered. This means that complete data availability is the only way in which a WEAP model can be constructed. The type of data necessary is articulately asked for by WEAP, and can be obtained either by empirical research or by hydrological models. Aspects incorporated by WEAP are head-flow, tributaries, seepage, evaporation, water use, etc.

Use

After completion of the network of rivers, water users can be fictively centered in a "demand site." The complete (known) water use within a defined part of the river basin is concentrated in this point. To this point, a transition link can be modeled between a source (such as a river or groundwater). From it, return flows can be modeled.

As a matter of fact, the points that represent water use are not quite straightforward: they are fictive centres of all the water use in a defined region. Centralizing water usage to simplify the model is permissible as long as it is kept in mind that the model does not make detailed distinctions between rich and poor (or large and small) farmers.

Reservoirs

Examples of special points are dams and groundwater nodes. In order for the WEAP model to be complete in the context of this research, the small dams must be modeled by means of reservoirs functions in WEAP.

An overview of the model components that are dependent on data availability can be found in Figure 6.3

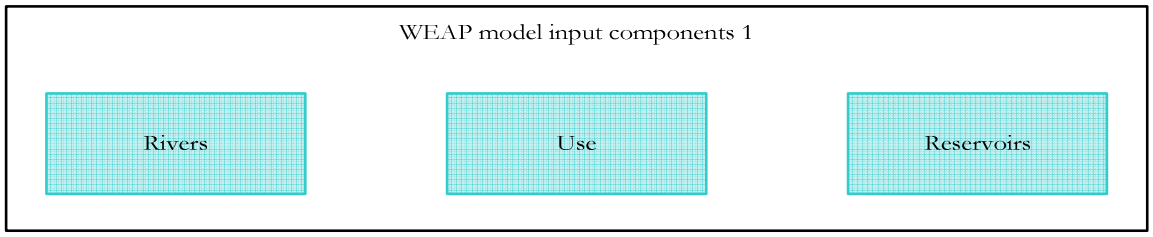

Figure 6.3 Weap model input components 1

Scenarios

Scenarios in WEAP are variations to a basic situation "without intervention." This basic situation is modeled in the "current accounts." Any first version of a water balance model is a reference scenario, which can be diversified. After diversification, differences in result can be internally compared between the reference scenario and other scenarios.

Results

WEAP then forecasts entered alternative settings (called "scenarios") with parameters such as stream flow, demand, supply, storage and losses. If necessary and relevant, costs, pollution etc can also be forecasted.

6.2. WEAP within this research

This section focuses on the situation in the PRB in DF and how it can be modeled into WEAP. The modeling approach explained in paragraph 7.1 is applied to the PRB situation, after which various scenarios are introduced. The model is run over again to check whether it makes sense with regard to physical behaviour.

6.2.1. Modeling approach and choices

In WEAP, scenarios are the basis for the model's output. The reference scenario (based on the current accounts) must represent the water balance in the PRB without intervention of new small reservoirs. The input components for this scenario are listed in figure 7.5. For the reference scenario, the following choices/assumptions were made:

Rivers

- Rivers flow into other rivers, but not every river branch or streamlet has been measured in whatever way. Therefore, only the most influential (biggest) river branches have been modeled, completed with the river branches in which a small dam was planned to be built

  Despite the incompleteness of geographical data points, hydrologic data is not incomplete (only less detailed) because the influence of these non-measured streams is implicitly taken into account with data points that are available downstream

Use

- In WEAP, the way water use is entered can be dependent of a user factor multiplied by a use ratio (for instance a user factor of hectare, and a use ratio of cubic meters per hectare). In this study, however, the direct water use has been modeled since the data was readily available as such
- The number of water users has not been taken into account; just the amount of water use. A possible disadvantage is the lack of distinction between large water users and smaller ones, but reduced complexity is an accompanying advantage. In terms of WEAP this means that one demand site can represent several water users, but only one specific amount of water used
- The "creation" water use (see Appendix F, water use for cattle growth) is presented by ADASA as a constant flow rate with a yearly maximum. However, the constant maximum flow rate is higher than the yearly maximum divided by the time within a year. In other words, when x is the amount of water a farmer may use for creation,

and y is the maximum flow rate per day, $x/365 < y$. I have chosen to divide the yearly maximum over the 12 months of a year, which might lead to a minor difference in peak load per month. This difference, however, is relatively small because of (1) the division by month and (2) the already existent water demand

- In DF, all water detracted for irrigation purposes will either be used by transpiration or by evaporation. Either way, there will be no return flow from the demand sited to any other point. In this model, all water used is applied for irrigation

Reservoirs

- Many reservoirs already exist in the PRB (Rodrigues, Sano et al. 2007), but it is assumed that these reservoirs have been distinguished in the analyses of the SA and ADASA respectively. In other words, existing small dams influence the rivers, but the in the data used by the SA this influence is considered a given. Therefore, data concerning water flows are directly used as model input and existing reservoirs have not been modeled separately.

Small dam spillway in the Buriti Vermelho Catchment

Figure 6.4 Spillway of a small dam in the Buriti Vermelho catchment

In the trade-off between available time and depth of this study, this choice contributes within the scope of this research to answering research questions

- Reservoirs have been modeled according to the dimensions mentioned in the SA document. This means that – taking variation due to seepage and evaporation into account – the regulated flow as presented in the SA document might not be achieved in the WEAP model. The latter is presumed to stick closer to reality, however, than mere calculations
- The evaporation of water from a reservoir can have large impacts on the water system, especially in a semi-arid region such as DF (with huge potential evaporation rates). Unfortunately, only a small part of the PRB has been examined thoroughly in

this regard. The data from the Buriti Vermelho basins have boldly been used for all other reservoirs, only varying according to the area of the reservoir water level

That the evaporation rates are relatively high and hard to determine per reservoir has also been admitted by Alvarez, Gonzalez-Real et al. (2008).

Furthermore, the existing evaporation (in the basic scenario without intervention) ratio is considered to be part of the available data. This assumption can be justified by the statements made by Winsemius, Savenije et al. (2008), in which the authors describe how "in semi-arid areas (…) evaporation is a much larger water balance term than streamflow". So the available streamflow can be regarded already corrected for evaporation losses. Therefore only the evaporation occurring in the new small dams will be modeled

- Seepage has been taken into account as well. Although it is highly dependent on the situational characteristics of the planned reservoirs, the WEAP model incorporates a standard seepage rate, based on the research of Dekker, Rodrigues et al. (2008). Seepage rates have been modeled according to the reservoir volume, therewith neglecting surface-volume ratios
- Because of the resemblance of small dams with weirs (hydraulic structures), the buffer coefficient of the small dams has been set in such a way, that only a small share of each month's water is retained to be released later. This choice can be justified by the hydraulic structures applied for small dams, an example of which is presented in Figure 6.4.

Figure 6.5 displays the actual input components for the WEAP model relevant for this research. All points listed above are summarized. The next paragraphs deal with the connection of separate input data and results. Figure 6.6 shows the WEAP interface when regarding the overview of rivers that are modeled.

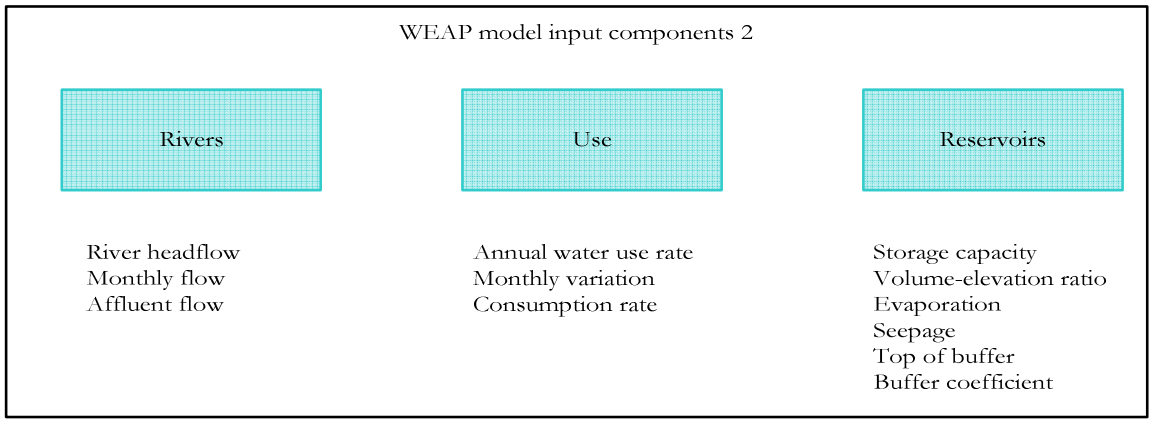

Figure 6.5 WEAP model input components 2

6.2.2. Scenarios

This project is about answering the question how to decide where to allocate new small reservoirs. Creating different models (or scenario's in WEAP) is a suitable tool to generate decision information about the technical trade-offs in this process.

The basic scenario (without intervention) models the water flows and use in the PRB within DF in its current state, so just with the small reservoirs that were present during the measurements performed to determine current flows within the rivers.

1. The first scenario in WEAP will be based on the plan made by the Secretariat of Agriculture of DF. The exact locations in the rivers of the PRB in DF are point of departure for the first scenario
2. Dry years and wet years in order to find out the influence of small dams on the availability of water during a dry year compared with a normal or wet year. (IPCC 2007) is a source that indicates how a dry year deviates from a normal year in semi-arid regions
3. Half size reservoirs. How does the impact of small reservoirs on the system change when the size of each reservoir is cut back to half the original size?

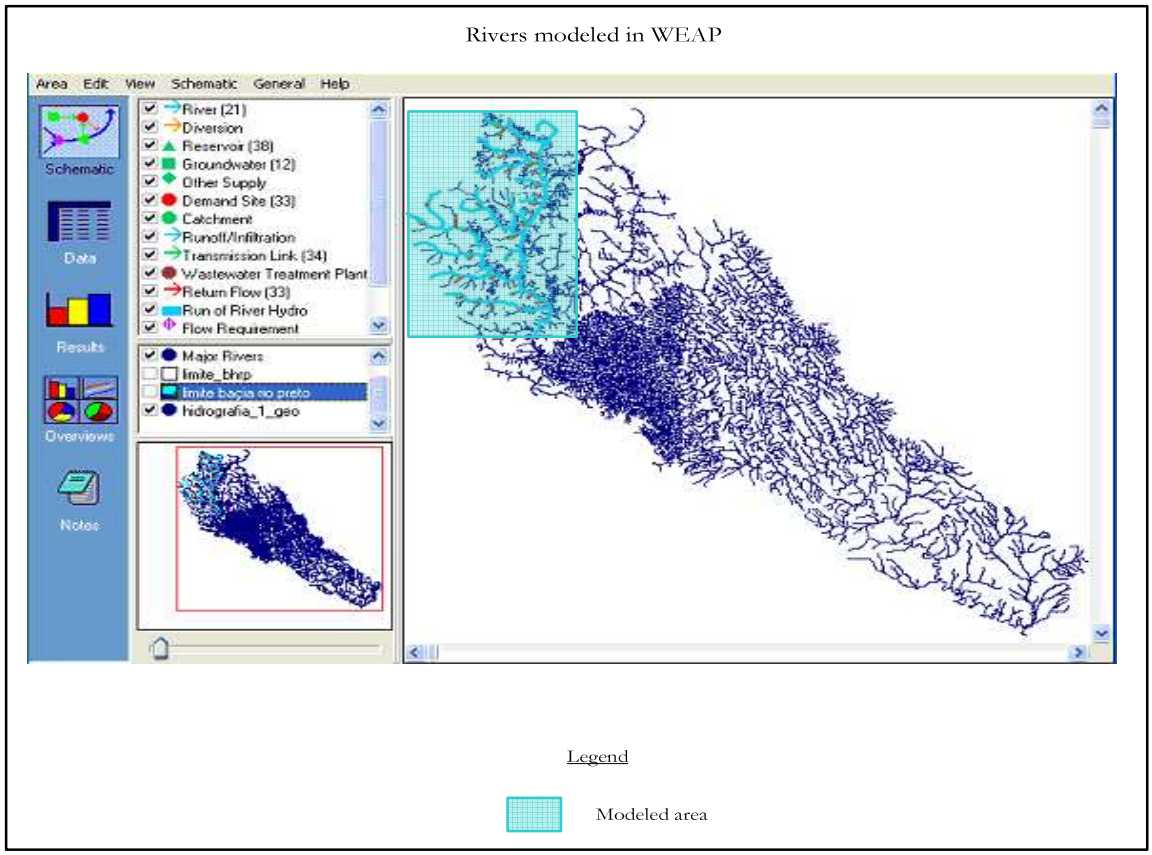

Figure 6.6 Main Rivers of Preto River Basin in Federal District in WEAP

6.2.3. Model plausibility check

In order to check whether the WEAP model of the PRB in DF represents rivers and dams in a plausible way, some plausibility checks have been carried out. Especially because the quality of data has been found to be questionable in chapter 5, this plausibility check must support the choice to investigate how small dams ensembles influence the PRB system. The factors examined are flows, behaviour of the individual small dams, and water use. A short summary is presented below.

- Flows: flows behave logically. When two flows are combined, the result flow is a combination of these two. During the dry season, less water is available in the system.
- Dams: when compared, dams with a lower buffer coefficient retain more water.
- Water use: if use rates increase, the system outflow decreases. The system behaviour

changes when not all used water is consumed. In this case, the buffer function of dams is strengthened.

6.2.4. Results

WEAP provides many results. Not all of them are relevant in the context of this research. In this paragraph, the results are presented working from high level (system results) towards lower level dam behaviour results. For results of dam behaviour, typical examples have been chosen (mid-range small dam).

Unmet demand and dry periods

Almost every demand site has full coverage in the PRB. Those sites that face an unmet demand in the reference scenario do not have to face this problem when small dams are implemented.

Streamflow at lowest point

In Figure 6.7, monthly streamflows in the reference scenario at various points in the river Preto are presented. Let us take a closer look at that point from the perspective of various scenarios. The red bottom line is the first inflow point of another river. The top line is the lowest point in the PRB in DF; this is the point just below the inflow of the river São Bernardo.

The two years presented in the same figure are the first two years during which dams are operational in other scenarios.

