Communication between irrigation engineers and farmers

The case of project design in North Senegal

Steven Scheer

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GLOSSARY

Aménagement Intermédiaire (AI): (Intermediate irrigation scheme). An irrigation scheme that varies in size from 30ha to 1000 ha. The term intermediate may refer to size only, but it is often more correct to regard the concept as a compromise between various socio-economic options. On the one hand, irrigation units in *AIs* may be more autonomous than is the case in *GAs*. On the other hand, *AIs* differ from *PIVs*, requiring major works to develop water sources and primary canal systems, serving schemes several hundreds of hectares in size. Furthermore, the concept of the intermediate scheme is based on the use of large plots, which it is hoped will lead to adequate production to meet subsistence needs, cover operating costs, and provide a marketable surplus. Another importance difference with *PIVs* is that the land users of a *waalo* area - the site of the future schemes - often do not belong to the same village (cf Diemer and Huibers, 1991).

BEC: *Buréau d' Etudes et Control*, part of the *SAED*, being responsible for irrigation design and construction.

Check structure: Structure that regulates water levels in canals.

Conseil Rural: A local council elected by farmers with some power to decide on how the valley is used.

Cycle of confirmation: Pattern of action and reflection the result of which is a confirmation of what is already known.

Cultural stream of analysis/enquiry: Organized exploration of the context of an intervention. Element of *SSM*.

Design engineers: See irrigation design engineers.

Disposition: Orientation ingrained in people (a 'second nature'). It is not readily amenable to conscious reflection and modification.

EDF: European Development Fund (*FED* in French).

Faalo: bank of the river.

FCFA or *Franc CFA*: Unit of money equalling 0,01 French Franc.

Foyre: Fire-place. The people who belong to the same foyre eat from the same pot. This is why the word is often used to indicate a household.

Freeborn: Category in the Haalpulaar society that was traditionally independent, including *toorodo* (nobles), *pullo* (herdsmen), *cuballo* (fishermen) and *ceddo* (warriors).

GA: Grand Aménagement. Large scale irrigation scheme.

Galle: Several *foyres* grouped together.

GIE: *Groupement d'Interet Economique*. Juridically prescribed organization structure often used in irrigation.

GMP: *Groupe Moto Pompe*. Motorized water pump with accessories.

Haalpulaar: Those who speak Pulaar. *Haalpulaar* people originate from several population groups who settled in the North of Senegal in the course of history.

Habitus: A set of dispositions which incline people to act and respond in certain ways.

Hardened History: The material outcome of past events.

Hard System: A system that results from engineering and management methodologies that searches for the best means to achieve an end considered desirable.

'High' AI: *AI*-concept that is marked by an elevated primary irrigation canal

Irrigation engineers: See irrigation design engineers.

Irrigation design engineers: Engineers, whose professional heartland it is to create a technical design, using knowledge of different disciplines like civil engineering, hydraulics, hydrology, construction engineering, geodesy, soil mechanics, soil science and agronomy.

Irrigating group: A group of farmers who irrigate together. The group composition changes when a member no longer irrigates or someone starts to irrigate. The group is responsible for immediate problems occurring during irrigation.

Jeeri: Area that cannot be flooded by the *Senegal* river.

Jom Leydi: Head of the land (literally). Also head of the Haalpulaar organization structure that is responsible for the use of land and water in a part of the floodplain.

Logic-driven stream of analysis/enquiry: The use of systems as 'logical machines' to question reality. Part of *SSM*.

'Low' AI: *AI*-concept that is marked by a low primary irrigation canal. Pumps are required to irrigate small irrigation units. The low primary irrigation canal also serves as a primary drainage canal.

PIV: Périmètre Irrigué Villageois (village irrigation scheme). A simple small-scale irrigation scheme that varies in size between 15 and 40 ha. The individual plots are small, and the produce is usually consumed locally.

Module à masque: Structure that allows for the intake of various quantities of water from a canal into a tertiary or secondary unit.

NGO: Non Governmental Organization

Participatory design: A design based on joint analysis and decision making by farmers and design engineers.

PRA: Participatory Rural Appraisal.

Practical Logic: Knowledge that is able to organize peoples' thoughts, perceptions and actions by means of a few principles. They are not strictly 'logic' but characterized by a loss of rigour for the sake of greater simplicity and generality.

Practices: The visible actions of people. These can be regarded as the outcome of their habitus and the structural environment in which they take place.

PTD: Participatory Technology Development

RRA: Rapid Rural Appraisal

SAED: *Societé d' Aménagement et d'Exploitation des Terres du Delta et de la vallée du Sénégal et de la Faleme.*

Slaves: Category of the *Haalpulaar* that were traditionally dependent.

Social Interface: Emerges in situations where parties who differ in terms of access to resources, social relationships and cultural backgrounds meet face to face.

Soft System: A system that has no fixed objectives or preconceived viewpoints. It is useful in complex human situations that are considered to be problematic.

SSM: *Soft Systems Methodology*. A methodology that aims to bring about improvement in areas of social concern by activating in the people involved in the situation a learning cycle which ideally is never ending. Learning takes place by means of the iterative process of reflection, discussion, action and again reflection. The reflection and discussions are structured by a number of system models. It is taken for granted that no objective and complete account of a problem situation can be provided.

Structural Environment: Environment where habitus is structured, while at the same time the environment itself is (partly) structured by habitus.

System: a set of mutually related elements constituting a whole, that has emergent characteristics that refer to the whole only and are meaningless in terms of the parts that make up the whole. A system is a conceptual tool and should not be considered as a reality.

Technical design: The combination of plans, drawings, calculations and analysis that are meant to implement irrigation infrastructure, by means of which it is physically possible to adequately supply crops with water.

Technical image: A set of technical dispositions

Technical knowledge. Knowledge about physical phenomena and characteristics in irrigation schemes (e.g. water flow, structures, topography, soils). This knowledge is the professional heartland of the irrigation design engineer. The farmers also have a technical knowledge, which is based on their experience in irrigation.

Toorodo: The cast of nobles

TOR: Terms of reference

UAI: *Unité Autonome d'Irrigation*. Autonomous Irrigation Unit (cf. tertiary unit)

Waalo: Part of the Senegal valley that may be flooded

WAU: Wageningen Agricultural University

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My study started in july 1988. It is indebted to many who supported me in one way or another while the research was carried out. The study was originally meant to be part of a joint *WARDA/WAU* water management research project in the *Senegal* river valley, which started in 1982. The rich material gathered by this project provided a sound base for my own research. Special mention must be made of Geert Diemer, who saw to the implementation of a follow-up research in which I took much interest, since it focused on a linkage between communication methods and the quality of irrigation design. In addition, I was fortunate to have two promotors, professor Luc Horst (Department of Irrigation and Soil and Water Conservation) and professor Niels Röling (Department of Comunication and Innovation), who were very open to the interdisciplinary character of the research. They gave me room for exploration.

Due to a reorganization of *WARDA* it was uncertain for some time whether I could carry out the research I had prepared. I thank Silvester Povel, my tutor in 1988 and 1989, for helping me to look for ways to continue the research in Senegal. I am also grateful to him because he encouraged me to visit the *Senegal* valley, so that 'I would know what I was writing about, before completing my research proposal'. During this short stay in Senegal my conversations and excursions with Ton Meijers and Els Feenstra inspired me a great deal.

It took one year before the field work in Senegal could start. By that time, I was very eager to take off. Jan Arie Nugteren and Jan Ubels offered me a way out of the stalemate of waiting in uncertainty: although everything was not yet formally arranged, I had a place to go, the *Ile à Morphil* small scale irrigation project in Cascas, North Senegal. This would turn out to be my base for two years. My research became part of the *Ile à Morphil* project, funded by *DGIS* and the *SAED*.

My interpreters were the major key to the people of the *Senegal* middle valley. At first, I was guided by Aliou Diop, an experienced interpreter who taught me many things about the norms and values of the *Haalpulaar* farmers. I thank him for his meticulous suggestions. Later, Abdoulaye Lom took over his role. I was very fortunate to cooperate with him, since he was both a technician and a farmer himself. In this way he could not only bridge different languages, but also the different views of farmers and engineers. To me he was a friend, a counterpart and an interpreter. Together with Daha Samb, the driver, we had a good and interesting time.

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Many others, directly or indirectly, supported my work: my friends and family, my teachers and friends that I met at the ITIP. I especially thank my sister Ernestien, who took great efforts in correcting this thesis. During our discussions I learned that language is much more than just an instrument. Furthermore, I am particularly grateful to Gerard and Stella Kerkhoven, who were prepared to correct the worst examples of 'dinglish' (i.e. Dutch English) in some of the crucial parts of the thesis, even late at night by telephone in a final phase! Whenever the reader feels that the English sounds Dutch, it is certainly not their fault.

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TO WHOM IT MAY CONCERN

This thesis is on technical aspects and communication methods related to irrigation design engineers and experienced farmers working together (or apart) on improvement of design and use of irrigation schemes in Senegal. It could be of interest to irrigation design engineers, especially those who design irrigation schemes in interaction with farmers. It may also be of interest to planners who set the conditions for the design process in which the engineers operate, as well as to those who are interested in indigenous knowledge. Readers who are interested in creating a locally-adapted improved technology, by building on the indigenous farmers' knowledge, may find useful ideas for Participatory Technology Development (PTD). To communication scientists, the thesis includes cases of misunderstandings between technicians (engineers) and others (Senegalese farmers). Ways to overcome these misunderstandings are presented.

How to read the thesis

Part I (chapters 1-2) consists of an introduction and provides some relevant analytical tools. In the first chapter, I will explain the research questions of this thesis and indicate their relevance, with reference to international discussions and literature. These questions are:

- What is the difference between design engineers' and farmers' knowledge with regard to the technical aspects of irrigation?
- To what extent do engineers and farmers learn through exchange of technical knowledge, why and how does this exchange take place, and if not why not?
- What is the effect, of the exchange or non-exchange, on the design?
- How can the exchange of technical knowledge be optimized?

A relevant theoretical and methodological perspective is required to tackle these research questions. Elements of existing analytic frameworks and methodologies inspired me to go into this (chapter 2).

Part II (chapters 3-7) describes the history and context of the area in which the research took place: the middle valley of the *Senegal* river in Senegal, West Africa. The physical context, the actors (state, donors, farmers and design engineers) and their strategies were studied. In addition, I give a general description of the technical knowledge of both farmers (chapter 5) and design engineers (chapter 7).

Part III (chapters 8-13) focuses on the differences in technical knowledge that come to light when design engineers and farmers, directly or indirectly, are confronted with each other's technical knowledge. Chapter 8 focuses on site selection of the irrigation schemes in two design processes. I selected these cases because planners considered them to be positive examples of farmers' participation. Chapter 9 deals with different views on irrigation and drainage requirements. Chapter 10 describes a difference of opinion regarding a new type of check-structure and in chapter 11 different ideas about the effects of topography are illustrated and related to differences in knowledge. Maybe the most interesting aspect is dealt with in chapter 12, i.e.: water flow in irrigation canals. Finally, the complex relationship between water flow and maintenance is described in chapter 13. In the annex there is an overview of differences in technical knowledge.

Part IV (chapters 14-17) is the 'solution'-part of the thesis. Chapter 14 is a key-chapter because it bridges the analysis of the actual situation in the *Senegal* valley and ideas about the improvement of exchange of knowledge. To this end, I introduce a methodology that may be used by design engineers in the design process. This *Soft Systems' Methodology (SSM)* is illustrated by means of the rich material of the previous chapters. In chapter 15, I describe a useful tool for the exchange of knowledge between design engineers and farmers: a scale model with actual irrigation. The scale model may well be used within the framework of the *Soft Systems Methodology*. The same holds for other models or methods in chapter 16. In this chapter, I refer to experiences of *Participatory Rural Appraisal (PRA)* and *Participatory Technology Development (PTD)* to complement my own experiences. The conclusion is in chapter 17.

Route-descriptions

The thesis can be read by people of different backgrounds, but not all parts are of interest to all. To this end I have made several route-descriptions, each of which can be related to particular fields of interest.

Solution-oriented design engineers' route	ch3; ch7; annex; boxes 14.3-14.5; ch15-17; summary
Theoretical route	ch1; ch2; ch14; ch17; summary
Communication route	§2.2-2.5; §4.4; §6.4; ch8-13; boxes 14.3-14.5; ch15-17; summary
Indigenous knowledge and PTD-route	§1.3, §2.4-2.5; ch5-6; ch9; annex; ch14-17; summary
Planners' route	ch1, ch3-7; annex; ch14; ch17; summary
Short route	Summary
Intuitive or interactive route	For this option, I suggest the reader to browse through the thesis, reading one or several boxes. These may stimulate him or her to examine other boxes or chapters. For an overview read boxes 14.3-14.5 and 17.2-17.3.

PART I

INITIAL PERSPECTIVES

Chapter 1

INTRODUCTION

1.1 Irrigation problems and the search for solutions

It has been known for at least three decennia that irrigation rarely meets the expectations of irrigation design engineers, donor agencies, governments, development workers, scientists, and, last but not least, the assumed beneficiaries. Problems that have been mentioned are the unreliable and unequal water supply, neglect of maintenance, construction and maintenance costs that are higher than expected, crop yields and cropping intensities that are lower than expected, theft and vandalism of water control structures, environmental damage, the widening or creation of social and economic disparities, etc (Houston 1962, Ubels 1990, Campbell 1995). After many years of discussion and research, it seems that *the* solution cannot be found. It simply appears that irrigation-oriented interventions are so complex that an easy answer does not exist. The search pattern of the last decennia can be illustrated by the many efforts to analyze, measure, compare and define complex irrigation situations (cf Sampath 1988, Tiffen 1983, Murray-Rust et al 1991, Plusquellec et al 1994), as well as by the checklists that indicated how many variables should be taken into account in the design process (cf Underhill 1984, Frederiksen et al 1987). However, the checklists do not indicate how to weigh these variables in different situations. Besides, which there is a general complication namely the fact that different irrigation objectives, like sustainability, productivity and equitability are not mutually exclusive or automatically consistent and harmonious (Conway et al, 1990).

History of the search pattern of design engineers

Over thirty years ago, the process of searching for solutions began by thinking along the lines of their professional core, by means of refining technical designs and survey methods. Technology was seen as the answer. In the second half of the seventies some professionals began to look further and came to the conclusion that social and economical factors should also be taken into account in the analysis. Organizational perspectives were introduced in irrigation literature (cf Wade and Chambers 1980, Coward 1980) and solutions, such as a better management of resources, more coordination between agencies, more training, larger budget allocations, higher water charges and more farmer participation were put forward.

The department of Irrigation and Soil and Water Conservation of the Wageningen Agricultural University also focused on refined technical designs until the end of the seventies, but it was found that the research focus had to be changed towards social, economic and political aspects of irrigation (Hoogendam and Slabbers, 1992). The socio-economic perspective of irrigation on local and macro level was emphasized and it became common for students to choose subjects like sociology, economy, anthropology and extension science in addition to their compulsory technical subjects.

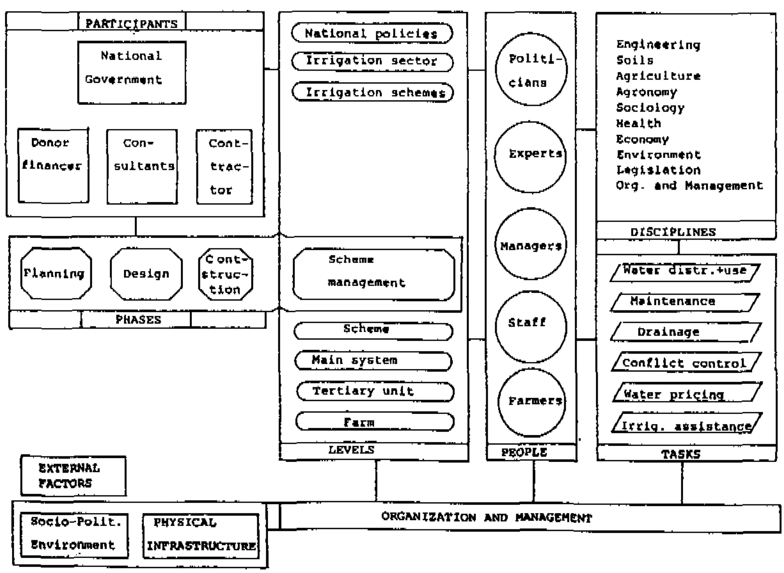
However, the new frameworks of analysis were still not satisfactory. It was found that many authors only saw organizational or economic solutions to irrigation-related problems, while the technical design was *taken as a given* (Horst, 1990). Equally socio-economic research by the Department could not provide the answer. Field studies were often only descriptive and, at best, recommended what socio-economic factors needed to be taken into account to improve the technical design, but how to include these factors in the technical design was not given, or only when applicable to a local situation. Not surprisingly, the wish emerged at the department to connect socio-economic factors to the technical design. Diemer (1990), an anthropologist working at the department, gave some direction by pleading for more irrigation-oriented studies of farming systems, local political systems and local patterns of organization as part of the design process.