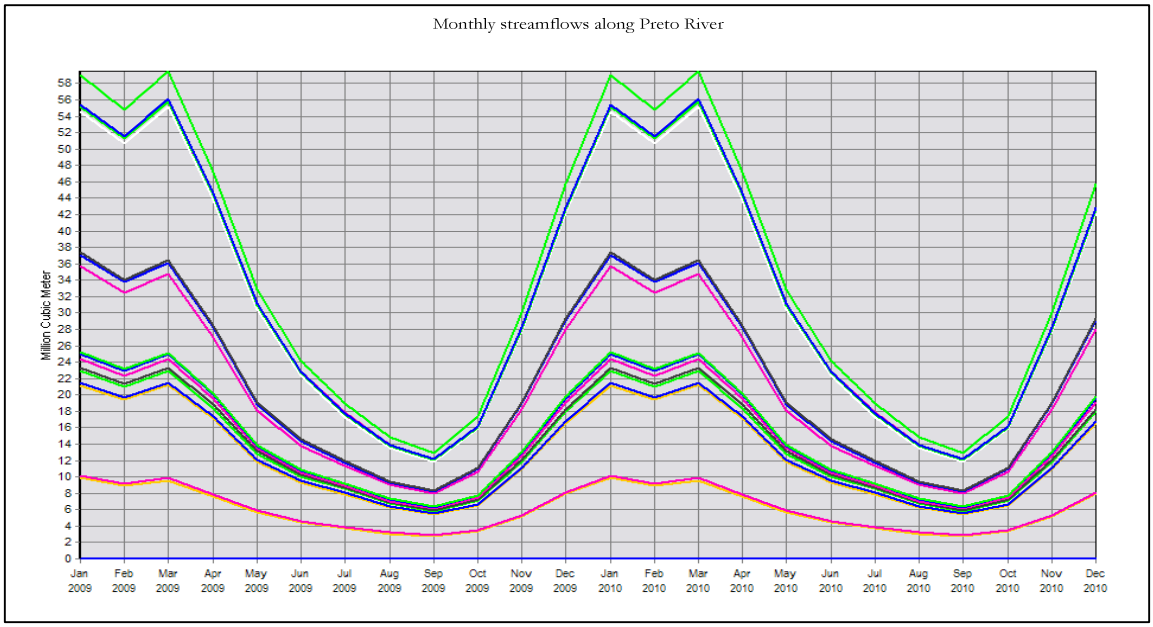

Figure 6.7 Streamflows along the river Preto

Figure 6.8 shows the scenarios "new dams implemented" and "dams half size" compared to the reference scenario in 2010, the second year after implementation of new small dams. This year has been chosen in order to be able to surpass the start-up period of the model. What stands out immediately is the amount of water flowing through the system when new dams are implemented: this amount is much smaller than the amount flowing through the system without dams.

When taking a closer look, it can be observed that the half size dams reduce the impact of water loss to some extent.

More detailed observations of reservoir behaviour must show how it is possible that unmet demand exists in the reference scenario (with more water), whereas all demands are met – even during dry periods – when new small dams are implemented (and less water is available in total).

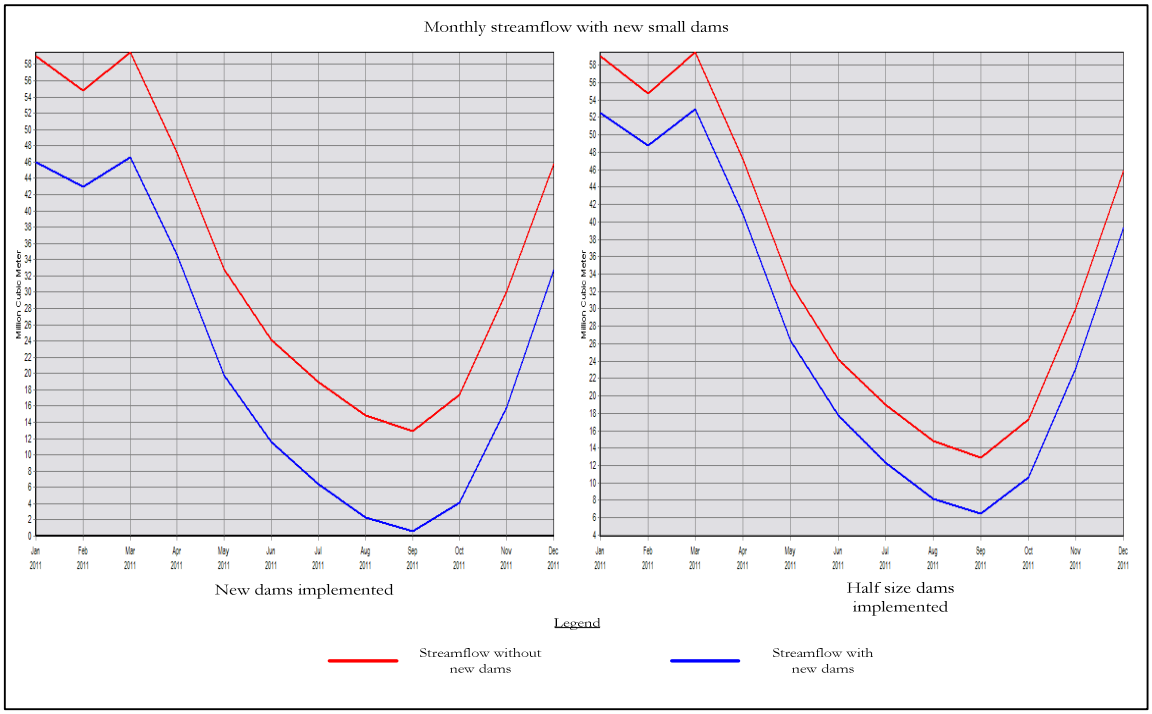

Figure 6.8 Monthly streamflows with dams

Reservoir flows

Typical reservoir behaviour is presented in Figure 6.9. The total outflow is smaller than the total inflow. When taking a very close look, the buffering function of the small dam can be observed. Since the buffer coefficient is set on 90 percent, dams retain 10 percent of each month's reservoir storage. In the next month, 90 percent of that month's reservoir storage plus the 10 percent of the last month (0.9 * (0.9 * current month + 0.1 * previous month)) is released. This mechanism is repeated each month.

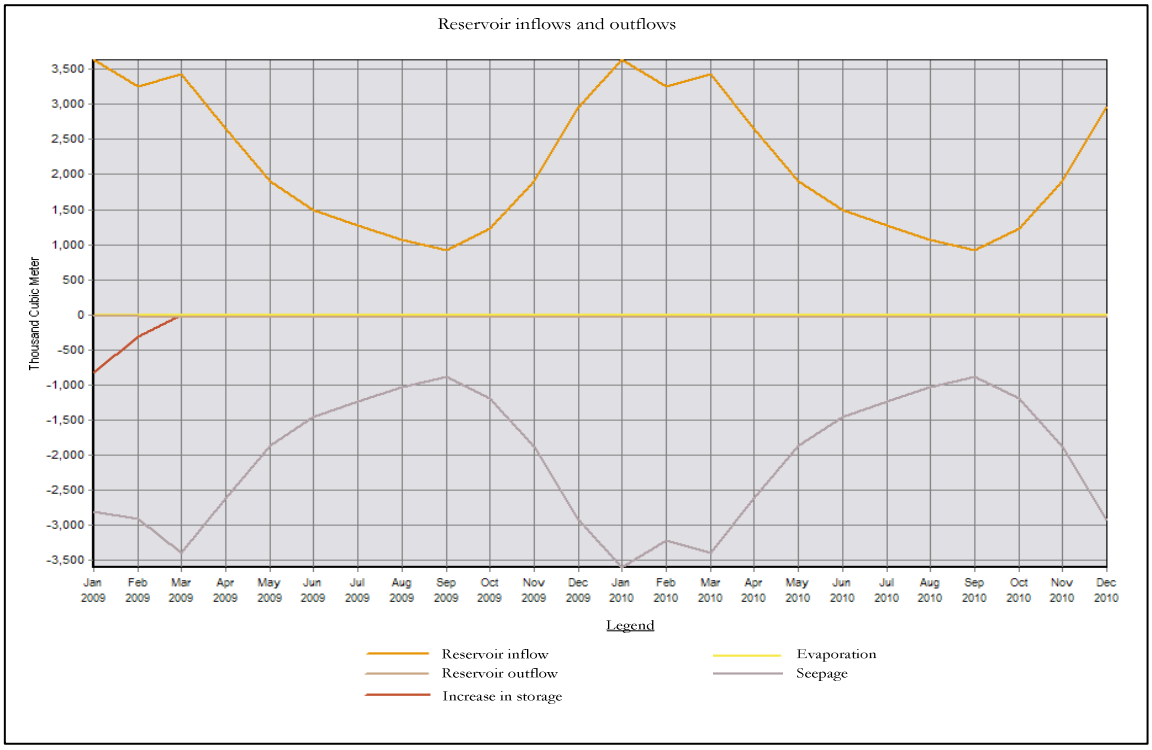

Figure 6.9 Typical reservoir in- and outflows

Figure 6.10 shows what happens when two dams are situated relatively close to each other, without additional streams in between. The inflow of the lower dam (at the right hand side) would have been equal to the inflow to the first dam, if this first dam would not have intervened. The increase in storage passes quite unsteadily, which can be related to an extended and unsteady start-up period. This is confirmed by the reservoir inflow, which only reaches its maximum after the second year of dams being operational.

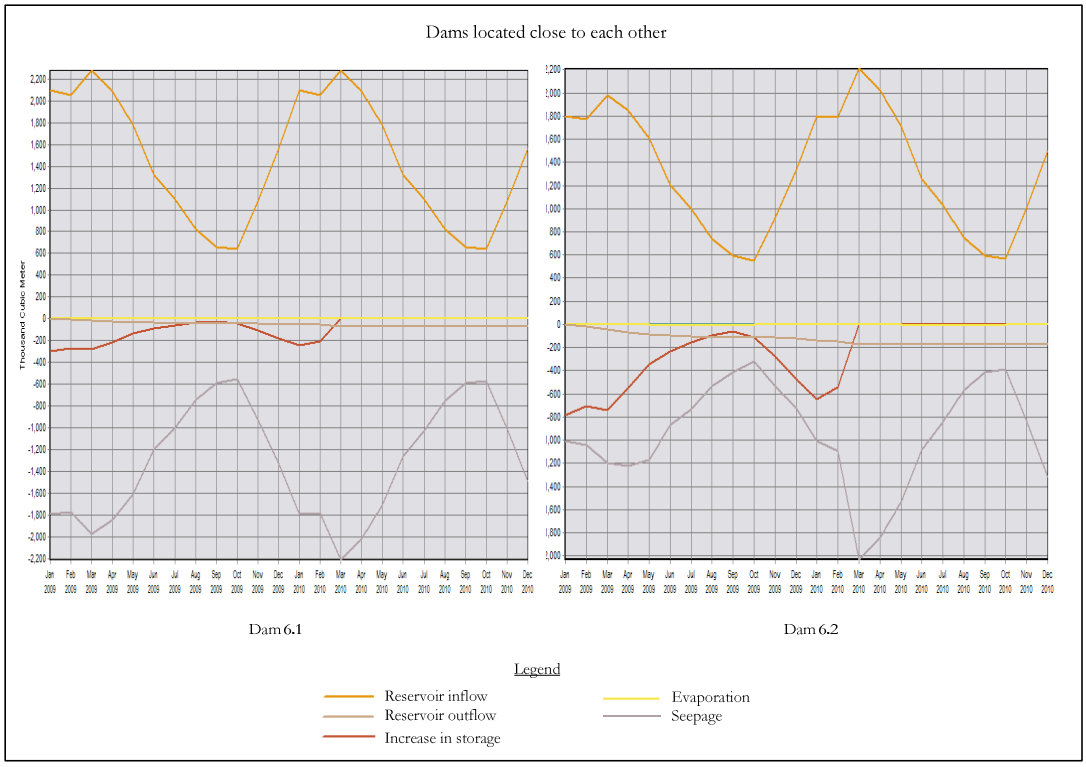

Figure 6.10 Dams located close to each other

General observations of the various scenario results are:

- With dams, more water gets lost than without. More water is available during the dry season, but also: less water reaches the system outflow point. Seepage and evaporation intensify this effect.
- Dry years: needs to measure the influence on water availability during drought, so if dams positively or negatively influence water availability.
- Half size dams do not influence the system much in a negative sense: a smaller amount of water gets lost. However, on the dam level, dam area decreases and streamflow is not really influenced negatively, so reducing the dam size does not undermine the functions. Even more so: the half size dams scenario is the only alternative in which the streamflow is more or less maintained.
- Small dams are actually small delays in the water balance, due to their buffering function.
- Relatively more water gets lost when the level-volume ratio is small
- When dimensions are modelled instead of the actual flow (see paragraph 5.5), the

outflows of a reservoir are lower than planned, due to the actual basic principle of a small dam (buffering), evaporation and seepage

6.3. Conclusions on the water balance accounting model

The sub question addressed in this chapter was related to the way policy makers can influence the water balance in the PRB in DF, and specifically what the role of locations of new small dams can be in their influence.

6: Which characteristics of the physical system that determine location-dependent impacts of new small dams can be influenced by policy-makers?

This question has been investigated using WEAP. The following points are factors that policy makers such as the SA can influence and which influence the water balance in the PRB.

- Spacing. Dams located close to each other generate unpredictable behaviour and water losses, which is to the detriment of meeting farmers' needs.
- Dimensions (not just straightforward: smaller dams influence the system less but still yield an improvement in water control)
- Volume-elevation ratio. Site-specific characteristics determine this ratio. With a high ratio (elevation rapidly increasing when storage increases just a little bit), evaporation losses can be reduced.
- Accumulative influence. One dam does not influence the system. There is a chance and threat to this. The chance lays in the possibility to design dams that do not influence their direct environment too much. The threat lays exactly in the influence dams have collectively
- Operation. The method of storage in the system as planned is delay. Small reservoirs operate as a sort of weirs. For this reason, a small amount of water is delayed in the system and released later. In fact, this is the kind of smoothening/peak shaving process that aims for a better distribution of water during the whole year, herewith establishing higher water availability during the dry periods.
  However, the effects of these smoothening functions are limited, due to the weir-like

function of small reservoirs, which results in a high "buffer-coefficient" (only a little bit of water is "delayed").

Only an actively operated dam, with which *more* water is being released during dry periods, can result in the picture that is presented in Figure 5.2.

Now that we know what kind of characteristics can be influenced during the process leading to a location choice for new small dams in the PRB in DF, a next step is to find out how, when and by whom necessary changes must be determined. The one who decides is the policy-maker – so much has become clear in the previous chapters. What lacks, however, is a structure to confer and defend choices made by the policy-maker before other stakeholders. For this purpose, the information generated in this chapter (about external influences on the PRB system) should be integrated within the process leading to the eventual location choices.