It was the objective of the international workshop *Design for sustainable farmer-managed irrigation schemes in sub-saharan Africa*, held in 1990 in Wageningen, to gain insight into the question as to how to include certain *social* characteristics in *technical* design choices. The participants of the workshop originated from eight African and four European countries and brought together a whole range of experiences, analysis and opinions. During the workshop, it became clear that the socio-economic factors that play a role are not easy to identify and do not directly relate to technical issues. However, both can be linked by the *daily use* that people make of a system (Ubels 1990). Ubels and Horst (1993) therefore recommended that the design focus of engineers should change from the physical system itself towards the use of that system. The design should be based on the analytic model of box 1.1, and, during the design process, the 'technical system' and the 'social systems' should both be tuned to the (expected) daily use.

It remains to be seen whether the concept of *daily use* will prove to be satisfying. It depends on how the concept will be used. Suppose that one would continue to elaborate the analytic model in a formal scientific way, asking questions such as: *what* is daily use exactly, *what* is the irrigation system and *how* can one connect the irrigation system and the community to the daily use? Probably the answer to every question would give rise to an array of new questions that needed solving. Consequently, one risks not only not solving irrigation problems, but ending up with the conclusion that a situation is still more complex than was expected beforehand. The model in box 1.2 illustrates the large number of factors, disciplines and actors that have to be reckoned with in irrigation interventions. Somehow an interdisciplinary overview is required, but 'normal professionals' (Chambers 1988), go on and on elaborating parts of the model in box 1.2. Today, an overview seems far away. Most scientific irrigation research in the world still focuses on *"subjects as*

	Technical system	Form of use	Social unit	
PHYSICAL ENVIRON-MENT		agricultural use	farming household	SOCIAL ENVIRON-MENT
	irrigation system	irrigation organization	community	
		external relations	institutional and commercial environment	

Box 1.1 Analytic model of the relation between socio-economic factors and the physical environment (source: Ubels & Horst 1993).



Box 1.2 Illustration of the complexity of an irrigation-oriented intervention (source: Jurriens & de Jong, 1989)

soil-water-plant relationships, yield response to water, infiltration characteristics and irrigation efficiency" (Hoogendam et al 1992, p19). With regard to the other research themes, bureaucratic management issues associated with irrigation schemes receive major attention. Other irrigation research "*....shows an enormous array of research issues: including the rehabilitation of schemes, the influence of social factors on design, farmer participation, economic viability and gender-specific studies of irrigated agriculture*" (p19).

1.2 A new paradigm?

The quest for 'new' solutions, in contrast to the lack of results in practice, can be regarded as a symptom of the unresolved underlying question as to how to proceed in a context of uncertainty, diversity and increasing complexity. 'Formal science' apparently fails to give the answer. People like Pretty (1994) and Röling (1995) suggest that a shift in paradigm is needed, which is based on the notion that reality cannot be observed objectively, and therefore no singular 'true' objective should be sought among the multiple perspectives on complex problem situations that exist. Neither objectives nor analysis frameworks can be defined beforehand, because these are part of the problem itself. No hard criteria exist. This implies that solutions for the complex human situations in irrigation schemes can only be found in a learning process that involves the different relevant actors.

Is this new paradigm the answer? The reader may not be convinced as the statement that 'objectives are part of the problem' seems to complicate the matter instead of clarifying it. Besides, if Pretty and Röling claim that no objective reality exists, they can easily be fought with their own weapons, because if they are right, how can they claim to have a better paradigm? However, a starting point is needed, to come to grips with the irrigation problems. There are good reasons to give the 'new paradigm' the benefit of the doubt: compared to the 'old' one, it takes complexity as a starting point and admits that no one knows the answer. There are no standard solutions in the face of any complex human problem situation. This implies that irrigation design processes should be meant for people to learn their way to the answer.

Participatory design

One of the consequences of the new paradigm is that ways of learning have wider validity than having the proper knowledge, and decision making in complex situations should be participative (Pretty and Chambers, 1992). Therefore, participation is an important concept in the new paradigm. Participation is often presented as one of the solutions to irrigation problems, but for different reasons, no solid 'proof' for its importance has been found by means of formal science. One of the reasons is, that multiple uses of the notion 'participation' exist. Pretty (1994, p18) presents seven typologies of participation. Often, participation seems to be reached by just telling the farmers what is going to happen, or what has already happened. In other cases, farmers participate by answering questions posed by extractive researchers or they may participate by being consulted, while external agents listen to their views. Equally, participation by providing resources, for example labour, in return for food, cash or other material incentives is often seen as useful. All these types of participation have nothing to do with collaborative learning. Participation that is required for a learning process should involve a joint analysis, action plans and decision making. This is interactive participation (Pretty 1994). The most progressive form of participation, self-mobilization, implies that farmers take initiatives independent of external institutions to change their irrigation system. In this , farmers may manage the learning process themselves.

Many design engineers favour participation by farmers, but mention the rigid conditions of design processes that inhibit them from involving farmers in the design process. The terms of their recommendations are less rigid planning, more space for a learning process and more participation of farmers (Lowdermilk 1985, Uphoff 1986, many contributions in Ubels 1990, Speelman 1990). Although there was no formal research to scientifically prove the positive impact of participation, they experience it a major problem. Several of them mention the positive effects of two or three meetings in which farmers' views on the general purpose of the rehabilitation of a scheme, as well as their ideas for the detailed design of the tertiary system are taken seriously (Tiffen et al 1987, Makadho 1990). Meijers (1990) gives examples to indicate that the quality of the design, its adaption to the socio-economic situation, can be improved by farmers' participation in decision-making. Even statistical evidence of los Reyes and Lopillo (1988) underlines the positive effects of participation during the design or rehabilitation process of irrigation schemes. Still, participation remains limited and often is only lip-service. It is observed by Vincent (1990), that - although several training manuals already incorporated the key features of success - actual conditions of design or rehabilitation processes still obstruct the implementation of these valid recommendations in which participation plays a key-role. All in all, participation is often seen as a key-factor in the success of irrigation projects, but in practice it does not get the emphasis it deserves.

Members of the workshop *Design for sustainable farmer-managed irrigation schemes in sub-saharan Africa*, recognized the importance of learning processes and participation, stating that "*designing no longer becomes a technical exercise executed by engineers sitting behind their desks, but a process of information exchange, discussion, negotiation and collective decision making ...*" (Ubels and Horst 1993 p98-99). But the result of the workshop with regard to this interactive design process hardly goes beyond calling for practical methods and procedures.

Some engineers have looked for solutions. Damen (1990), for instance, describes a step by step approach for senior staff of the Irrigation and Drainage Branch in Kenya, to ensure that a scheme is created by means of a genuine joint effort of farmers and irrigation staff. In this guideline, not only surveys are planned, but also a considerable number of meetings with farmers and farmers' leaders are discussed in detail. During three meetings, the request meeting, the agreement meeting and the 'handing over' meeting at least 70 percent of the future users have to be present. Each meeting treats different topics. De Fraiture & Scholten (1990) equally recommend a design process that consists of several rounds of discussion and negotiation. Useful tools to facilitate the understanding and consequences of a design issue may be: simplified maps and field visits (Damen 1990), presentation of technical alternatives (Meijers 1992), pegging out traces in the field (Damen 1990, Meijers 1992), scale models (Office de Niger 1990, Scheer 1992) and field trips to other irrigation schemes (Meijers et al 1993). However, experiences with these tools in participatory design processes are not well-documented.

In general, the answer to the question *how* to proceed in a participatory design process remains limited to the idea of sequential meetings with farmers, during which several relevant themes are treated. In this thesis it is this *how*-question that will be elaborated on and receive special attention.

1.3 Indigenous knowledge

It is the irrigation design engineer's 'professional heartland' to identify the physical environment, using knowledge about many different disciplines such as hydrology, topography, meteorology, soil science, soil mechanics, civil engineering and plant science, and subsequently to design a physical infrastructure and method for water distribution on the basis of available water, irrigable area and other physical limitations. The technical design evolves along physical laws and rules of thumb that originate from hydraulics and construction engineering. In this thesis the required knowledge for such a design will be referred to as *technical knowledge*. It is used to attribute meaning to physical phenomena in irrigation schemes.

Knowledge and associated technology are contextual and differ for each individual. The new paradigm recognizes that multiple perspectives on reality exist and any perspective is as valid as any other, even when it may not be regarded as desirable. As a consequence, indigenous knowledge is as valid as 'formal scientific' knowledge. Researchers in the field of applied anthropology (e.g. Chapman 1975, Brokensha et al 1980, Richards 1985, Diemer 1990) showed that Western or urban knowledge should not be overestimated and that the riches and validity of the knowledge of rural people should be higher valued. Haverkort et al (1991) state: *"In any specific case, there are bound to be areas of knowledge and skills which exclusively belong to indigenous knowledge"* (p7). This would imply that design engineers can learn from farmers, even about the disciplines in the depth of 'their' professional heartland: hydraulics, water distribution, topography, design, etc.

In their role of users of irrigation infrastructure, farmers are bound to have knowledge about the physical phenomena in irrigation schemes. It may be attached in a different way to language, may be ordered in a different way or may have other levels of abstraction, but they do have *technical knowledge*. To some extent this is recognized by design engineers. For example, members of the above-mentioned workshop, not only experienced the value of (technical) data provided by farmers, but also concluded that farmers can even discuss technical details of an irrigation design. The importance of these discussions during the design process is also pointed out by many others (los Reyes and Lopillo 1988, Shearer 1987, Vermillion 1989, Vincent 1990). The recognition that farmers are capable of discussing technical issues with design engineers is an important step towards the appreciation of farmers' technical knowledge by design engineers. But it is still not clear to what extent design engineers are prepared to learn from farmers. If a design engineer took the conclusions of applied anthropologists about local knowledge seriously, he or she needs to go one step further and should try to learn from farmers beyond their provision of those data that may be fit merely into his or her technical framework of reference. This is overlooked in irrigation literature and probably a blind spot in the engineers' knowledge.

Technical knowledge of farmers

Literature in which farmers' knowledge, of e.g. hydraulics, hydrology and soil science, receives serious attention is hardly available. In most of their field studies on irrigation, anthropologists see irrigation as a means to understand important principles of rural social organization. In the more 'straightforward' descriptions of irrigation ethnographies the artefacts of irrigation technology may be described (Coward and Levine 1987), but the anthropologists still focus on social perspectives like membership of the board and water distribution regulations and give no clear insight in the technical knowledge on which the design of technical artefacts is based. It would be interesting to find out more about ritualized actions in ancient irrigation systems, because these probably 'hide' technical knowledge (personal communication Vincent, 1994). However, such a study is beyond the scope of this thesis.

In studies by irrigation engineers, the dualism between social and technical aspects may be expressed in terms of irrigation as a social construction (Artifacto '90, 1990); the social nature of irrigation artefacts (Kloezen and Mollinga 1992); the material dimension of social practice (van der Zaag 1993); irrigation technology and the individual agricultural production process (van Bentum, 1995); but their analytic attention to the behaviour of farmers in irrigation systems largely focuses on something that can be described as their *socio-economic knowledge*. Whenever case studies about farmer-managed irrigation give a physical scientific description of the irrigation infrastructure and measurements of water use, they hardly refer to possible differences between technical knowledge of farmers and that of design engineers. Illustrative is a table in Diemer and Slabbers (1991) in which the techniques of farmers and engineers are compared (box 1.3).

Dimensions	Farmers' schemes	Design engineers' schemes
Land		
- owned by the farmer	yes	not often
- owned privately	yes	yes
- owners have one plot	not often	most often
- plots are of equal size	seldom	yes
Crops		
- varying within farm	often	no
- varying within time	often	seldom
Labour		
- entirely used for irrigated agriculture	not often	yes
- irrigation performed by plot owner	not necessarily	yes
- irrigation performed by men	not necessarily	yes
- maintenance organized by the community	often	no
Irrigation allocation		
- based on rights	not often	yes
- supplementary character	often	not often
- simple rotation system	no	yes
- based on soil-water-plant relationships	not often	yes
- fixed water quantity	not often	yes
Regulation		
- based on physical characteristics	no	yes
- partly based on mythical and religious aspects	sometimes	no
- developed by farmers	yes	no
Location of the site		
- natural slope less than seven percent	not necessarily	yes

Box 1.3 Resemblances and differences between the irrigation technique of design engineers and the irrigation technique of farmers (Source: Diemer and Slabbers 1991) (own translation).

The differences in 'techniques' are mainly the result of an unadapted (implicit) design engineers' use of *social and economic* norms, for instance norms about the role of irrigation in the farming system and its adaptation to the social organization. The only explicit difference of *technical* norms in the table concerns the steepness of a natural slope that stills allows for irrigation. Vermillion (1989) recognized criteria of farmers that are explicitly technical, like the combination of irrigation and drainage functions in one canal. Other examples of farmers' technical criteria can be found, for instance in Huibers and Speelman (1990), but they are not elaborated upon. In general, their technical knowledge, beyond the provision of technical data for design engineers, remains a blind spot in literature.

1.4 The central question of this thesis

It is necessary to shed light on two blind spots in the knowledge of design engineers. The first is a lack of consciousness about the probably crucial importance of technical knowledge of farmers. The second concerns the procedures and methods that could be used by design engineers to engage in a participatory design process. I will especially focus on how the two types of technical knowledge can be exchanged, in other words, how farmers and design engineers may learn from each other. Subsequently, insight into the relevance of such exchanged knowledge should be considered critically.

Consequently, four questions can be distinguished:

1 What is the difference between the technical knowledge of design engineers and that of farmers?
2 To what extent do engineers and farmers learn through exchange of technical knowledge, why and how does this exchange take place, and if not why not?
3 What is the effect, of the exchange or non-exchange, on the design?
4 How can the exchange of technical knowledge be optimized?

Location of the research

The field research was carried out during two years in the Senegalese part of the Senegal middle valley. In a practical respect, the department of irrigation, through cooperation with the West Africa Rice Development Association (WARDA), had already collected relevant research material in this area. But also in theoretical respects the valley is an interesting research site: it has been marked by a dynamic irrigation development during the past two decades which has resulted in a range of irrigation design processes and schemes in the middle valley, whereas the area itself is a more or less homogeneous environment.

Chapter 2

SOME INITIAL THEORETICAL PERSPECTIVES

2.1 Introduction

When I left for Senegal in 1989 I wanted to investigate to what extent participation by farmers as well as the use of information by engineers during irrigation design processes influenced objectives such as productivity, stability and equity in the resulting schemes. These would provide me with clues of how design engineers should design. My research focus changed. Right now, I see that the following initial perspectives have determined to a large extent my research:

- I was interested to know how farmers used the physical infrastructure of irrigation schemes and how they regarded it;
- I was focused on what happened on the social interface (Long, 1989) between farmers and design engineers; I was especially interested in the cultural aspects of communication processes at the interface (Oomkes 1989);
- I had a design engineers' background and was armed with their *technical knowledge* as well as practical ideas of some irrigation design engineers, who had tried to implement principles of participation;
- I quickly became action-orientated, because the *Ile à Morphil* project asked me to stimulate farmers in the area to maintain their irrigation schemes.

It was from these initial perspectives that ideas for my thesis evolved. In the course of my field research these became more and more *grounded* in the data that I gathered and analyzed. I 'learned' my way to a more relevant perspective (cf box 2.1). This reminds one of the *grounded theory* (cf Hamilton 1995, p16), a methodology that is grounded in data systematically gathered and analyzed. One important guideline for a researcher who uses this methodology is to periodically step back and ask: "What is going on here? Does what I see fit the reality of the data?". In this way not only the theory, but also the 'reality' of data as well as the applied methodology are tested with each new sequence of 'stepping back' (p17).

On my return to the Netherlands in 1991, I integrated ideas of Bourdieu (1977, 1990, 1991) and Checkland (1988, 1989, 1990) into my study. Elements of their theories seemed highly relevant to the data I had collected. I combined these elements in my own way into one initial perspective, that allowed me to deal with the field material. I 'grounded' the perspective by comparing the 'goodness of fit' with my data. In this way, I continued the learning process after the field research had ended. Of course, this learning process in the Netherlands had to do without the active feedback of Senegalese farmers and was dependant on 'passive feedback' of my field notes. But even this kind of

In december 1990 I had spent 18 months in the valley. During this time I frequently talked and had interviews with farmers. I asked them to explain their water distribution, the maintenance, the operation of their structures, etc. It did not seem difficult to understand what they meant, because they usually talked in terms of examples that could be found in their scheme. They for instance used expressions like '*the pump is tired*' when the water would not easily come to their plot, which seemed on the one hand an adequate way of saying that the water quantity reaching their plot was not enough and on the other hand indicated that the pump should be renewed - a question farmers not seldom ask visitors. I rejected the status of such expressions as facts, and thought of it as some kind of allegory.