Other conclusions

Communication role of the model Relations between policy decision-making and model output, output serving as decision-making and communication input etc. But the communicative role has its limits. Because site-specific information is limitedly generated, stakeholders can only respond limitedly. This is something to address in the design.

Applying the WEAP or water balance accounting approach has probably not revealed all technical requirements. Nevertheless, it has contributed in finding out what kind of approach is necessary on various scales. The applied approach can be considered very fruitful in terms of system requirements, i.e. in terms of "reservoir ensembles." Additionally, it has indicated what information is required on the reservoir level itself.

Furthermore, modelling the reservoir ensembles with WEAP has exposed how the Secretariat of Agriculture initially assumed the function of small reservoirs wrongly.

Requirements

#	Location requirement	Measure
1	There must be a minimal streamflow at the point where the river Preto leaves DF	Q (m^3/s)
2	Volume-elevation ratio	-

3	Minimal distance between dams	Qin (m^3/s)
4	The demand coverage with dams must be greater than demand coverage without new small dams	Demand coverage with > demand coverage without
5	Seepage must be minimized	Mm/day
6	Farmers must maintain or gain ease of access to water for irrigation purposes	-
7	New dams must be small dams	Storage between 10000 m^3 and 260000 m^3 Surface between 1 ha and 35 ha
8	New dams must be as small as possible while fulfilling all other requirements	m^3 m^2

Interlude: The Programme of Requirements

Performance

Inputs & outputs Impacts

The previous chapters concluded with preliminary conclusions. These conclusions are more or less parts of a solution space for designing locations for new small dams made explicit. Another view is, that they are stated doubts following from the analysis of the respective institutional, network and technical situation. Because these doubts are well defined, it is possible to transform them into requirements. Every doubt reveals a gap, and each gap can be bridged. Example: if an analysis of a road accident reveals, that a T-split had too many blind spots, than the requirement for a new T-split might be: "The traffic situation must be completely visible form the T-split for all traffic participants." But also: "Traffic rules must be clear," or: "Traffic signs must be unambiguous."

These requirements are not to be confused with goals. The underlying goal of the above requirements is to make a new T-split as safe as possible, or just safe.

#	Location requirement	Measure
1	The decision-making process leading to location choices must be transparent and participatory in nature	% of informed farmers
2	APRORP must be involved in the decision-making process	Yes/no
3	Farmers must be informed about the existence of plans for new small dams	Amount of farmers up to date > 90 percent
4	Location options must be communicated by the responsible institute to farmers/-organizations	Information meeting attendance > 70 percent
5	Location criteria must be discussed by the responsible institute and farmers/-organizations	Information meeting attendance > 70 percent
6	The EIA must run parallel with the environmental licensing procedure concerning locations for new dams	Time difference in reporting < 1 month
7	Each dam must be subject to a unique EIA procedure	Yes/no

#	Location requirement	Measure
8	EMBRAPA and EMATER must monitor the decision-making process leading to new small dams	Yes/no
9	The distance dam-river head must be at least 50 meters	m
10	Interference with current land use must be minimized	M^2
11	Farmers' opportunity costs must be minimized	R$
12	Current water rights division may not suffer from newly constructed small dams	M^3/day/water user
13	Location must allow for the small dam to fulfil its distributive function	Q (m^3/s) per period
14	The location may not be contested by stakeholders	Information rate (%)
15	Stakeholders involved must know who other stakeholders and what other institutions involved are	-
16	There must be a minimal streamflow at the point where the river Preto leaves DF	Q (m^3/s)
17	Volume-elevation ratio	-
18	Minimal distance between dams	Q_{in} (m^3/s)
19	The demand coverage with dams must be greater than demand coverage without new small dams	Demand coverage with > demand coverage without
20	Seepage must be minimized	Mm/day
21	Farmers must maintain or gain ease of access to water for irrigation purposes	-
22	New dams must be small dams	Storage between 10000 m^3 and 260000 m^3 Surface between 1 ha and 35 ha
23	New dams must be as small as possible while fulfilling all other requirements	m^3 m^2

Table I-1 lists the requirements for (the process leading to) locations for new small dams. The numbers in red are constraints. If these requirements are not met, the whole design of new locations has failed, even if it concerns only one of them. Constraints enjoy a separate status – a boundary condition with a binary measure of success (met or unmet) – which is why they have been highlighted. Other distinctions have not been made between types of requirements, because most of them can be considered as touching upon several aspects which requirements can be formulated for, such as process, environmental, functional and maintenance requirements.

7. Design of integrative institutional arrangements

At this point in the research, information about technical, institutional and stakeholder requirements for locations of new small dams has been gathered. This chapter aims at integrating that information in such a way that it contributes to the continuing process leading to a location choice for new small dams in the PRB in DF.

The sub questions addressed in this chapter is formulated from an institutional perspective, which can be justified by the conclusions of chapter 4 concerning the expectations of stakeholders regarding the initiative of policy-makers in the decision-making process leading to a location choice of new small dams in the PRB in DF. Because of the presupposed responsibility of governmental stakeholders in this process, a contributing instrument must be designed in the context of the institutional framework of DF.

8: Which institutional arrangements must be designed to accompany the decision-making process leading to a location choice for new small dams?

The main question presented in paragraph 1.3 is formulated in such a way that the requirements listed should "coherently" contribute to the process leading to a location choice. The added value of institutional arrangements that are going to be designed in this chapter is related to the connection between possible improvements of the communicative function of the water balance accounting model and the Programme of Requirements.

This chapter is structured as follows. First, the legitimacy of appointing an integrating part consisting of institutional arrangements in the decision-making process concerning new small dams in the PRB in DF will be explained.

Subsequently, the roles and required functions of integrative institutional arrangements are expressed, based on the context of this research. Hereafter, a fictive example of the institutional arrangements in practice is presented by means of new fictitious storylines.

Next, a "user instructions" manual will be provided, with recommendations about timing aspects of the integrative institutional arrangements designed in this chapter.

7.1. Justification and functions

Although requirements have been formulated, integrating these requirements into a set of arrangements has to be a useful act. This section addresses the justification or legitimacy for the design of integrative institutional arrangements, and lists their functions to underline the intended utility.

7.1.1. Justification

The justification for the legitimacy of applying an integrative set of institutional arrangements in the decision-making process concerning locations for new small dams in the PRB in DF is twofold. There is basically one theoretical and one practical justification.

Theoretical justification

The chosen approach to address the problem, taking place in a socio-technical context, is a separated technical-institutional-stakeholder/process approach. To make the connection to reality (which is a holistic concept) later integration is inherent to the chosen approach. Otherwise, only separate parts of a problem are addressed, and separate solutions do not automatically imply a successful solution for the initial problem.

In terms of the small dam project, this can be easily explained. Without irrigating farmers, the required water availability would differ completely from the required water supply in the current situation. In the analysis of this research, needs of farmers and impacts of dams on the water balance have been addressed separately. Without a connection between the needs of farmers and the available water, the outcomes of these analyses would be useless.

Practical justification

The small dams project that started in 1995 and ended in 2005 failed! Although this research was not intended to find out the exact reasons of failure, it has become clear that the lack of interaction between farmers and institutions has contributed significantly in the failure of the initial small dam project.

Also, the necessity of involving stakeholders in the institutional procedures is prescribed

by the institutional framework in Brazil. Furthermore, EMRBAPA already involved many of the stakeholders and institutions listed in the analyses of this research in projects addressing the rural development in DF (Azevedo 2007).

In sum, there is an epistemological need, a law requirement and a right climate to truly integrate technical information with institutional and stakeholder requirements.

7.1.2. Functions and role of the integrative arrangements

In the context of location requirements for new small dams, one of the observations made in the modeling process is related to a variety in spatial scale. Small dams have impact on both their direct environment and – when regarded as ensembles – on a larger river basin system. The water balance accounting model used in this research predominantly addressed the larger scale. This has the advantage of generating insights in water availability in the PRB and the influence of small dams on it, but also a disadvantage of losing a precise overview of specific location characteristics of different small dams.

The conclusion linked to this observation, is that WEAP is a modeling tool that is useful in communicating system impacts of small dams. The involvement of institutional and stakeholder requirements can be improved, though. Therefore, the role and function of the integrative institutional arrangements must be related to both the enhancement of information and communication on the one hand and the integration of requirements of locations for new small dams on the other.

Functions

The functions of the integrative arrangements are based on the possible improvements that were recognized above, being the involvement of institutional and stakeholder requirements in the communicative function of the water balance accounting model.

Since the communicative function of the water balance accounting model is the point of departure for design of integrative institutional arrangements, a crucial function should be the facilitation of information between various participants in the process leading to a location choice for new small dams. A function that can be derived from this information facilitation is the already mentioned integration of various types of information (such as requirements). In concreto this comes down to incorporating the aspects mentioned in

Table 7-1 into a set of institutional arrangements used to guide the process.

Table 7-1 Aspects to be incorporated in integrative institutional arrangements

#	Aspects to be incorporated	Examples
1	Physical behaviour	• Boundary flow requirement • Calculation of impact of dam on environment and water availability • System perspective: mutual dam impacts • Visualization of suitability of regions for new dam construction
2	Institutional requirements	• Environmental impact assessment and licensing • The exact geography of DF which enables for institutes to recognize protected areas
3	Stakeholder requirements	• Visualization of farmers' accumulative sentiments • Calculable requirements (minimal and maximum flow requirements) • Does not appoint responsible institute but Communicates between institutes; and Does not have to yet, because it is about locations • Forces ANA and ADASA to exchange knowledge because of minimal downstream flow requirement that might change during the year and over the years

Role

The role of a set of institutional arrangements is to test whether requirements of stakeholders and institutions have been incorporated. For the integrative arrangements, it is

important to incorporate the requirements that have been formulated during this research. By doing this, the relevant outcomes of earlier analyses can be used and emphasized. So the role of the arrangements will also be based on the communicative function of WEAP. Moreover, it will improve this function, because it facilitates the possibility for institutions and stakeholders to check whether or not their requirements have been translated correctly into the decision-making process.

Figure 7.1 shows a possible interface for the integration of institutional arrangements that meets the requirements listed above.

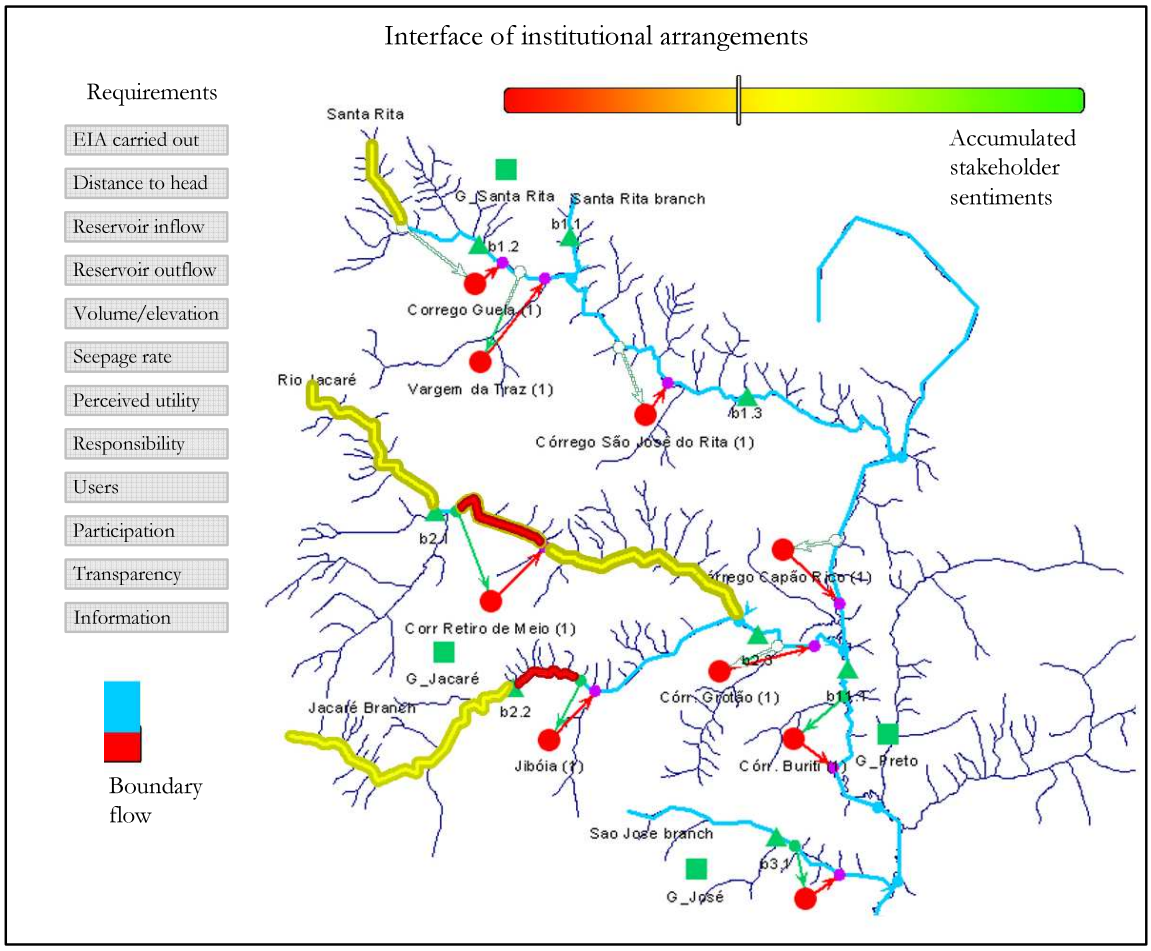

Figure 7.1 Integrative institutional arrangements: a possible interface

7.2. Components of the integrative institutional arrangements

This section goes deeper into the visualized aspects of a set of integrative institutional

arrangements such as presented in paragraph 7.1. Components, timing of use and interpretation of the results are discussed. The perspective of the role of the original role of WEAP in the decision-making process leading to new small dams is also respected in this section.

7.2.1. Components of an interface

The set of integrative institutional arrangements should be accompanied by an interface that enables stakeholders to comment on impacts of decisions made by the policy decision-maker (in this case the SA). This interface must incorporate the following aspects:

Requirements Box

In the top left, a blue box encloses all calculable requirements and their input values, such as water demand, distance of dams to the nearest head, and so on. Only if all requirements are filled out, the interface can work.

Categorized rivers

Based on the impacts of dams on downstream water availability and system behaviour, the suitability of a location for a new dam being implemented is expressed in categories. The colour of a river part changes after a dam is planned. The suitability of a river branch for a new dam to be planned depends on

- Upstream dam dimensions
- Amount of water flowing into the river part from streams

Accumulated stakeholder sentiments

The slider at top right indicates the score expressed in satisfaction of the "current" plan. It also shows how the current plan meets requirements in terms of institutional processes.