In december 1990 I made an overview of my notes on the physical infrastructure and discovered that the pump - mentioned in 160 paragraphs - was frequently linked to other elements of a technical design, especially with maintenance requirements (31%) water distribution (19%) and canal breaches (14%). On rereading the corresponding paragraphs I discovered that the most obvious systematic reason was that farmers seemed to make a connection between the two subjects. On the other hand, I rediscovered what I already knew: Farmers often gave explanations in terms of '*the pump is too strong*' (in the case of canal breaches) or '*the pump is tired* (in the case of a long rotation period) or '*we have to increase the force of the pump to reach the far away plots*' etc.

This led me to the hypothesis that farmers see the power of the pump as a force that somehow pushes the water. I began to see reality with eyes that are unlike design engineers' eyes: Take for instance the way water slowly advances when the pump is started each day, it seems to hesitate when a higher point of the canal bottom is reached and it 'waits' a minute before it continues, it seems to stop and even return when a closed slide is reached, etc. The flow is always accompanied by the distant throbbing of the pump. From then on, I had a new perspective on farmers' words. This is how my search for a farmers' concept of water flow started and it had taken a very long time before I could put my own concept into a broader perspective. In fact, I had been looking for the glasses on my nose. The hypothesis of the pump pushing the water appeared to be too limited, but I had been offered the opportunity to test the farmers' concept of water flow which was so different from the design engineers'. This started my personal learning process.

Box 2.1 Learning my way to new perspectives: The force of the pump

feedback often surprised me and I think that the knowledge that I acquired in this way is relevant for design engineers and farmers who want to 'learn their way' to a viable design.

In this chapter I outline some relevant approaches and theoretical perspectives to tackle the research questions that were identified in the previous chapter. I make an effort to link them in order to come to a theoretical starting-point in this thesis, which is useful to come to grips with the field material. Each of the next four paragraphs of this chapter take one of the four research questions of chapter 1 as a point of departure. In the following sections I make the step from theory to methodology and research techniques. In the final section I will outline the structure of this thesis.

2.2 The cultural dimension of knowledge

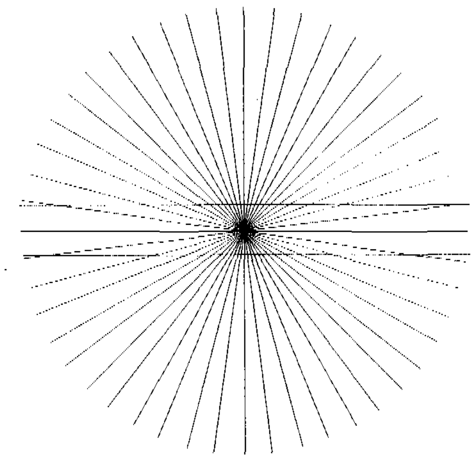
What is the difference between design engineers' and farmers' technical knowledge?

We all have an intuitive feel for what knowledge means. According to Havelock (1986) knowledge is "*the one thing that accumulates among humans, that can be passed from one human to another almost intact (in the best circumstances) and that can be stored from generation to generation or perhaps for an infinity of generations .....*" (p13). According to Checkland (1989), knowledge is used to attribute meaning to what people observe and experience. Design engineers are generally urban based, scientifically educated and often Western. The Senegalese farmers live in rural areas, rely on their practical experience-based knowledge and are African. Indigenous knowledge, in general, is concrete and relies strongly on intuition, historical experience and directly perceivable evidence (Haverkort, 1991). One of the results of this thesis is a specification of the differences between engineers' and farmers' knowledge. Before being able to determine these differences, it is important to be aware of problems that occur when two different types of knowledge are investigated and compared.

Peoples' knowledge is so natural to them that they often forget how it affects their interpretation of reality (box 2.2), but when they meet someone of another culture, they may be confronted with the fact that knowledge has a cultural dimension. If universal standards existed it would be possible to compare farmers' technical knowledge with design engineers' technical knowledge from a 'universal' perspective. But the existence of such standards can be doubted. Cross-cultural research has unmasked many 'universal' criteria as criteria which were in fact ethnocentric. Examples can be found in the search for intelligence standards (cf Koppel 1985). Some people even question the universal character of Aristotelan or modern logic (cf Gellner 1992, p18). Therefore, cross-cultural researchers who try to reveal aspects of other cultures' knowledge necessarily have to deal with the blind spots built in their own knowledge. This renders cross-cultural research extremely delicate. In comparing design engineers' and farmers' knowledge I will have to face similar problems.

Cross-cultural researchers with a relativist perspective, maintain that all cultures are equal, and reality, or the way it is perceived, depends on the specific knowledge of that culture. However, rational reasoning in this sense would obstruct any attempt to compare farmers and design engineers knowledge (cf Haket 1990) and I do not share the above

Our eyes see three parallel lines, but our mind interprets it differently
Comparable processes occur when hearing, feeling, tasting and smelling



Box 2.2 Our interpretation of reality is beyond our control

relativist viewpoint, nor do I pursue universal standards or values, but take the view that heterogeneity of knowledge does not need to be a limitation for a researcher as long as his or her own knowledge will be closely monitored in the ongoing process of trying to understand each other. In the learning process during field work, I was able to move my own technical knowledge horizon slightly towards farmers' technical knowledge, and by comparing this new knowledge with the 'design engineers knowledge' I already possessed, I could distil characteristics of farmers' technical knowledge (cf box 2.1).

2.3 Exchanging knowledge

To what extent do farmers and design engineers exchange technical knowledge and why (not)?

Knowledge can be somehow passed on from one person to the other and when this happens, learning occurs. Learning as an adult takes place consciously (Griffith 1994). Six principles of adult learning can be distinguished:

1) Learning for adults must be problem-centred;
2) Learning for adults must be experience-centred;

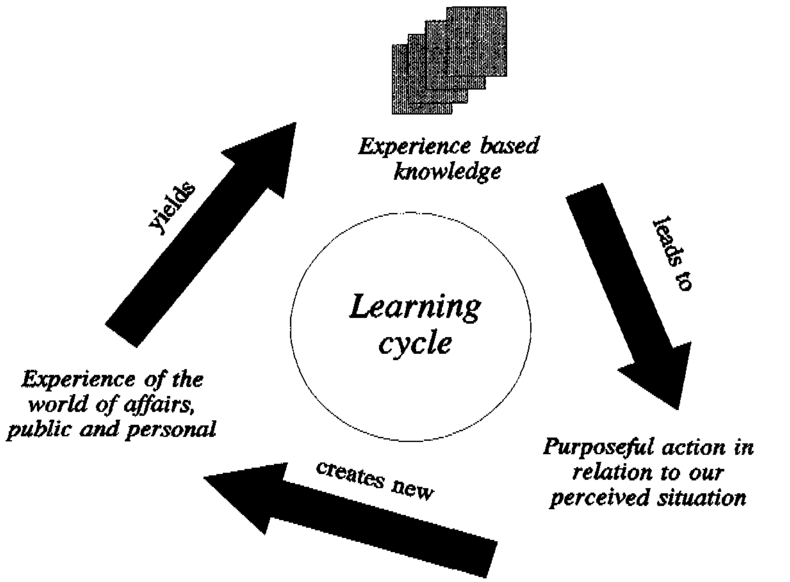
3) The learning experience must be meaningful to the learner;
4) The learner must be free to examine the experience;
5) The goals must be set and the search organized by the learner;
6) The learner must have feedback about progress towards goals.

Adults have an experience-based knowledge and may take purposeful action in relation to a perceived situation. This creates new experience, leading to new knowledge. This learning process can be represented by a learning cycle (box 2.3). However, it would be overoptimistic to assume that people continuously follow learning cycles in the course of their daily lives.