Boundary flow

At the lower right of figure the lowest inflow into the river Preto is visible. Right under this point, there must be a minimal flow, which is determined in advance and depends on the time of the year. If this minimal flow is not met due to reservoir impacts, the whole system fails.

7.2.2. Application

Three fictitious storylines are presented below, expressed from the point of view of a variety of stakeholders such as the interviewees consulted in chapter 3. The storylines show what changes if the SA applied the integrative institutional arrangements in different ways.

Fictitious storyline 1: repetition

Although no harm is intended by the Secretariat of Agriculture, the process leading to new small dams is characterized by one-sided decision-making. Farmers are informed by the SA about the necessity of new small dams, but are simply overlooked during the decision about the locations of these dams. Physical system behaviour dominates the decision-making process. ADASA has been incorporated in the generation of data about water use and water rights, but farmers downstream of the Lamarão branche are harmed by a decrease in water availability caused by unequal distribution rather than drought.

The SA defends this by stating that upstream farmers are smaller farmers with more potential to grow, which is economically attractive. Upstream farmers, however, have no idea what to do with superfluous water.

Therefore, farmers are mad. Mad at each other, because some feel how they are put in a disadvantageous position while history has taught that it was possible that they could unite to form a voice towards the governmental policy-makers. Mad at the government, because it did not learn from mistakes made earlier, despite all the good intentions. Both farmers owning their own land and farmers using governmental property run a chance of being damaged by the policy of the SA.

Fictitious storyline 2: process with institutional arrangements

At two moments in time, farmers and farmer organizations are invited for an information meeting with all governmental stakeholders involved in the process leading to a location choice for new small dams. One moment is right after the initiation of the project, the inventory of physical and institutional requirements and the formulation of the SA strategy concerning new small dams. Right after this moment, in-depth studies will be carried out. The second moment is right before a final decision on the locations will be made. The

agenda of these meetings comprises the proposed planning of locations by the SA, indications of changes in water availability for farmers involved, the status of progress in terms of institutional obligations/constraints and feedback of farmers. All types of requirements for locations of dams addressed will be bundled using a decision support tool, a possible interface of which is presented in Figure 7.1. Stakeholders present can respond to this figure and data used to indicate the suitability of locations can be changed to see how the suitability responds.

Most farmers know that they have had a chance to respond to the plans of the SA. ADASA can anticipate the amount of water rights that will be requested and can confer this number with ANA. EMBRAPA and EMATER are also present at the information meetings, giving advice to both farmers and governmental stakeholders about the possibilities for water use.

Still, some farmers feel that they have to give in too much. Now that the majority seems to be happy, they feel a pressure to cooperate, although they will be harmed and compensation measures are hard to discuss. Now that most farmers gain something, they let their own interests prevail over what was earlier called common interests. However, APRORP proposes long term plans and hands these plans over to both farmers and the SA, herewith starting a next round of policy-decision making.

Fictitious storyline 3: good governance without institutional arrangements

The SA tries to involve farmers and other stakeholders in the process leading to a location choice for new small dams. Initially, most farmers are interested because of the sensitivity of the history of small dams, but after some time, the process becomes fuzzy. Only the representatives of farmers such as APRORP, or governmental organizations such as EMBRAPA and EMATER can keep up with the unsteady progress of the process, which is unsteady because of demands and requirements of farmers. Every time the SA proposes a location, it is either the farmer directly involved due to direct environmental impacts or a group of farmers downstream. Furthermore, it is not clear what the status is of farmers owning their own piece of land when compared with farmers using governmental property. Where farmers started to form one voice, they become separated and increasingly indifferent, because they have the feeling that their inputs are useless.

The process is delayed. Still, ANA and ADASA establish a communication line, because

farmers express their needs more clearly and the measurability of water rights is enhanced. Nevertheless, the responsibility of the SA to take a final decision evolves into isolation, despite efforts to let farmers participate in the process.

7.2.3. Interpretation of results and timing of use

Separate analyses have been carried out during this research. The arrangements designed in this chapter have a testing role. Part of its communicative functionality is the ability to test whether or not stakeholders and institutions involved agree to the way their requirements have been translated into requirements within the decision-making process leading to new small dams.

Therefore, the usefulness of the integrative institutional arrangements depends on the amount of information that has already been provided to and gained from stakeholders and institutions involved. Even if little information has been gathered, the arrangements can guide the process in terms of initial communication. Nevertheless, a right timing of use increases process efficiency, as demonstrated with the difference between fictitious storylines 2 and 3.

The right timing is related to two aspects: the stage of the decision-making process and the frequency. With respect to the former, the role of the policy maker and the way other stakeholders perceive this must be taken into account. This is related to trust, accountability and quality of governance. If the policy maker (in this case the SA) is supposed and assumed to take crucial decisions, integrative institutional arrangements can best be applied right after all analyses have been carried out. If the contrary is the case, the arrangements must indicate frequent information meetings in order to keep information up to date. In this case, however, the SA is the appointed decision-maker. These institutional arrangements must be designed to prevent future resistance to evolve and to confirm information traffic (communication) amongst public and private stakeholders.

7.3. Conclusions

8: Which institutional arrangements must be designed to accompany the decision making process leading to a location choice for new small dams?

A set of institutional arrangements that test how stakeholders', institutional and technical requirements have been translated into process requirements in the decision-making process leading to new small dams in the PRB in DF must be designed. These arrangements must integrate all requirements encountered in this research.

Arrangements can be worked out. The result would be a tool, for example a decision-support software kit with an interface such as Figure 7.1. Changed location plans would directly be visualized and expressed in suitability regions for new small dams, based on all kinds of requirements and constraints addressed.

Conclusions about the arrangements

One very important observation is related to the research approach applied in chapter 7 – water balance accounting. Knowledge about proper locations for new small dams was not available yet. Not even the minimal requirements were known. Nevertheless, in the model drafted in the previous chapter, the locations planned by the SA were taken as point of departure. Knowing that these locations were at least questionable, modeling them revealed requirements for better locations.

This approach – a soft version of adapted management – has a chance of generating more knowledge about the water system, institutional efficiency as well as stakeholders' sensitivities during the implementation of this project. Using it, implementation and analysis run simultaneously.

A conclusion that can be drawn from paragraph 7.2 is related to frequency of informative meetings. The possibly unexpected recommendation that stems from the line of thought in that paragraph is that the set of arrangements designed in this chapter might best be used only one or two times in the decision-making process leading to new small dams.

Part 4: Interpretation

Part 4 "Interpretation" connects the research outcomes to the research framework. A sense of the status of conclusions found will be developed before presenting the actual conclusions. In the conclusions, findings are presented in the context of problems, objectives and questions researched. The first intention of this part is to leave the reader with a satisfied sensation regarding the extent to which expectations about the outcomes of this research have been met. The second intention is to present the conclusions and recommendations concerning the continuation of the process leading to a location choice for new small dams in the PRB in DF.

8. Reflection

The research described in this thesis is the very first research into policy-decision making related to the small dam project in DF. It is carried out based on a personal project definition. This has made conducting the research both challenging and pleasantly exciting.

This chapter discusses and reflects on expectations of this project related to eventual outcomes, on the process leading to these eventual outcomes, on the role of a master student carrying out a research within the context of a "real" problem, and on the impact of choices. There are two perspectives from which the reflections in this chapter are described: the perspective of the researcher, and the perspective of the person carrying out this research. When the perspective changes from researcher to person, this will be noticeable through the change of passive phrases into the use of active phrases.

8.1. Expectations

Two main parties with expectations prior to this project exist, being myself and my supervisor(s). My supervisor at EMBRAPA, Dr. Lineu Rodrigues, accepted my proposal to investigate the decision-making process leading to new small dams in DF, right after the project failed due to the history explained in chapter 3. So at the time I was formulating this research, the previous project ended for real. My enthusiasm to study the project's sensitivities and address it from the TIP approach inspired my supervisor at EMBRAPA again, though. His expectations were that through my involvement, revealed insights in issues such as responsibility and the depth of studies carried out earlier could contribute to investigating the future possibilities for new small dam ensembles in the PRB.

However, my supervisor at EMBRAPA did not expect me to doubt the very grounds of this project once again, or to say that stakeholders needed to be involved in the decision-making process. The type of conclusion that will be drawn in chapter 9 and the line of thought supporting these conclusions – especially about governmental responsibility in terms of decision-making – is largely influenced by the discussions we had about stakeholder involvement and information feedbacks.

After some time in Brazil and after the start-up time of my research, our expectations were tuned. The expectations of both parties changed from what kind of research would be

done into how various activities (interviews, stakeholder and institutional analysis and especially modeling) could contribute to finding what requirements for locations are. Since this was the exact question that lays the foundation for this research, the answer to it has been kept from my supervisor for a long time. Still, someone who was pointing at the status of analyses and modeling activities as just being instruments on the way to a useful answer/product kept me on the alert.

Another change in expectations regards the involvement of developing rural communities in this research. Before starting this research and defining the geographical boundaries of it, I expected based on earlier research that the variety of stakeholders in the process leading to the implementation of new small dams would be larger. I had expected to address equal access to water services for farmers and small developing villages, rather than improved access to water for various kinds of farmers. This might explain my initial tenor to propagate more stakeholder involvement. Later, when I discovered the importance of the words "project," "results" and "money" for several stakeholders, I started to take a look at the situation from the perspective of a researcher rather than as a person with expectations of inequalities.

The final product meets the expectations of me and of my supervisor of EMBRAPA, especially because of the frequent and thorough but pleasant discussions we had with each other and with stakeholders during my stay in Brazil.

8.2. Theory

When regarding the theoretical framework constructed in chapter 2 in retrospect, the theories addressed were useful for several things. Firstly, they contributed in formulating requirements. Because of the link made between trust, compliance and governance, some requirements for the process leading to a location choice for new small dams could directly be formulated. The link made between trust, compliance and governance also helped in understanding mechanisms related to stakeholder behaviour and the influence of the institutional framework thereon. Thirdly, theories often exist because of repetitive patterns in comparable situations. Therefore, the theories addressed indicated solution directions and lines of thought valuable for this research.

However, theories can also be doubted due to considerations based on experience with

practice, which serves the underlying academic motive for this master thesis research.

In addition to making suggestion about possible extensions or comments regarding theories addressed, it is interesting to consider whether or not the presented theoretical framework strutted the practical part of the research to a *satisfying* extent.

Socio-technical system

As already suggested by Trist (1980), regarding a problem in the context of a socio-technical system has its limits. In this research, it is suggested that the idea of a socio-technical system is useful within a temporal demarcation, whereas Trist points at limitations with regard to system components. According to the latter, not every part of reality can be observed from a socio-technical point of view. The insight that evoked during this research relates to the possibility to let go of the socio-technical view at some points in time, in order to be able to compare system optimizations in the socio-technical context with optimization in a respective technical or stakeholder context. The most important remark related to letting go of the socio-technical point of view, however, is the danger of getting drowning in the system-approach.

The same goes for cutting up the socio-technical dimensions in little TIP pieces. Although the P of process can accommodate virtually every left-over of the T and I parts, these three dimensions determine largely the perception of the nature of an existing problem. A nice example is the presumed balance that exists between the three dimensions. In terms of analysis, all three aspects must be investigated equally profound, but in terms of design, the emphasis on institutions can no longer be called a subtly deviating share of attention. Stakeholders would almost be damaged in their values if treated equally alongside governmental institutions, in terms expected decisive power, that is.

Research framework

The remarks made above also concern the research framework used in this master thesis project. However, one additional observation can be made. When researching the institutional framework, it is useful also to investigate the institutionalisation of trust-relationships between parties with public interests and other stakeholders next to other characteristics of institutions. This leads to a better understanding of how stakeholders understand and comply with institutions.

Good governance

The good governance indicators were slightly under exposed within this research. Although they have had an important impact on the shape of the theoretical framework, they are relatively poorly represented in the design of the integrating institutional arrangements in chapter 7. This is mainly caused by the dominance of two of the indicators: transparency and participation. Furthermore, focusing on the role of good governance in policy decision-making was not in accordance with the goals of this research, which had a more practical inset. Nevertheless, it would be interesting to see how pursuing good governance would contribute tot the trust relationship between public stakeholders and other stakeholders.

Accountability

In terms of theoretical considerations regarding accountability, this research has merely confirmed how hard it is to relate a value judgement to the concept. One addition to the theories addressed can be made. When looking beyond the bottom-up – top down issue, behaviour of governmental stakeholders can be judged based on how they can be held accountable for their actions. This is closely related to transparency of the institutional framework and the facility to judge governmental behaviour independent from governmental interests. An example is the institutional framework in the context of the small dams project in DF, related to accountability: the government could only be held accountable for its actions if farmers appellate the public prosecutor, which scares away the farmers that enjoyed only low-level education. Therefore, an incentive for transparency and public participation was absent.

Computer model

The dominant role of the water balance accounting model used in this research was to facilitate communication and information between governmental and non-governmental stakeholders, based on an integration of physical/technical requirements and behaviour with institutional and stakeholder requirements.

Herewith, the computer model itself does only fulfil a role in the analysis phase of a policy life-cycle, but it is also indirectly represented in the decision-making part of that cycle.

Programme of requirements

Last but not least, this has been a rather strange research project in terms of analysis and design, since the end product was already specified by the most important stakeholder (SA) although the requirements needed yet to be formulated. In other processes, the PoR is the very basis of designing an artefact.

The reason for this being strange is the fact that alternative solutions to address the water scarcity in the PRB in DF exist, but that possible alternatives were precluded from this research and the SA's agenda.

Possible implications of this original course of events have been listed in paragraph 2.1.6. The most important of these implications turned out to be the shift from product design to product testing. The PoR is one of the two pillars strutting the design of integrative institutional arrangements presented in chapter 0, the most important role of which is to test to what extent requirements for locations for new small dams have been incorporated in the process.

8.3. Process

Some cultural differences and biases affected the process of this research. First of all, the status of governmental institutes was quite different from other problems I worked on before. The government in the region where this research was carried out has quite a negative connotation. Nevertheless, it is expected to resolve all high-level problems interfering with the Brazilian daily life. The negative connotation of the word government is closely related to the (presumed) corruption and critical attitude people have with respect to government involvement. Hence the paragraphs on trust, compliance and governance.