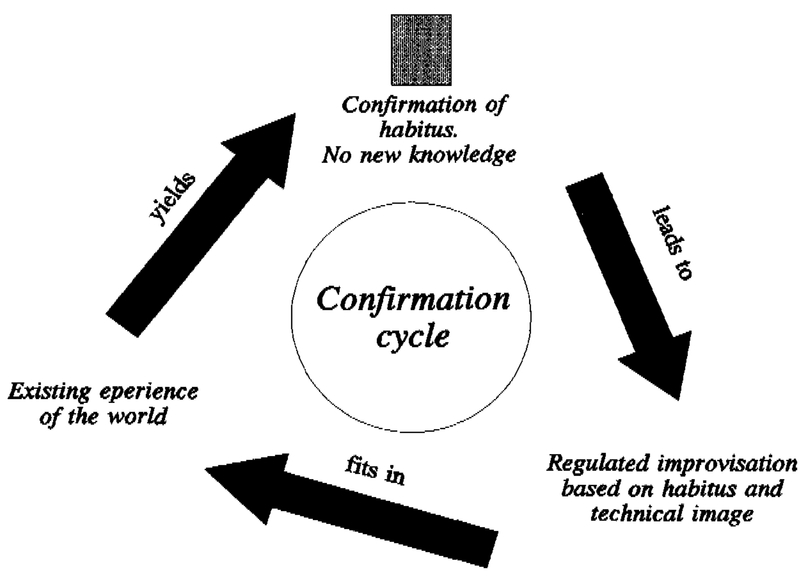
Bourdieu's concept of habitus

I use elements of Bourdieu's theory of practice (1977, 1990, 1991) to explain *why* farmers and design engineers might *not* learn from each others' technical knowledge, because he recognizes cultural differences and explains why people attribute meaning to the world in the way they do and why they act like they do. The theory also offers methodological starting points. According to Bourdieu the individual undergoes a myriad of mundane processes of training and learning and thus acquires a *habitus, "a set of dispositions which incline people to act and react in certain ways"* (1991, p12). These dispositions are ingrained in the body, become second nature and endure throughout the life history of the individual, operating in a way that is *pre-conscious* and hence *"not readily amenable to conscious reflection and modification"* (p13), in other words, a large part of peoples' behaviour remains obscure to them, because they have no conscious mastery over their dispositions. Their unconscious behaviour, however, may be organized *as if* they consciously follow interests, or calculate their chances of success: in the words of Bourdieu, peoples' deeds contain an 'objective intention' which always outruns their conscious intentions. The habitus provides individuals with a *practical sense*, a 'feel for the game' that orients them in acting and responding in the course of their daily lives. It does not limit the number of improvisations of an individual, although it clearly restricts their character: people may improvise in a way analogous to a train, entering new lands by bringing its own rails (cf Ruyer in Bourdieu, 1977, p79).

The habitus is relatively homogeneous for individuals from similar backgrounds, and therefore people who belong to one social group may appear to be collectively orchestrated without being the product of the orchestrating action of a conductor. In this case, the improvisations of people emerge in a situation where the habitus and a social or material environment are easily 'compatible' with one another. Although the habitus reflects the social and material conditions in which it was originally acquired, it is not entirely subjugated to these and people are capable of changing the very environment in which they grew up. When an individual is confronted with an unknown environment, he or she can rely on the habitus as well, because it is capable of generating improvisations and perceptions as long as the new 'objective' situation partly fits the situation as



Box 2.3 A learning cycle (source Checkland 1989)



Box 2.4 A confirmation cycle

expected by the habitus. In this way, people do not engage in a conscious learning cycle, but an unconscious 'confirmation cycle (box 2.4) and the habitus stands for the principle of selective perception of the individual tending to confirm and reinforce - rather then transform itself (Bourdieu 1990, p60-61). This could give a clue about why design engineers and farmers are not consciously aware of the specific qualities of one another's technical knowledge.

Farmers' and design engineers' technical dispositions may be identified as a part of their habitus. These are similar to technical knowledge, but more clearly incorporate motivations and carry the characteristics of habitus. The technical dispositions of design engineers and farmers make up their *technical image.*

2.4 Influence of knowledge exchange on the design outcome

What is the influence of exchange or non-exchange on the quality of the irrigation design?

The first problem one encounters when trying to evaluate irrigation design outcomes, is what the irrigation system is expected to achieve. It has been made clear in chapter 1, that scientists look for more or less objective ways of measuring the sustainability of irrigation systems. But recognizing the fact that no such 'objective' goals exist, one might as well stop the search for the precise definition of a notion such as sustainability. However, the general idea of sustainable irrigation, which suggests an ability to maintain irrigation activities in the face of stress, may well be reached in a process during which new knowledge is socially constructed, for instance when farmers and design engineers together develop a locally adapted irrigation technology. Such social constructions "*are not more or less true, in any absolute sense; rather, they are simply more or less informed and/or sophisticated* (Hamilton 1995, p14).

Having experienced the failure of design methods that simply searched for systems as efficient means to reach some clearly defined goal, Checkland (1988, 1989, 1990) founded and developed the *Soft Systems Methodology (SSM)*. In Checkland's view, a *system* - for instance an irrigation system - is not something that exists in reality, but a certain notion or concept in the minds of people. It is impossible to attach fixed objectives to complex human activity systems, because it is an essential quality of these systems that the objectives are controversial. This is why the questions "*what are the objectives*" and "*what is the system*" are part of *SSM*, a problem solving process.

According to Checkland, a system is a set of mutually related elements, in a way that the set constitutes a whole, which has so called emergent properties that refer to the whole only and are meaningless in terms of the parts that make up the whole. This 'whole' may be able to survive in a changing environment by taking action in response to shocks from the environment. In practice, this means that irrigation systems are only relevant when human activities complement the tangible elements of the irrigation infrastructure. It is essential to regard an irrigation system as a conceptual tool. In other words, one can say: "Until I have a more relevant picture, it is practical to treat these people and those concrete structures, canals and plots *as if it were* a system", but that is very different from declaring that it *is* a system. Depending on one's point of view, an irrigation *system* may serve many goals, although - to most actors - the watering of plants is one of them.

SSM is based on the same principles as grounded theory (Hamilton 1995). It is a learning process. To design engineers, learning may not be enough, but should lead to actions and problem solving through the identification and implementation of a *system* that is relevant with regard to the perceived problems of all actors involved. In *SSM*, the outcome of an irrigation system's design should reflect its *learned relevance* for actors like design engineers, farmers and planners. A system shows learned relevance when it is 'well-informed' with regard to the diverse perspectives off all actors involved. If thus a system were implemented, peoples' expectations of a certain solution are more or less likely to come true. Of course, small differences between expectations and reality can be expected. But when a design engineer is dissatisfied with the practical use of the realised irrigation system, for instance because farmers, in his or her view, do not distribute the water properly or destroy structures, one may become suspicious. In addition, when farmers quickly abandon the irrigation infrastructure after construction or alter it completely, putting a great deal of effort in the changes, then something is wrong with the relevance of the system. If, on top of this, planners' cost-benefit expectations are merely reached, the irrigation system may not be relevant to them either.

In case a complex human activity system (e.g. an irrigation system) lacks learned relevance, its design quality will be low because the outcome is highly unexpected. Sustainability is doubtful under these circumstances and would be highly coincidental. In Soft Systems' thinking sustainability is not some absolute criteria based on ecological carrying capacity or biological diversity, but a characteristic that emerges from a *soft* system, the result of negotiation and agreement (Röling, 1995).

2.5 How to exchange technical knowledge

How to improve the exchange of technical knowledge in the design process: Towards a participatory design.

To answer this '*how*' question, I will use *SSM*. It can be seen as a collaborative approach that alternates analysis with action. Checkland distinguishes two streams of analysis, the logical stream and the cultural stream. While following the logical stream, a relevant system is selected, that may change a situation considered to be problematic by at least one person. The system is carefully defined with regard to its objectives and underlying world view, its beneficiaries or victims, the guides of the process and the constraints outside the system. After its definition, the system is modelled and discussed collaboratively. Based on these discussions, it may be adapted or abandoned. The second stream of analysis is the organized finding out about the context of the intervention, during which the *'myths and meanings'* people attribute to their relationship with others are a central focus, and social and political aspects get attention. The two streams of enquiry interact: The systems' definition should be based on the 'myths and meanings' of the people who are involved, and collaborative discussion about systems' models, in turn, provides clues for the cultural part of the analysis.

In this thesis, participatory design of irrigation systems is regarded as a learning process and participation during the design process is meant to be interactive (Pretty 1994): it involves a joint analysis, action plans and joint decision making. *SSM* can be used to structure this participatory design process. Several elements of this methodology can benefit from the positive learning experiences of *Participatory Rural Analysis (PRA)*, *Rapid Rural Analysis (RRA)* and *Participatory Technology Development (PTD)* (Chambers 1992, Engel et al 1989). All these methods and analyses depart from the importance of local knowledge and use a menu of methods to 'tap' or 'mobilise' it. I will tap more from these fields of knowledge in the third part of this thesis (chapter 14-16), when I discuss the *how*-question.

2.6 What to look for in the field?

Practices and practical logic

As people are not conscious of their technical image, it is not possible to ask them about it directly. Therefore it is necessary to connect people's knowledge to their visible actions. These *practices* obtain an objective intention and should be observed and analyzed to in order to come to grips with the technical images. Besides, people will be able to express a *practical logic*, which is not a logic in the Aristotelan sense, but which is characterized by 'fuzzy concepts' and a loss of rigour for the sake of greater simplicity and generality (Bourdieu 1977, p110). Practical logic is able to organize the totality of peoples' thoughts, perceptions and actions by means of a few principles that may not be compatible with each other in the logical sense, but are practical for the individual because they engender practices that are relevant to his or her environment and can be immediately mastered. Therefore, practical logic also provides useful material for a researcher.