On the other hand, I encountered both inefficiency and efficiency in governmental procedures. The subtle difference lies in the planning: the people I have worked with in Brazil are also very critical when it comes down to bureaucracy. A very effective informal system deals with this inefficiency, hence my remarks on lack of informal connections between farmers and the government. The informal system is no doubt important in many parts of the world, but in the region where I conducted this research, it seems to be crucial. Bluntly formulated, I can put that planned efficiency does not exist, but is compensated by opportunity flows.

8.4. Results

The most important issue to reflect on in this paragraph is scale. The scale of this research was the biggest challenge in terms of demarcation as well as interpretation of results of this project. The research question addresses both the scale of site-specific characteristics and the scale of the PRB in DF system. That is why at first sight, the WEAP model did not provide the type of results aimed at, but after I realized in time that location choices affected several scales, it was useful after all.

Definition of scale also influenced the way requirements have been formulated. The formulation of the requirements in such a way that they contribute to the process leading to a location choice for new small dams is characterized by the possibility to integrate several kinds of aspects on the system level. This reverberates in the institutional arrangements designed, and in the conclusions about the trust relationship and information facilitation of the government in relation to other stakeholders (and in accordance with institutional formats).

Next, the eventual role of the WEAP model is a result that needs to be addressed in the context of results of this research. In advance, it was supposed to generate decision information about suitable locations for new small dams. The role of the model is:

- To generate this decision information (a role that is fulfilled better than expected during some phases of the research)
- To predominantly gather all the information and make a representation of the "system" in an understandable way (communication)
- To fulfil the iterative function within generating decision information, because of some sort of "testing" function.

The expected share of utility lied on the decision generation part. This expectation had to be adjusted, though. In practice, the model output turned out to be most useful in terms of process continuation in a communicative role.

This communicative role is represented in the integrative institutional arrangements that have been designed in chapter 7. Initially, this set of arrangements was called a tool. However, I never had the intention to develop a decision-support software tool or something alike. Therefore, the most important aspect concerning the institutional

arrangements that changed during the thesis project was the name of the set of arrangements and the expectations I created using the word "tool," "blueprint," "architecture" or "arrangements."

So now, the question is why expected results did not always turn out to be actual results. Several causes for this mismatch in expectations and outcome can be contrived. The capability of me being a SEPAM engineering student, and not a hydrology student might have kept me from understanding the type of model I was going to use, despite profound literature research and understanding of tutorial and test cases.

The real question is perhaps how detrimental initial miscalculations (e.g. regarding the role of the model) are. Taking the profoundness of my conclusions and observations as a criterion, I can say that initial miscalculations contributed to my understanding of the complexity of the problem researched.

Perhaps thorough hydrological research would have been prerequisite for an integrative approach as used in this research. In that case, the choice to focus on the mechanisms instead of on quality of data, which would have been possible with the RAINRU model, was a rash one. To the defence of my choice, I can bring forward the next points:
It would have just influenced the order: now system prevailed instead of small scale, and now interpretation on a system level is possible. Furthermore, it is better defined in this situation what is the context within which specific hydrological data should be interpreted.

Reflection and future

The first thing that needs to be done after finishing this research is to bring it back to the environment where the problem exists. In a meeting at the Secretariat of Agriculture, in the format according to the institutional arrangements designed and to the meetings I attended before, a presentation must be given about the last failed process and about this research, working from the analysis to the design of institutional arrangements for an enhanced process leading to a location choice for new small dams. This process can then serve as an example for the implementation of the actual new small dams.

9. Conclusions and recommendations

In this chapter the final conclusions of this research are drawn. These conclusions will be presented in a structured way. Firstly, the problem, research question and goals concerning new small dam locations in the PRB in DF are presented again. Secondly, we will take a look at the extent to which goals of this research are met and why. Thirdly, the research question will be answered (based on the answers to sub questions posed in this research) and placed in a realistic perspective. Finally we will draw conclusions about solutions offered by this research to the problem statement described earlier.

Furthermore, recommendations based on these conclusions and on other research results are formulated in this chapter.

9.1. Conclusions

New small dams for irrigation purposes are potential solutions for water scarcity during the dry season in the PRB in DF in Brazil. One specific aspect to be decided upon by policy-makers is the location choice for each new dam. This choice has to be made in a broader context of the actual graveness of the water scarcity, the number of small dams that must be built to address that scarcity and the impacts of alternative solutions that lead to an increase in water availability. This research focused on the process leading to location choices alone.

The exact problem related to the process leading to new small dams in the PRB in DF was formulated as follows in paragraph 1.3:

> ***In a context of planning locations for new small dams addressing water scarcity during the dry season in the Preto River Basin in the Federal District, Brazil, resistance, uncertainty and conflicts exist amongst stakeholders and institutions with regard to the question what are proper locations for new small dams.***

Based on the problem stated above, research objectives have been formulated that address the unknown and uncultivated parts of the problem. In order to understand the conclusions mentioned in this chapter, it is important to realize that these objectives are not the same things as rephrased parts of the problem; for those would not be research

objectives but policy or even stakeholder objectives. The main research objective of this research is:

To shape the minimal requirements for locations of new small dams in such a way, that they coherently contribute to the process leading to a location choice for new small dams in the Preto River Basin in the Federal District.

The final part of the backbone of this research is the research question, which catches the reason for carrying out this research as well as the part of the problem for which this research is intended to offer a solution within one question.

What are the minimal requirements for locations for new small dams and in what way can these requirements coherently contribute to the process leading to a location choice for new small dams in the Preto River Basin in the Federal District, Brazil?

Let us work back from an answer to this research question to an assessment of the resolution of the problem. The answer to the main question is based on the answers to sub questions posed in this research, hence the variety of components in it. The answers to sub questions resulted in case specific conclusions. These conclusions are presented before answering the main research question.

Case specific conclusions

Stakeholders have diverse expectations concerning changes that will be caused by the implementation of new small dams, ranging from reduction of conflicts because of increased water availability to environmental damage and even an increased amount of conflicts due to disproportional privileges. Stakeholders are fragmentised as to where they stand towards new small dams. Dams allow for water availability during the dry season, but might form a threat for land use and environment. Furthermore, it is necessary for institutes and stakeholders to understand each other and to know what they represent and stand for. In addition, institutional arrangements in the decision-making process related to small dams must include a protection mechanism in order to see if stakeholders' requirements are part of the process.

In the context of this research, many of these stakeholders are public stakeholders. This

makes the distance between public and non-public stakeholders in terms of communication possibilities large. Moreover, informal relations that are quite common in other situations do not compensate this distance, which is to the detriment of conflict resolution possibilities.

The applied model in this research exposed why the original decision-making process lead to conflicts amongst stakeholders. Stakeholders are sometimes unintentionally poorly informed, due to flaws in research carried out earlier. Water balance accounting helps to formulate requirements and to connect interests with planning on a high scale, i.e. the PRB in DF scale. Furthermore, applying a water balance accounting model improves the system impact overview that policy makers should keep in mind.

All analyses resulted in a Programme of Requirements presented in the reflective interlude (see page124), which delivers part of the answer to the main research question.
For the sake of completion, the role of this Programme of Requirements in the policy decision-making process leading to new small dams in the PRB in DF on the short run is to test whether stakeholder and institutional requirements are translated into process requirements properly. The model interface serves as a starting point for this communication process.

Finally, an integrated approach with regard to formulating requirements for locations of new small dams works better than the formerly used separated approach. The stakeholders with the highest resistance against governmental intervention still expect the government to take the initiative and to take decisions. Since governmental interference is experienced negatively, though, the government must plan and inform the stakeholders involved before and after the decision-making process about proper locations is carried out.

Answer to the main research question

That the answers to the sub questions form an answer to the main question can be justified by the fact that the sub questions themselves have been derived from the main question. This is also a refinement when valuating the answer given below. It must be kept in mind that the answer to the main question is a result of answers to research questions, theoretical anchorage and demarcations determined before; in other words within the boundaries of this research.

The components out of which the answer to the main research question exists will be explained after the answer has been given. It is advisable to read the answer a second time

after having read the explanation on its components.

Under the conditions that (1) it is intended to contribute to achieve a solid trust-relationship by keeping it transparently and open for farmer participation and while keeping the initiative of the eventual decision with the governmental stakeholder such as the Secretariat of Agriculture, (2) it is consistent with existing policies and procedures such as the environmental licensing procedure, (3) it is intended to be made as complete as possible based on location-based research and information about system impacts, a list of minimal requirements[8] for new small dams in the Preto River Basin in the Federal District in Brazil can be used as the basis for integrative institutional requirements at two points in time (before collecting data concerning locations of new small dams and right after preliminary choices concerning that location), herewith communicating, integrating and evaluating institutional, stakeholder and physical requirements and contributing to the process leading to new small dams in terms of compliance, support and knowledge extension.

The answer formulated above needs some contextual explanation. It consists of several components: conditional, functional and result components. These three components are clarified further below.

Conditional component

The first part of the answer to the main research question is based on the answers to sub questions 1, 2, 3, 4 and 5 about the role of stakeholders, the influence of institutions, the characteristics of the physical system and the expectations of stakeholders concerning the changes caused by a location choice for new small dams in the PRB in DF based on the historical background of the project. This part includes (explicitly) the trust relationship between the Secretariat of Agriculture and other governmental stakeholders on the one hand and farmers and -organizations on the other, as well as (implicitly) good governance indicators subtracted from relevant theoretical considerations. Furthermore, institutional constraints such as a properly carried out environmental impact assessment and involvement

[8] As presented in the Interlude starting on page 124

of governmental stakeholders at the right level (federal, state or river basin) is laid down in condition 2. Finally, condition 3 mentions physical information that must be expanded to an intended maximum, based on both localized research and river system impacts of new small dams.

These three conditions demand a certain attitude of the Secretariat of Agriculture with regard to the process leading to a location choice for new small dams, consisting of building trust, achieving compliance of non-governmental stakeholders, allowing for participation and completeness of information.

Functional component

This part of the answer to the main research question incorporated the answer to sub question 6 about the influence policy makers have on the PRB system when deciding where to place new small dams and sub question 7 about the actual list of requirements for locations of new small dams. This part is related to the functionality of the integrative arrangements presented in chapter 7, which enables the policy maker to test whether or not the requirements for locations of new small dams are consistent in terms of institutional, physical and stakeholder contexts. This part also accounts for sub question 8 about institutional arrangements supporting the process leading to a locations choice for new small dams. By indicating the timing and frequency of use, institutional arrangements safeguard the quality of that process related to the interaction between governmental and non-governmental stakeholders.

Result component

The contributing results mentioned in the answer to the main research question are compliance, support and knowledge extension. Integration and information of stakeholders leads to these results because it improves the trust relationship between public stakeholders and farmers, the quality of governance, more exact knowledge of what kind of aspects of the PRB to investigate related to small dam impacts and increase of knowledge of "how to get things done" in DF.

Conclusions regarding research objectives and problem

In this research, many requirements of locations for new small dams have been collected.

The answer to the main research question shows how the PoR contributes to the process leading to a location choice for new small dams in the PRB, which confirms the achievement of the main research objective. Creating decision information has been supported by facilitating knowledge expansion and by providing a focus when expanding this knowledge about small dam impacts on their direct environments and on the PRB system. One example to support this conclusion is related to both localized research and the cost-benefit analysis that has not been carried out. This research contributed to defining what kind of costs and what kind of benefits must be investigated before deciding where to locate new dams, and on which scale these matters must be investigated.

Uncertainty concerning locations for new small dams in the PRB has already been reduced. Moreover, a basis has been laid for further reduction of uncertainty amongst both public and farmer stakeholders through the design of institutional arrangements and a set-up for an integrative requirement communication tool. Reducing uncertainty does not eliminate the existence of conflicts. However, stakes and sensitivities of all parties involved in a location choice for new small dams have been mapped. Due to a clear vision of both public and private stakeholders about the responsibility for eventual decision-making combined with well-structured stakeholder participation and process transparency through use of the integrative institutional arrangements, conflicts have a high possibility of being resolved or being contributing to the process. Comparable institutional adaptations can incorporate reasons for resistance of stakeholders in the process leading to an eventual location choice for new small dams in the PRB in DF.

9.2. Recommendations

Two types of recommendations are provided in this paragraph, being recommendations for further research and policy recommendations.

9.2.1. Research

Site-specific research

For both technical aspects of the physical system in the PRB in DF and stakeholders' interests and requirement, extended knowledge is necessary. For the project leading to new

small dams and suitable locations for these dams, every stakeholder must be approached to be involved in the process and to express his stakes.

The need for more site-specific knowledge about river flows, seepage and alike has become evident using a water balance accounting model.

Cost-benefit analysis of locations

A cost-benefit analysis on locations is a crucial analysis that has not been carried out in this research. Such an analysis brings about highly relevant decision-information *and* is closely related to the feasibility of the eventual project.

Two types of cost-benefit analysis regarding locations need to be carried out: one related to the value of water that can be used for agricultural growth of the region related to investments in small dams, and one must be carried out to internally compare various dam locations for the same dam.

Cost-benefit analysis of alternative measures

This research surpassed the idea of alternative ways to improve the irrigation systems used in the PRB in DF. Therefore, additional research into alternative solutions for (future) water scarcity is recommended.

Water quality and environmental flows

In terms of decision-information generation, environmental quality of the area has only been mentioned superficially in this research. The vegetation type called cerrado is very popular among some farmers and communities in DF.

Environmental flows are the minimal flows that are necessary to let rivers fulfil the functions that are valuable for both human activities and the environment. Small dams might influence these flows. Water quality might also be influenced by the construction and use of new small dams. These aspects need to be researched as well.

9.2.2. Policy

Gain detailed information

Before initiating the implementation of new small dams, policy makers must ascertain themselves of the level of detail of information. For example, the actual functioning of small

dams must be researched in more detail. Another interpretation of this recommendation must be, that location specific information is the most important basis for choices concerning the implementation of new small dams.

Separate phases, but connect them with communication

Phases in the decision-making process leading to a location choice for new small dams are recommended to be separated. Gaining information, educate stakeholders and inform them about plans can be done jointly. For a chance of success on finding proper locations for new small dams, separating these phases is recommended, though. Still, these phases must be bridged by exactly the afore mentioned activities: Information, education and communication of and with stakes and stakeholders.

Invest in support and think ahead

Information of potential stakeholders might seem to be a threat to the success of the decision-making process leading to a location choice for new small dams. However, investment in support is crucial to avoid resistance that might evoke later. Future stakeholders should be included in the process. To find these future stakeholders, careful investments and investigations are necessary. Part of this recommendation is to expand the communication network with farmers.

Plan locations for dams one by one, but also use a system impact overview

Planning locations for new dams simultaneously is hard, because of system impacts of dam ensembles. This is the exact reason for focusing on the impact dams have jointly, even if this complicates researches into the effects of dams.

Apply integrative institutional arrangements to guide the decision-making process

As the process leading to a location choice for new small dams in the PRB in DF continues, it must be structured by the integrative institutional arrangements listed in chapter 7. Both content and timing aspects should be respected. If necessary, those aspects can be adapted. Even more so, a flexible attitude is applauded. Nevertheless, the basis for the process is recommended to be the set of institutional arrangements mentioned before.

These arrangements can also surpass the boundaries of the location choice process. A

water rights database for ANA and ADASA can contribute to the quality of input data for the decision-making process, but also to future problems. Enhanced communication between these two organizations set an example for communication between water regulative bodies throughout entire Brazil.

Appendix

Appendix A: References

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Appendix B: Laws, the Water Resources System and instruments

1: SINGREH

The Sistema Nacional de Gerenciamento dos Recursos Hidricos (SINGREH, National Water Resources Management System) was introduced in 1997, with national law 9443/97 (the National Water Resources Policy) as its legal basis. This law lays dawn the next concepts:

1. Water as a public good
2. Water as a limited resource, carrying an economic value
3. Human consumption and animal nourishment have priority
4. Multiple use of water
5. The hydrographical basin as basis for planning and management/control
6. Decentralized and participatory management

The law also contains many propositions with a sustainable character, such as future availability and appropriate quality, rational water use (baring in mind the water resources) and prevention of critical hydrologic events (droughts or floods). It continues with emphasizing the need for integration of water management with environmental issues, subject to systemic management of quantities and qualities. All this has to be in concurrence with the local economic, social, cultural and physical characteristics, integration of water planning in regional and land use plans, and integration of river basin management with estuary and coastal zone management.

This law – and with it the SINGREH – encounters, seemingly, many goals. These goals are rooted on the idea of water as a public good. As bluntly/directly as they are put, they represent highly complicated processes.

Further below several institutes safeguarding one or more of the concepts laid down in the SINGREH are described. As it is presented in (República Federativa do Brasil, Ministério do Meio Ambiente et al. 2007), every institute is equipped with a clear package of tasks, aimed at realizing the goals so progressively described in law no. 9443/97 (Presidente da República 1997).

2: Plans and the Plan

The National Water Resources Plan (PNRH) has only been approved in January 2006. The plan supports the SINGREH on a lower institutional level. With this plan, Brazil was categorized into 12 hydrological regions and 56 hydrological units. The goal imbedded in the PNRH is threefold (Ministério do Meio Ambiente 2006):

- Improvement of availability of water
- Reduction of water conflicts
- The perception of water socio-environmental water conservation

Next to "The Plan" there are water resources plans on river basin level, drafted by the water agency of that basin and submitted for approval to the responsible basin committee. These long term plans entail project-plans and planning for the water resources within a river basin, based on a thorough diagnosis of possible problematic situations. This incorporates studies into current and future water use and availability, types and scenarios of land use within the basin and founded indications of water rights division priorities and pricing.

All of this should support water resources management and form the foundation for water resources policy decision-making.

3: Outorgas

Water rights distribution is a process referred to in Portuguese with the word "Outorga," which means allowance, or something close to that. Outorgar (verb) is an administrative act, with a party receiving the allowance and someone providing it. This right can be applied for purposes of final consumption, but also for other purposes. Concessions are laid down in a contract between the party providing the outorga and the one receiving it.

In practice, outorga means water rights division. There is much bureaucracy involved in applying for water rights, but it is quite clear when a big water user must apply for water rights. The difficulty with water rights is, however, whose responsibility it is to appoint the water rights to a water user.

This instrument is used on the federal level, to control quality and quantities of water use. Furthermore, this instrument is used to achieve equal access to water. Priorities (order of access) are defined in the water resources plans.

ANA is the organ that may divide outorgas for federal rivers, or that can decide to

delegate this competency to the state level.

It is also applied on the state level, by a state organ, called ADASA.. These organs will be clarified below. A problem worthwhile to discuss here is the distinction between state and federal rivers.

This distinction is formulated as follows. A river is a state-river when head and tail are located within the same state. That is quite straightforward. A federal river is one which crosses at least two states. This is also rather simple to comprehend.

The problem is, however, that rivers are parts of complex hydrological structures rather than clear defined entities. Affluents complicate this matter, for example. An affluent is a river branche flowing into a river of a higher order. There are state rivers with federal affluents, which means that the river branch crosses several states and the principle river remains in one state (where it can flow either into the sea or into another river).

The Preto river is such a complicated river. It crosses several states (Minas Gerais, Goiás) and DF, before it contributes to the Paracatu river, which is a state river. The implications for division of responsibility can be expressed in one term: fuzz. After the description of the two organs responsible for granting outorga (ANA and ADASA), more will be clear.

4: Cobrança

One goal of law no. 9433/97 is to see to it that the price to be paid for water is directly linked to outorgas, and to see to it that the resources subject to cobrança are used predominantly within the basin where the cobrança is raised.

Cobrança is used in the context of determining the price of water resources usage. It sets the directives for actual water prices. This means that the water is recognized to be an economic good (i.e. a good that behaves itself as other goods subject to the rules of economy (demand/supply, transaction, etc.).

Furthermore, this instrument intends to support rational water use and provide for resources to finance studies, projects and programs. This means that at least part of the money raised by the government from water users is supposed to be fed back to water resources management.

5: Federal law and the Constitution

Principles for society functioning in harmony are laid down in the Brazilian constitution. This basis for Brazilian society contains laws and rules about division of power, of resources and of fundamental freedoms. It addresses economic and "public order" roots of society.

The reason that it is shortly mentioned here, is the fact that the first complete version was only introduced in 1988, representing many points of view about natural resources, energy and the cultural diversity of Brazil that are typical for the institutional structure of the Brazilian water framework.

With respect to the water law framework art. 5 and art. 58 of the Brazilian constitution (Presidência da República 1988) are relevant.

Appendix C: Parties

1: National water resources council (federal)

The water system needs organs for implementations on various institutional levels. Close to the law, but completely devoted to policy making is the federal National Water Resources Council.

This institute formulates the policy within the water resources system. Furthermore, the council has become responsible for drafting resolutions concerning national water policy and for formulating the instruments needed for water management.

The minister of Environmental issues is chairman of the committee, which in total consists of 57 members with a mandate for 3 years. The members stem from organizations of civil society (research organizations, universities), representatives of the National Water Resources Council and representatives of various sectors of water users.

The National Water Resources Council carries out the following tasks:

1. Appoint the managers of the System;
2. Approve the composition of Basin Committees;
3. Settle potentially evolving conflicts between Basin Committees and between State Water Resources Council;
4. Approve and guide the National Water Resources Plan; and
5. Approve the list of general criteria for water use rights (outorga) concession and for settling the price of water (cobrança)

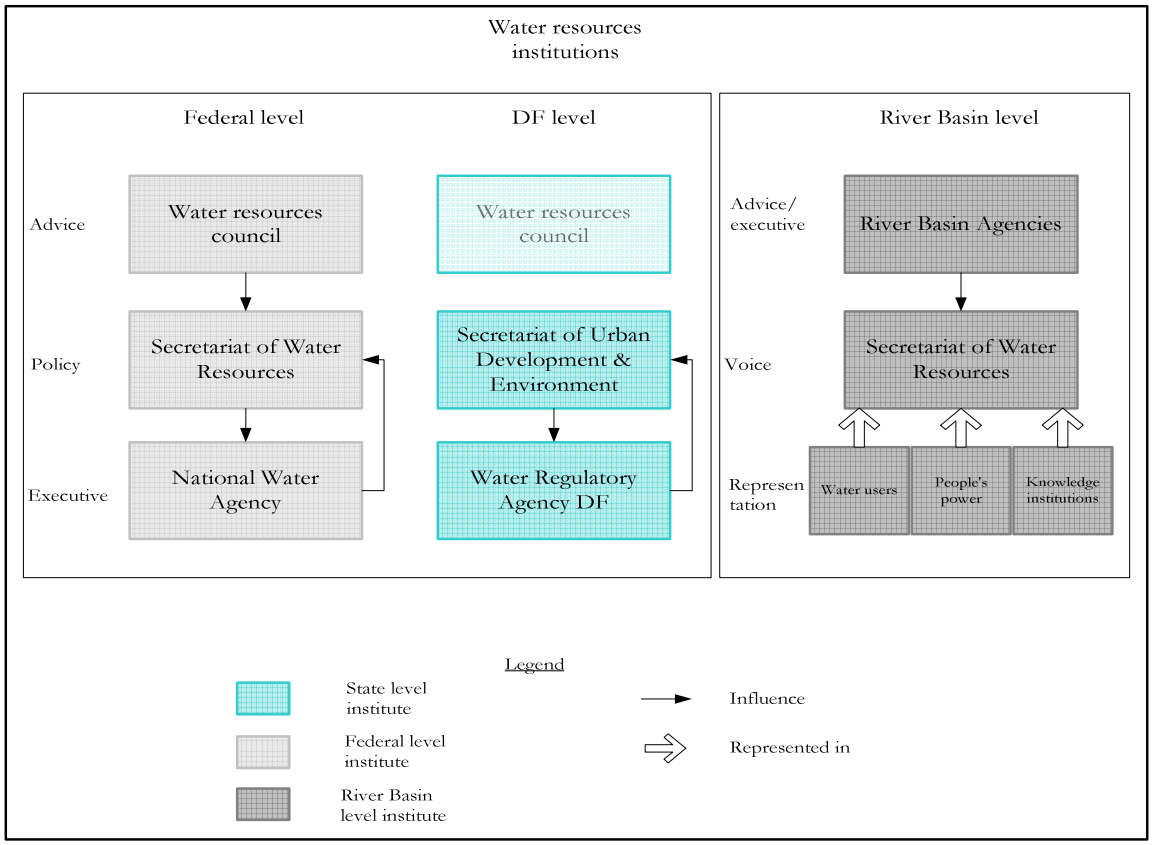


Figure 9.1: Water institutions in the small reservoirs project

2: River Basin Committees and agencies

As instances of consultation, River Basin Committees (CBHSF 2001) represent regional stakes of stakeholders in river basins. They serve as units for the planning and water control in light of the System/Plan. The composition is laid down based on three pillars: The power of the people-, the Civil Society- and the Water Users- pillar. The actual size of the Committees can vary. However, the composition is restricted to the form within which none of the three pillars can obtain an absolute majority (<40, <40, >20).

The Committees adopt the task of filling in the spaces of straightforward law between the various aspects of water resources management. More concretely, this withholds the next tasks:

1. Settlement of conflicts with regard to water resources;
2. Approve and guide the National Water Resources Plan;
3. Propose to the Council which "insignificant" users can be relieved from the water rights concession, so that they can use water directly (important for small farmers!);

4. Set values and pricing mechanisms for water pricing.

The Preto River Basin is a sub basin of the river São Franscisco (GOLDER/FAHMA 2006). Therefore, the São Francisco river basin committee holds responsibility over the Preto River Basin. However, the former is a very big river, with many challenging situations in its estuaries.

River Basin Agencies

The agencies are executive bodies responsible for the implementation of plans made by the river basin committees. The agencies have a public nature in some states, a private in others and a mixed form in the remainder of states.

During the implementation of the System, it is therefore not necessary to create a new party to perform the tasks of a River Basin Agency, but rather to appoint a party as being capable of performing these functions.

The tasks of a river basin agency are:

1. Fulfilling the task of executive secretary for the basin committee involved
2. Preserve the registration of users and update the balance of water availability
3. Put in practice the raise of water use costs
4. Work out the National Water Resources Plan, to be approved by the basin committee involved
5. Carry out studies and draft plans for determining the water price for cobrança.

3: National Water Agency (ANA)

ANA is an executive and regulative organ, based on law 00/9984 and mentioned in law 9443/97, a financially and managerially independent and autonomous institute. It was established to provide an impetus for the National Water Resources Plan, probably after complexity and difficulties of the SINGREH had been recognized, as it did not put forward the results as hoped for by society.

Furthermore, it is the organ appointed responsible for the implementation, monitoring and evaluation of the PNRH. Furthermore, ANA is supposed to safeguard the implementation of the System. As an organ, it has to make sure that water resources management is in compliance with the guidelines, institutional structures (in settling

conflicts, water rights division and water pricing), and the Plan.

Tasks of ANA:

1. Appointment of individual (indistinctive) water rights
2. Inspection of water use and water resources users
3. Water pricing, including the possibility to appoint tariffs of operation to water basin agencies.

If parties asking for water use will interfere with resources on the federal level (in a federal river or in an area falling under federal law, ANA leads the procedure of granting the water rights (outorga) asked for.

4: OGRH (Orgao Estadual Gestor de Recursos Hidricos): SEDUMA

The OGRH normally is guided by the river basin committee, who sets out the directives for water rights and pricing. There are multiple forms possible for the embodiment of an OGRH, but the form of a Secretariat of Water Resources incorporating and executing the tasks of an OGRH is quite common (website SRH Bahia).

Many states have a secretariat of water resources (SRH), serving as an umbrella for basin committees when relevant/necessary. DF, however, has none. The functions normally carried out by a SRH fall under the secretary of urban development and environmental issues (SEDUMA 2008).

In this case the secretary of urban development and environmental issues (Seduma) covers for the next issues normally falling under the responsibility of SRHs: Water rights and Inspection (fiscalisaçao). According to studies carried out by the secretary, the irrigation capacity of the Preto Basin is close to being exceeded.

5: ADASA

The Water Sanity Regulatory Agency of DF (ADASA 2008) – existing since 2004 – has adopted as its main goals the regulation, control, inspection of water quality and quantity within the water bodies of either DF, or the domains delegated by the republic or the by other states. Furthermore, it bears the responsibility for the public services of water provision and the sewage system of DF.

This institution is also formally part of the department of SEDUMA.

ADASA recognizes water as a good having multiple purposes, and as an economic good.

The activities described above include the distribution of Outorgas. This is in concurrence with the activities of ANA, since ANA can appoint other governmental bodies (on the state level) to exercise the power of distributing activities.

However, during a conversation with ANA (Lopez 2008), the delegation of this power knows no feedback: there is no direct communication between ANA and ADASA about how water rights are divided within the delegated area.

During a conversation with (Azzi 2008), the weak link between the two agencies was confirmed. The only physical feedback of ADASA to ANA up till now, since the origin of ADASA, consisted of one report with water rights granted.

It seems to be crucial, however, that ANA has exact and adequate knowledge of the division of water resources when drafting a long term plan of availability of water resources. Additionally, ANA cannot grant water rights in areas where it has authorization, when it lacks the knowledge of how water has been divided according to the latest state of affairs.