Stuctural environments

Environments may structure the habitus, while at the same time the environment itself is structured by the habitus. Therefore, it is important to link practices and practical logic to the *structural environment* in which people acquired their habitus. By more or less 'objectively' observing this environment, peoples' 'objective intentions', can be deduced as produced by their habitus.

The area where the irrigation infrastructure is laid out is highly appropriate to observe peoples' practices and to deduce their technical images. From the methodological point of view, it is advantageous that the physical infrastructure is so tangible, because it is not only the *structured*, materialized result of the design engineers' practices; it is also the environment that *structures* the practices of farmers by setting the physical 'objective' conditions. Farmers' practices, in their turn, may again *structure* the physical infrastructure, for instance by not maintaining it or by adapting the lay-out of the canals. Consequently, the material outcome of farmers' practices can be traced back to the infrastructure by comparing the original systems' design with the actual irrigation infrastructure. The latter can be regarded as the *hardened history* of relevant practices of farmers and design engineers. The term hardened history is borrowed from Hoogendam (1993).

Van der Zaag (1992, p230) distinguishes three important types of practices that need to be described with regard to the infrastructure: Water distribution, maintenance and management. As irrigation in the research area is farmer-managed, these will mostly be practices of farmers.

Farmers' practices in the environment of the physical infrastructure should not be seen separately from practices in other structural environments. Diemer (1990) shows how important other environments are to the irrigation practice. With regard to non-technical, but relevant farmers' practices, he stresses the need for an irrigation-oriented study about their farming system, the local political system and the local organisation patterns (p219). The conclusions of the workshop held in 1990 indicate that an irrigation-oriented study of the institutional and commercial environment is also relevant to the practices in the irrigation infrastructure (Ubels & Horst 1993, p15).

Design engineers have been studied less than farmers. Their practices during visits to the irrigation infrastructure are of great interest, but they normally operate in a different environment and their design practices take place in offices far away from the physical infrastructure, often closer to (other) planners and donors than to farmers. Their technical dispositions have a professional character, and find much of their roots in the structural environment of formal education.

Social interfaces

Bourdieu might say that farmers acquired their dispositions in an environment which is different from the environment in which design engineers acquired theirs and when they meet, the interaction owes its basic character to the different environments expressing themselves 'objectively' via the habitus - despite numerous improvisations. The question is, whether the concept of Bourdieu leaves space for learning. The *social interface* concept of Long (1989) may be a useful addition. When farmers and design engineers meet one can speak of a *social interface*. Their practices take place at this level as well. Social interactions on interfaces may reveal patterns and structures, but it is stressed that these also have an unexpected emergent nature. Since this thesis treats the exchange of their technical knowledge, social interfaces between design engineers and farmers are obviously important. According to Long, a study of social interfaces should "*aim to bring out the dynamic and emergent character of the interactions taking place and to show how the goals, perceptions, interests and relationships of the various parties may be reshaped as a result of their interaction* (p2). Researchers should also explore how these interactions are affected by, and in turn themselves influence the *life-worlds* that lie beyond the interface itself. The life world concept implies both action and meaning. It is a "*lived in and largely taken for granted world*" (Schutz and Luckman in Long 1989). Van der Zaag (1992) already combined the concept of practices with the social interface concept, but the way I combine the ideas of Bourdieu and Long is my responsibility.

When reading Long (1989) and Bourdieu (1977, 1990, 1991), one finds correspondence but also different accents. Bourdieu, for instance, would probably not speak of an emergent and dynamic character of interactions on social interfaces, but would stress the 'regulated' character of the improvisations when people with different habitus meet. Where Long suggests that bridges can be developed and life-worlds may change in a process of reshaping goals and perceptions, Bourdieu stresses that the interaction between individuals is defined by the *objective structure* of the relationship between the groups they belong to and habitus endures throughout the life-histories of individuals without important changes.

It is beyond the scope of this thesis judge the ideas of Bourdieu or Long and I use their approaches and concepts as tools. The reason why I wish to add elements of the social interface concept is, as van der Zaag (1992, p5) points out, that practices at social interfaces are more dynamic than others. The social interface concept of Long leaves more space for possible conscious learning and it seems plausible to me that interfaces with cross-cultural face-to-face encounters may be places of learning, when situations emerge in which the actors cannot fit a new situation into their previous expectations.

2.7 Research techniques

Farmers' and design engineers' practices were observed by 'participant observation' in the relevant environments and the social interfaces of design engineers and farmers in different design processes. I also listened to design engineers', farmers' and other actors' accounts of the events on this interface. Although Long calls for social network analysis, I mainly focused on relations between design engineers and farmers, and I did not analyze the social relations within the group of design engineers or farmers.

My search for relevant practices was guided in two ways. On the one hand, through the observation of the hardened history, which provided me with questions regarding the history of the social interface. On the other hand, I looked for 'technical' misunderstandings between farmers and design engineers on the social interfaces I observed. Sometimes I, being a design engineer, talking to the farmers myself, became part of the research material. I had the opportunity to learn from my own mistakes and this enabled me to direct my search for situations where farmers and design engineers missed a 'clear' opportunity to learn. I could estimate the importance of confirmation cycles and their effect on the learned relevance of the system. In the second section of this chapter I indicated that all research workers are subjective, but this should not be considered as a weakness when it is consciously taken into account. In the learning process I widened my horizon in dialogues with farmers, not only by asking questions, but also by making clear what I thought about certain things and taking my time to answer their questions. I engaged in similar dialogues with design engineers, extension officers, officials and students of the department of irrigation who were doing field work for their Masters thesis. During these conversations I took notes which I worked out later in the day. I coded the field notes according to my own note book and processed them on personal computer.

I lived the greater half of my two-years' field research period at the project base of the *Ile à Morphil* project. One of the activities of the project was design and implementation of small scale village irrigation systems. I worked at the office - the environment of a Senegalese and a Dutch design engineer.

During the first phases of the research, I lived with my interpreter Alios Diol for six months in two farmers' villages nearby several small scale irrigation schemes (20 ha). Through participant observation, semi-structured and open interviews, I became acquainted with the relevant environments of farmers. I focused on what farmers perceived to be irrigation related problems. Later, I could learn from the experiences of David Nieuwenhuizen and Trea Christoffers, M.Sc. students who lived in the farmers' environment near a 500 ha irrigation scheme as well as from Lot de Fraiture, who was doing research on the women farmers' irrigated gardens in the *Ile à Morphil* project area.

In a second phase, I developed a 'canal maintenance programme' for the project, trying to keep the balance between collaborating with the project and exchanging ideas with the farmers. I worked together with Abdoulaye Lom, my colleague and interpreter. In this phase, my research was oriented towards canal maintenance and four villages were chosen for a pilot program. The small scale village irrigation schemes were diagnosed and surveyed jointly with farmers. Meetings were held to discuss causes and consequences of observed irrigation problems. In this period, a scale model of a village irrigation scheme was designed, constructed and tested with the help of Evert Jan Pierik, a M.Sc. student who was doing his practical year. While developing the maintenance programme, I was a very active participant on a social interface and took care to monitor in my field notes my own as well as the farmers' behaviour.

In a third phase, I did different farmers-design engineers learning experiments by setting the learning conditions myself. I experimented with drawings, adapted maps, the scale model of the irrigation infrastructure and farmer-to-farmer visits.

In the fourth phase, I broadened the research area and visited six other project areas, 21 villages and 47 irrigation schemes or tertiary units (20 ha) within a period of two months. While selecting the projects I took care to include the most progressive communication experiments and a variety of technical concepts - half of the schemes were medium scale (up to 1000 ha) and half of them small scale ($\pm$ 20 ha). I also selected irrigation infrastructures of different ages. All projects were to be found in the Senegalese part of the Senegal middle valley, the territory of *Haalpulaar* farmers. The villages and units within the projects were selected with the help of extension officers on the basis of the farmers' managerial capacity with regard to water distribution, maintenance, external contacts, etc. I took care to include units that were considered to be well-managed, normally-managed and badly managed. Thanks to the illustrator of the *Ile à Morphil* project, I was equipped with well-tested drawings of the farmers' perspective on irrigation related problems. With the help of drawings I conducted semi structured interviews that I developed on the basis of the first three phases. Finally, I made an inventory of the 47 irrigation units in the environment of the physical infrastructure. During these field walks I was usually accompanied by farmers.