By the way, some weaknesses related to this state of affairs regarding water rights division came under the attention in light of this research. ADASA is a very young organisation (established in 2004). It is, as an executive organ, highly dependent on data of the river basins where it exercises power, in order to make a planning consistent with the water resources plan.!

The availability of data is marginal, however. Perhaps this is due to the "youthfulness" of the organisation, or to the possibility that data have not been recorded properly in the basins of ADASA. For sure, it complicates the provision of outorga during its first few years of existence.

7: Secretariat of Water Resources (federal)

The federal Secretariat of Water Resources (SRH) (MMA 2008) is an organ appointed to draft the formulation of the PNHR, as well as to safeguard the implementation of it. In 2003, directive no. 4775/03, the link to the institution has with the SINGREH has been articulated. In this document, the next activities were appointed to the SRH as tasks:

- To monitor the performance of the SINGREH
- Promote the integration of water resources management with environmental resources management
- Guide the elaboration and support the implementation of the National Water

resources Policy

- Support technical and scientific research related to the National Water Resources Policy
- Promote, in cooperation with international and federal organs and institutes, studies and research into water resources and propose solution directions
- At the level of competency, coordinate research, plans etc. to study and monitor groundwater (and groundwater developments) in light of water resources management

Furthermore, the SRH is entitled to be the executive-secretary of the National Water Resources Council (CNRH).

Appendix D: Parties outside the water framework

1: Ibama

The Brazilian Institute of Environmental Issues and Reusable Natural Resources (Ibama) is (among other things) responsible for the "Licenciamentos Ambientais," (Sobrinho and Filho 1997) or environmental licensing procedure in infrastructural projects. The process of applying for such a license consists roughly of three phases:

1. Licença Prévia (LP): Preliminary license.

This License marks the beginning of the project, making a planning of activities leading to the next steps possible.

2. Licença de Instalação (LI): Implementation license

This license makes it possible to build the infrastructure necessary to offer the service planned.

3. Licença de Operação (LO): Operations license

The service may be offered actively; the infrastructures built may be used for the intended ends.

Each license must be obtained before the activities related to the respective license may be executed. In other words, after the implementation license is obtained, a construction may be built, but not yet operated. This means that it is possible that at a certain point a construction is finished, but the criteria for obtaining the next licenses are not met, leaving the construction unused.

When applying for the LP of a small reservoir, the applicant must be able to show that he has applied for and obtained the water rights necessary (ANA referred to this as a parallel process). After this, an Environmental Impact Study (EIA[9]) will be initiated, complemented with a Report on the Environmental Impact (RIMA).

Each phase of the licensing process has a reference to the EIA/RIMA, which continues

[9]Although the name is similar to what we in the Netherlands translate from the MER procedure (Environmental impact assessment), it is not quite the same.

to investigate the influence of the project/service on its environment.

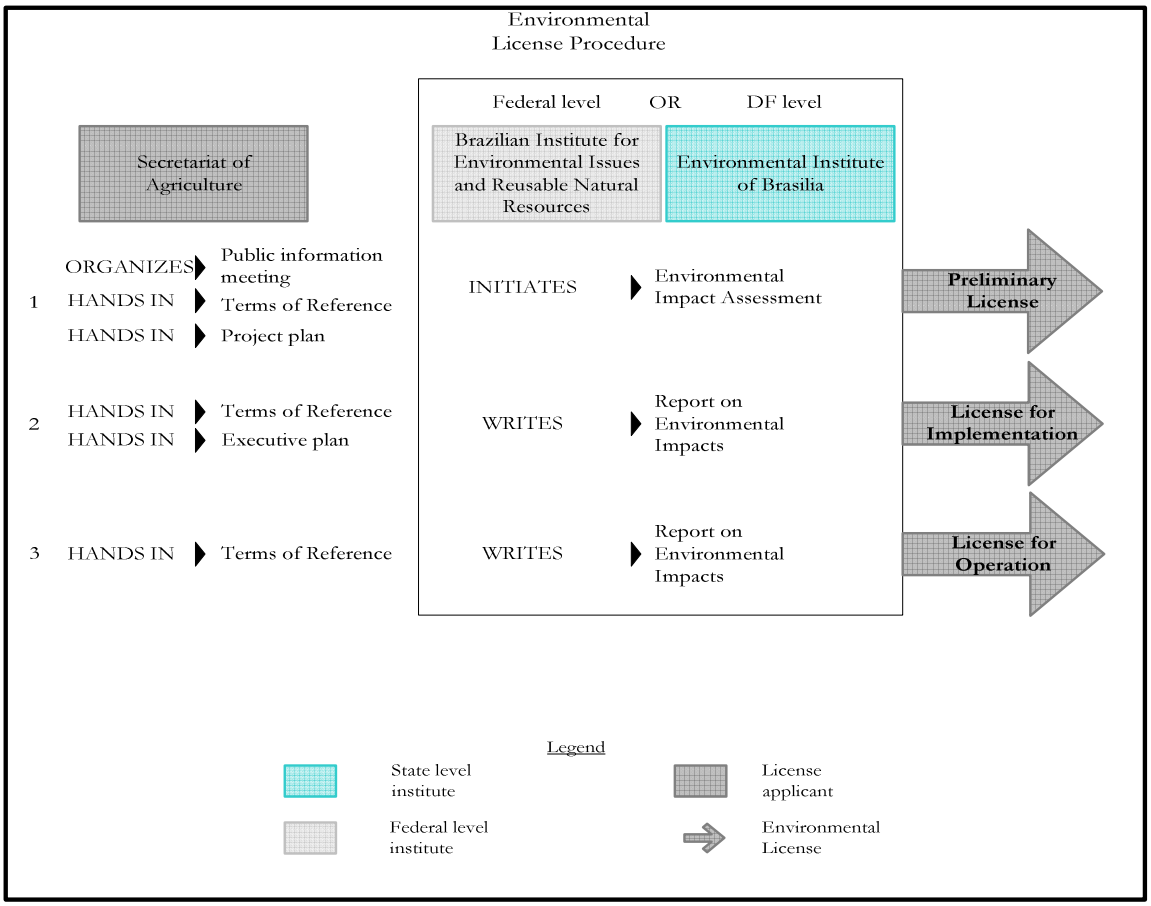
The profoundness of the EIA depends on the size of the project, expressed in money and affected area. A project plan (Projeto Basico Ambiental, PBA) handed in by the initiator of the project indicates the magnitude of the study. This PBA is subject to change during the EIA and public meeting(s).

Furthermore, an audiencia publica must have been organized prior to obtaining the first license (LP). Resolution 237/97 does only formulate the obligation of this meeting as "when pertinent (quando couber)", but the slightest involvement of parties with interests in the area subject to the EIA/RIMA fulfils this requirement.

This public meeting marks the point of intersection between the processes of (1) EIA/RIMA (2) obtaining water rights and (3) the general process of realizing a big infrastructure project where parties involved should have a chance to be protected against disadvantageous consequences (Schaedler 2008).

Additionally, most of the information that serves as input for the EIA/RIMA process must be handed in by the initiator of the project. Each phase leading to the accompanying license is formulated in a Terms of Reference document (IBAMA 1997), in which the exact specifications of the planned project/construction/service is described.

After the public meeting, the PBA is succeeded by the Executive Environment plan (Projeto Executivo Ambiental, PEA), which serves as an input for the request for the LI.



It should not make a difference whether this initiator of the project is a private party or a governmental one. In reality, however, some parts of the processes necessary to run through are relatively easy to manipulate for governmental institutions (such as the SA), based on means of pressure (the SA holds licenses for land use and can force parties to be cooperative). Based on the apparent disadvantage of bureaucracy, a governmental organization can also claim to need more time to make all the arrangements necessary for the permit. In this case, the Secretariat of Agriculture obtained an LP in 2002 for the initiation of the project including two small reservoirs: one in the Ribeirão Extrema and on in the Rio Jardim, both branches of the Rio Preto. Although only valid for two years, Ibama (according to Hugo in that time less strict than nowadays) granted an LI four years later.

2: IBRAM

Part of SEDUMA is the Environmental institute of Brasilia (IBRAM). Its goals are:

- Execute and let execute the environmental and water resources policies of DF

- Control and inspect, with police force, the management of water and environmental resources in DF, as well as all possible activities or actions causing or possibly causing pollution or downgrading of environmental or water resources.

These objectives are clear, but need to be delegated from the federal level to the state level, even when the area subject to inspection and control has federal interests.

This delegation is shaped by law. IBAMA has to appoint the areas of delegation to IBRAM.

The entire environmental licensing procedure carried out by IBAMA is exactly the same under the mandate of IBRAM, so resolution 237/97 is the legal basis for the procedure.

According to (Filho 2008) it is clear, however, what the sequential licenses mean. The first two (LP and LI), need to be accompanied and preceded by Terms of Reference, an environmental impact study (based on information handed in by the applicant) and a provisional plan and a definite plan respectively. IBRAM subsequently checks and interprets all the information handed in by the applicant. Towards the last license (LO), the activities of Ibram in a process leading to operations consist of monitoring and verification of the final plans.

The public meeting that is optional in the procedure leading to the LI was, according to Dalio, has never been called for up to this point.

About the weaknesses of the Audiencia publica.

- 3 publications on the internet
- 3 publications in a Diario publico.

But nobody reads this! Only when a lot of money/stakes are involved, and the news is out in the open, there will be people pro-actively responding to threats and chances of an infrastructural project.

3: APRORP

The Association of Producers of the Preto River (APRORP) initially focused on possibilities for recreation and sports for producers (farmers) in the Preto River Basin (Portal do Rio Preto 2006).

The main activities of APRORP are aimed at the people related to the producers of the Rio Preto, and consist of integrating families and the community of farmers, usually by

means of sending newsletters and organizing events.

This rather innocent description of the mission statement of APRORP did not prevent them from blowing the whistle firmly, when two farmers were harmed in their interests (section 3.2.1). Of course the entire community would suffer from the proceeding project, also bearing in mind the consequences of accepting an undemocratic process.

4: USUAGUA

USUAGUA is a small party that aims at representing a group of water users and their families in two sub-basins of the São Francisco river basin, one of which is the PRB.

5: EMATER

EMATER (Institute for Technical Assistance and Rural Extension) is the institute that supports rural development and the role of technology in it. Therefore, the interests of EMATER concern good rural development in DF. Small reservoirs should add to the rural extension, and this is as far as EMATER's interests go. In a way, the interests of EMATER and EMBRAPA cross over here. This mutual interest in small reservoirs makes the two institutes, which both enjoy public support, excellent monitors of the decision-making process leading to new small reservoirs.

6: Ministerio Público

The public ministry facilitates conflict resolution between state- and non-state institutions, in order to protect democratic values and social and individual stakes.

7: Secretariat of Agriculture

The Secretariat of Agriculture wants new small reservoirs to

- Increase revenues of rural products
- Extended offer of products throughout the year with stable revenues
- Stabilized discharge of water (supply)
- Preservation of the environment
- Conservation of a minimal flow within the river

Despite the failed former project, the SA remains a problem owner. Taking the functions of small reservoirs into account, both institutional responsibility and interests of the SA

make the implementation of new small dams to a project of the Secretariat of Agriculture. SA has to deal with distrust of farmers and other institutes that are sceptic with regard to intentions and profoundness of researched environmental impacts.

8: EMBRAPA

EMBRAPA is the Brazilian agricultural and livestock research institute.

The mission statement of EMBRAPA is close to deserving the predicate "motherhood statement." It runs as follows (translated from Portuguese): "Its mission is to facilitate solutions for sustainable development of rural areas, with emphasis on agricultural business, by means of management, adaptation and transfer of knowledge and technology, for the benefit of various segments of Brazilian society" (EMBRAPA 2008).

This mission statement, although vague and very general, concurs with the idea of a more or less impartial problem-owner. As EMBRAPA sees to it that knowledge transfer occurs properly from government to agricultural stakeholders, EMBRAPA is the appointed institute for monitoring decision-making processes concerning agricultural land use.

Stakeholder Analysis - Overview of stakeholders

Stakeholder	Interests/core values	Goals	Expected situation	Gap	Causes	Solution directions
Secretariat of Agriculture	Make DF's market competitive internally (farmers within DF) and externally.	Improve access to water of farmers within federal district Increase irrigated area in DF Preto Basin with 9800 m^2.	Resistance of farmers or other stakeholders (communities, environmental agencies) after frustrated earlier process	Negative perception of government interference; Bad name in history; Sensitivities and "natural resistance" due to distrust	Sense of un-equal investment-profit ratio (land lost vs. profits gained, new competition, lack of sense of urgency) in old plans	Bottom up-strategy, addressing sensitivities of stakeholders involved; Information sharing
Irrigating farmers	Profitable and stable existence	To make profits and stabilize future productivity	Malefic influence of new infrastructures for small dams	Decreasing profits w.r.t. zero-option (opportunity costs >>0).	Land loss and environmental damage, loss of productivity	Compensation, alternative techniques, water rights (institutional solution)

Stakeholder	Interests/core values	Goals	Expected situation	Gap	Causes	Solution directions
IBAMA Environmental organization	To conserve or enhance environmental quality by means of the law, to mitigate environmental impacts of new infrastructures.	Limiting the environmental impact of small reservoirs, and if present, make sure that it is compensated or mitigated.	New small reservoirs are constructed without bearing in mind laws, regulations or procedures (EIA RIMA, see chapter 5)	Ecological impact being neglected Federal reserves being affected	Procedures not consistent with laws, monitoring is impossible because of opaque process, Environment damaged	Timely involvement, transparent communication on vulnerability of the environment, water quality and location choices.
River basin committee Comite de Bacias	Proper water use within a river basin, sub basin or combination of (sub-)basins.	To represent water users of a sub-basin, basin or combination of basins	Internal friction and incompatible stakes of representatives within basin committee	Unsolvable and fundamental conflicts, lack of common ground	Involvement only after hydraulic and institutional situation has been defined	To establish this committee ex ante instead of ex post
ANA National Water Agency	Management of water use, implementation of the national water resources management system. Federal level	Consistent water rights division with regard to new small reservoirs	Messy function of SINGREH	Mess: which parts of water rights division falls under ANA?	Lack of communication between institutions	Create liaisons with ADASA (to start with…)

Stakeholder	Interests/core values	Goals	Expected situation	Gap	Causes	Solution directions
ADASA Water and Sanitation regulating agency in the Federal District	Safeguarding "the public interest" concerning water use. Distribution of water rights	Distribute water rights in new situation of where new small reservoirs are implemented	Implementation of new small reservoirs, user conflicts augmented.	Lack of information of water demands	Novelty of organization, lack of communication with ANA	Enhancement of communication, increase in quality of available data
Farmer Communities Rural cores	Sustainable and independent existence	To keep at least sufficient access to water	Uncertainty about future water availability	Uncertainty about future situation and water availability/quality	Not possible to draft a long term development plan	Representation in basin committees, rules and regulations
APRORP	Social integration and well-being of farmers in the Rio Preto basin (of DF).	Small reservoirs for farmers in a public private partnership construction	No new reservoirs, at least not according to demands of farmers	Lack of water availability	Limited approach of SA and other institutions	Feedback loops, open debate, institutionalize low level influence of water users

Stakeholder	Interests/core values	Goals	Expected situation	Gap	Causes	Solution directions
EMBRAPA Brazilian agriculture and livestock research institute	Develop sustainable solutions in rural areas, with emphasis on farmer activities, through development and transfer of knowledge and management	Implement and monitor knowledge development w.r.t. land use and irrigation in DF (Emphasis on products)	Monitoring role	Monitoring role	Not directly involved or responsible, but highly interested in outcome (whatever that is)	
Codevasf	Agency responsible for executive activities in the São Francisco River basin	Development of PRB		Lack of efficiency, lack of knowledge available	No agenda	Set agenda, plan process, involve more knowledge stakeholders
EMATER (Institute for technical assistance and rural extension)	Knowledge and service distribution in the rural areas of Federal District	Emphasis on farmers (users)	Supporting role for farmers	Not involved	Surpassed in policy decision-making	Involvement

Appendix E: Example Calculations input water demand WEAP

	demand l/s	demand m3/month	Share	
j	12.18	33608.41	0.594711	
f	19.36	48239.39	0.853611	
m	126.28	339213.9	6.002493	
a	204.58	531256.9	9.400753	
m	251.13	673612.1	11.91977	
j	248.88	646082.5	11.43263	
j	320.18	858555.6	15.1924	
a	309.69	830459.2	14.69523	
s	263.66	684392.2	12.11053	
o	177.52	476455.1	8.431018	
n	101.76	264747.4	4.684787	
d	98.42	264593.6	4.682065	Additional "creation" (m^3/year)
				11826
Annual total		5651216	100	
Area		103.94		
Used water per km2		54369.98		

Monthly water use/user

4.03	**7.89**	**27.74**	**105.71**	**151.77**	**149.5**	**220.6**	**209.93**	**163.94**	**78.64**	**3.34**	**0**
8.15	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**	**8.15**
0,10	**0.12**	**0.12**	**0.45**	**0.94**	**0.96**	**1.16**	**1.34**	**1.3**	**0.46**	**0**	**0**
3,2	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**
58	**58**	**58**	**58**	**58**	**58**	**58**	**58**	**58**	**58**	**58**	**58**
24.07	24.07	24.07	24.07	24.07	24.07	24.07	24.07	24.07	24.07	24.07	24.07
5	5	5	5	5	5	5	5	5	5	5	5

Total monthly water use

36.25	**19.36**	**126.28**	**204.58**	**251.13**	**248.88**	**320.18**	**309.69**	**263.66**	**177.52**	**101.76**	**98.42**

The water demand input factors are listed below:

- Monthly irrigation
- Monthly irrigation currently researched
- "Creation" water use (livestock and personal use)

- Creation currently researched
- Yearly additional creation (maximum)
- At some points: fishery water use

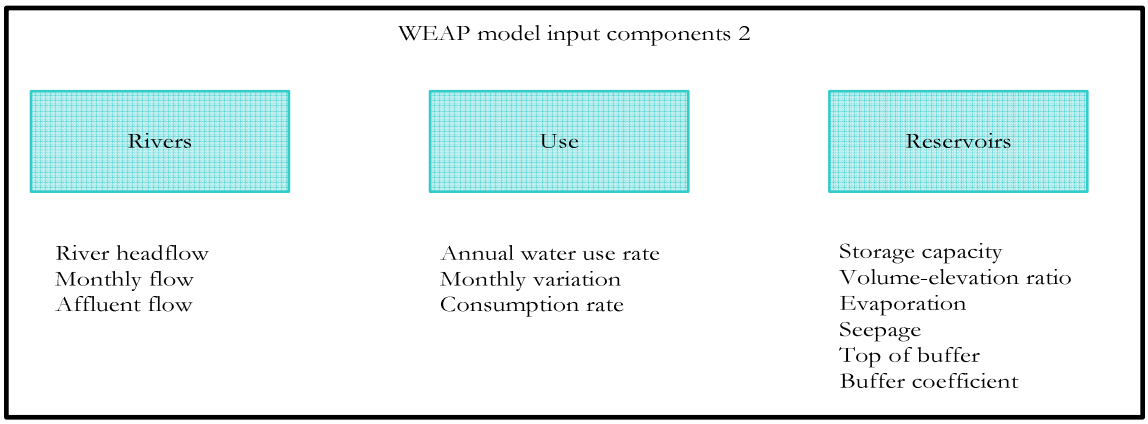
All of these data can be found in ADASA's document. In this document, the demands are listed in liters per second (l/s), which had to be converted into m^3/month. WEAP asks for a monthly share of an annual total demand.

Furthermore, because of the different length of various months, not every month has the same conversion ratio. For the month February, a 28,25 day conversion rate is chosen.

Next to the monthly demand, the farmers use an optional non-stop water withdrawal for livestock purposes. There exists an annual quota, which are divided over the months as an equal contribution to the other monthly uses.

The total of these uses provides the column "demand m^3/month" which is converted to a monthly share by dividing the annual total by the monthly total. This share serves as WEAP input.

Appendix F: WEAP inputs



Rivers

There are 6 rivers modeled with WEAP: The river Santa Rita, the river Jacaré, the river Extrema, the river Jardim (with affluent Lamarão), the river São Bernardo and the river Preto. All other streams are affluents. Data about river discharges have been entered for each river at several points: the headflow (all except for the river Preto), at demand sites and at points were new reservoirs were planned by the SA. Evaporation and seepage losses have been assumed to be represented in the river discharges as measured/calculated.

Use

The way use has been modeled is explained in appendix E.

Reservoirs

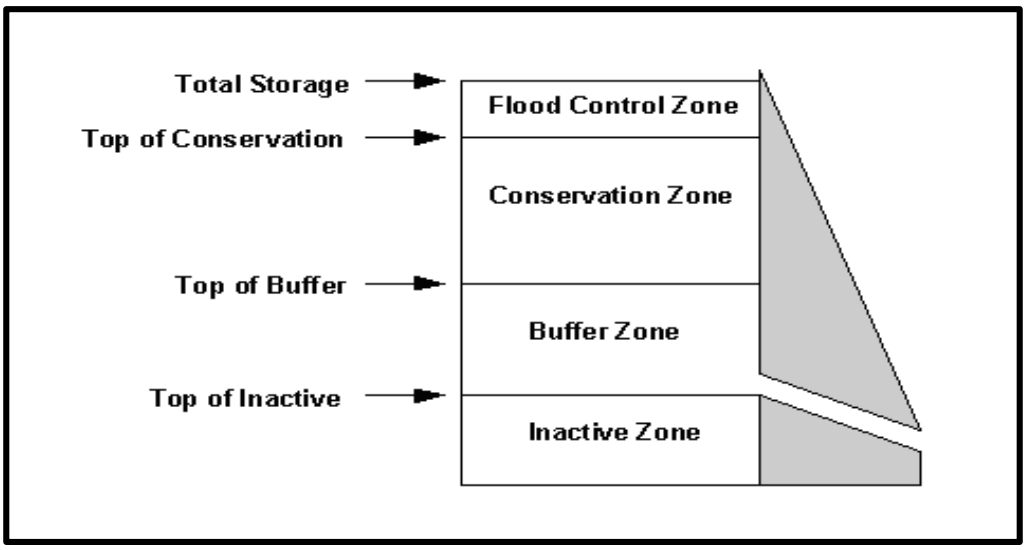
For the reservoirs, storage capacity, the volume-elevation ratio, evaporation, seepage, top of buffer and the buffer coefficient were entered into WEAP.

For modeling seepage, groundwater storage points have to be modeled, because WEAP calculates the interaction between groundwater and surface water. Therefore in WEAP, seepage is called "loss to groundwater." Seepage has been calculated from a volume point of view. Dekker and Rodrigues (2008) investigated one reservoir in the Buriti Vermelho catchment in the PRB in DF, and found the seepage rate to be 1.36 mm/day. The volume of all reservoirs divided by the volume of this example reservoir has been multiplied by this seepage rate.

Evaporation is modeled in mm/day. For the evaporation rates, the same typical and well

researched reservoir in the Buriti Vermelho catchment has been used. Since the volume-elevation ratio has been provided for by the studies of SA, WEAP calculates the actual volume of evaporated water.

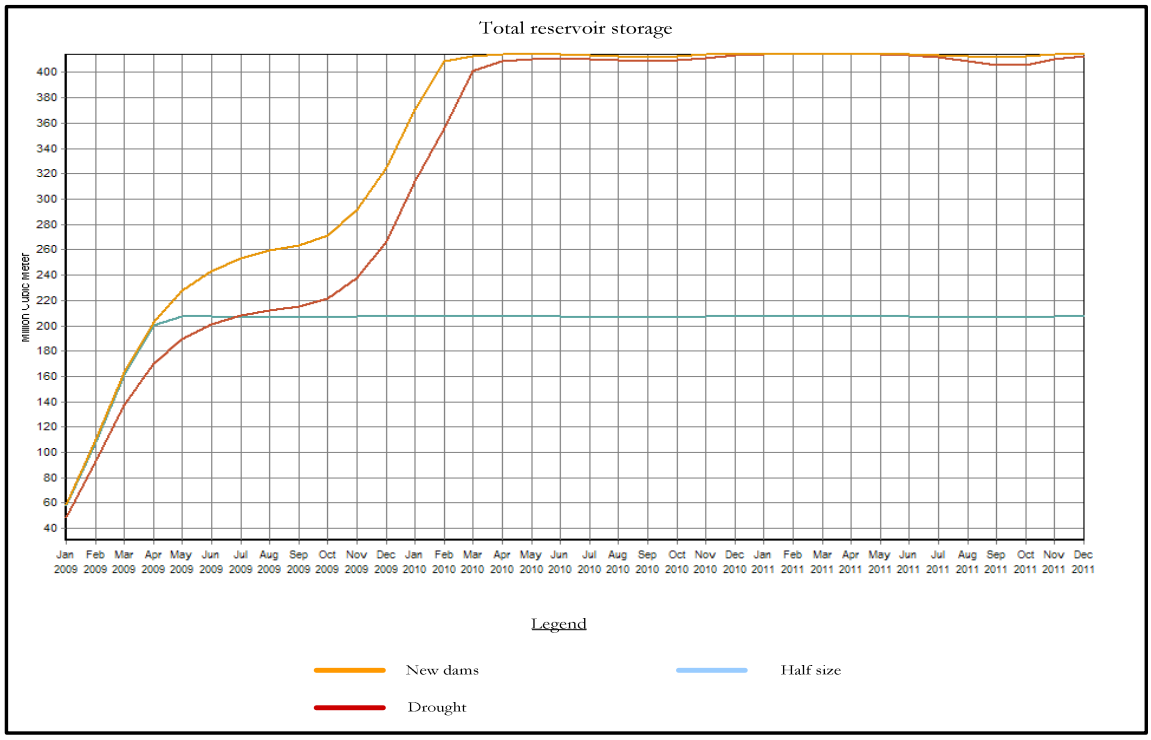
The top of buffer is depicted below. The two most important factors of this depiction of a reservoir are the conservation zone and the buffer zone. When the water level drops into the buffer zone, water will be released according to the buffer coefficient. The buffer coefficient Cb for this model is set on 0.9, because small dams behave like weirs, and weirs are used to control downstream water levels with variable discharges upstream. A buffer coefficient of 0.9 means that 0.9 times the current storage is released into the system in that month (Cb x S_{t-1}). The residual 10 percent (1-Cb) is retained and added to the storage of the next month (t). For this month, 0.9 times the current storage plus the residue of the last month is released into the system (Cb x (S_t + (1-Cb) x S_{t-1})).



Appendix G: Additional WEAP outputs

Relevant outputs for this research are streamflows, reservoir in- and outflows, demand coverage and reliability and reservoir storage volumes.

Figure F shows how reservoir storage volumes increase during the first two years of their operation. It shows clearly how half size reservoirs only have about half the storage of the originally planned reservoirs. This is remarkable, since WEAP also shows results that indicate that with these half size reservoirs, full demand coverage is met.



Appendix G The Rainfall-Runoff Model

The Rainfall-Runoff model (Savenije 1997) takes a threshold value (an interception taking place between rainfall and run-off) as the basis for run-off predicting calculations.

It works as follows:

1. Gather data on rainfall in a defined area within a defined time frame
2. Gather data on discharges in the same area
3. Organize the data in such a way, that memory is introduecd in the system. For example: rainfall in month 1 influences discharge in month 2 (influence (t-i) on t)
4. Execute multiple regression analysis to determine the influence of the respective time delays (t-1), (t-2)...(t-i) on the predicted run-off. In fact, coefficients of multiple predictors are determined
5. The result is a model with a certain fit (of predicted run-off with historical run-off data) for one of the possible memory-models
6. Maximize the fit by varying the threshold value (iterative process: at highes R square, the threshold value will be more or less correct

When coefficients and threshold values are found, run-off can be predicted using new rainfall data (extrapolate model)

Check: Run-off coefficients converge to zero. If the coefficients converge to 0, this indicates that the influence of t-i decreases after i years. This will be in accordance with reality: it is possible to store water in the system, but not to generate water.

Appendix I: Institutional considerations

In a complex socio-technological problem there are many perspectives that are valuable to adopt, such as a philosophical perspective, a technical (in this case, hydrological) perspective, a law-perspective or an ethical perspective. So why accredit the analysis from an institutional point of view?

Various reasons can be drafted. I think, the most important one is the intended output of this analysis: knowledge of what might be constraints and criteria when formulating a program of requirements for new small dams. Institutional constraints, that is.

Furthermore, insight in the institutional framework clarifies the problem and is important for accentuating the actual problem. Especially in a later phase of this research, linking the actual situation back to the analyzed institutional framework (as it is supposed to function) will be valuable.

Lastly, knowledge about the institutional framework, with respondents being part of this framework as references, can serve as a coat rack for subsequent phases of this project, such as design and implementation of alternatives (if relevant/necessary/possible).