2.8 The structure of the thesis

Part I: Initial perspectives

You are now reading the final section of part I, which contains the introduction and theoretical perspectives.

Part II: Environments and practices

The structural environments in which farmers and design engineers acquired their technical images will be outlined in part II of this thesis (chapter 3-7). In chapter 3, the physical and institutional environment will be described. In chapter 4 I describe practices of farmers in the non-technical environments they are familiar with: their households and their villages. In addition, their practices and attitude with regard to external actors are outlined. In chapter 6 the education of design engineers receives attention. Equally, their working-position and their general attitude with regard to farmers' participation are put forward. The chapters 5 and 7 will throw light on practices of farmers and design engineers that directly relate to their technical image: farmers' practices in the environment of the physical infrastructure (management, water distribution and maintenance) and engineers' design practices in the *Senegal* middle valley. Chapter 7 describes the different irrigation design concepts used in the valley.

Apart from historical aspects and background information, this part of the thesis provides the building stones for the answer to the first research question: What is the difference between design engineers' and farmers' technical knowledge?

Part III: Social interfaces, design processes and technical images

In this part (chapter 8-13) I will show what happens when farmers and design engineers leave their familiar environments and meet each other on the social interface. Research question 2 (the exchange of technical knowledge) and 3 (the influence of the exchange on the quality of design) will receive attention.

The choice of project-cases, themes and social interfaces leaves space for a certain variety in technical themes and design processes. On the one hand, several technical themes are dealt with: the technical aspects of site selection (8); irrigation and drainage requirements (9); canal structures (10); topography and earth works (11); water flow (12, 13); and canal maintenance (13). Together with water distribution, which has been researched extensively (cf Huibers & Speelman 1990; Meijers & Mollinga, 1991) and which will be treated in chapter 5, these themes cover the most relevant technical subjects in the *Senegal* middle valley. The sequence of chapters is such that the reader will gradually get a more complete picture of the technical images of farmers and design engineers (research question 1).

On the other hand, I have made certain that a variety of design processes were treated in order to present the broadest possible perspective. Naturally I chose the design processes with the most participatory features. In chapter 8 two projects are described that claim to have participatory elements or orientation towards farmers' conditions. In chapter 9 I discuss the project in which communication between farmers and design engineers was the most developed. In chapter 10 and 13 two typical top-down projects are analyzed. Equally the balance between small-scale village irrigation schemes (20 ha, most often one village; chapter 9, 13) and medium scale irrigation schemes (larger schemes, up to 1000 ha, several villages; chapter 8, 10) was kept. Chapter 11 and 12 are not centred round a single design process.

Part IV: Emerging perspectives, experiments and new perspectives

Where part II and III are analogous to the cultural stream of analysis in *SSM*, part IV (chapters 14-17) will start off with the logical stream of analysis. In this part the fourth research question (How can the exchange of technical knowledge be optimized?) will receive attention. Firstly, in chapter 14, the research question is redefined with reference to the information brought forward in part II and part III. In other words, I define a learning system that is 'grounded in' the data and analysis of part II and part III.

In chapters 15 and 16 my own experiments with the exchange of technical knowledge are discussed. Chapter 15 describes a three dimensional model of a village irrigation scheme. In chapter 16 the use of diagrams, maps, drawings, field visits and a water-levelling instrument receive attention. In this chapter I will refer to *PRA, RRA* and *PTD* as well. The learning experiences of chapter 15 and 16 inspired me to make several models of the learning system of chapter 14.

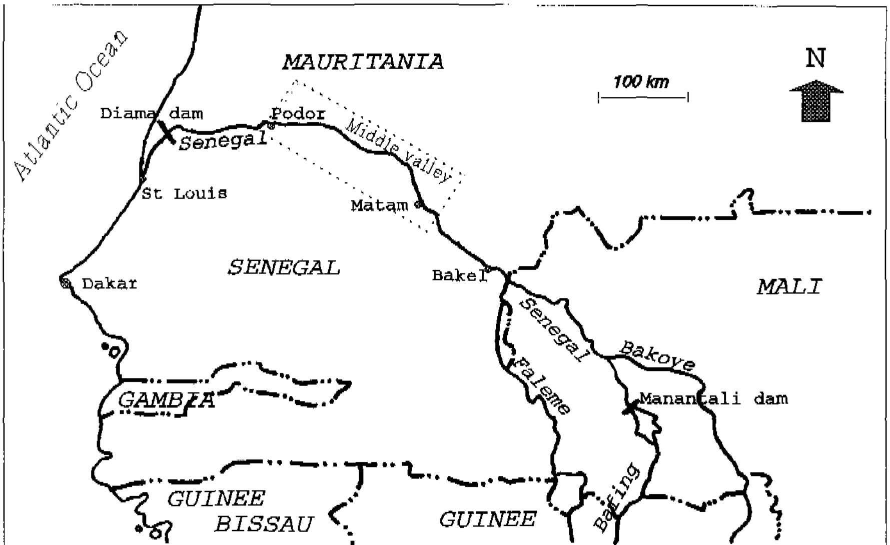
The conclusions of this thesis will be drawn in chapter 16. Not only the research questions will be answered, but also the initial theoretical perspectives and the methodology used will be reflected upon.

PART II

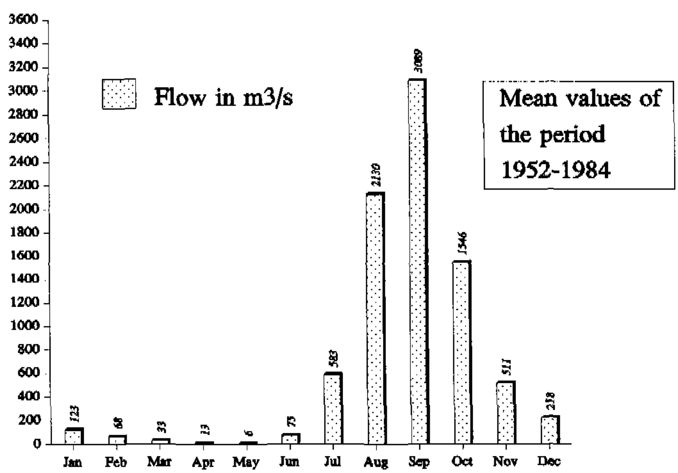
PRACTICES AND ENVIRONMENTS

OF DESIGN ENGINEERS AND FARMERS

IN THE SENEGAL MIDDLE VALLEY



Box 3.1 Senegal and the river Senegal



Source: Euroconsult/RIN (1990)

Box 3.2 The regime of the Senegal throughout the year (near Bakel)

Chapter 3

THE PHYSICAL AND INSTITUTIONAL ENVIRONMENT

3.1 Physical environment

The *Senegal* river receives its name in Mali, where the *Bafing* and the *Bakoye* fuse, not far from the border of the country Senegal. Most of its water springs from the rainforest-covered mountains in tropical Guinee, the *Fouta Djalon*. From here, the water follows its course to the *Sahel* region in the north (see box 3.1). Especially in this region, infamous for its drought periods and food scarcity, the river remains a true vein of life for plants, animals and men.

The decision of Mali, Mauritania and Senegal to control this life-bringing source seemed to be inevitable. The construction of the *Manantali dam*, completed in 1988, would clear the way for irrigation the whole year round, generate hydro-electricity and create continuous navigability. Before the construction of the dam, the river's regime was remarkably irregular throughout the year. Measures near Bakel show that the water flow during the month of may (6 m^3/s), averaged only 0,2 per cent of the september flow (3000 m^3/s) (Box 3.2). Now, this base flow should be at least about 300 m^3/s. Clear figures about what to expect in the future are not available because governments and engineers have not yet decided on the precise strategy to be followed with regard to the management of the dam. One unresolved question is in what way cheap electricity can be optimally combined with year-round irrigation. Another question is whether the loss of traditional floodplain agriculture, depending on the regular overflowing of the river downstream from the dam, should be partly balanced by releasing an artificial flood from the storage reservoir each year. Nevertheless the river surprised many by filling the reservoir quicker than expected. In the case of abundant rainfall in the river's catchment area the dam cannot store all the water and, consequently, it cannot stop the river from overflowing. Although the effect of the dam on the area downstream is not yet fully known, it is clear that it takes more than a dam to tame the river. And so, scarred but not beaten, the *Senegal* continues majestically, gently sloping down, finding the country Senegal on its left bank and Mauritania on its right bank, leaving the upper valley and reaching the middle valley. In this particular area on the Senegalese left bank I conducted my research (see box 3.1).

Here live the *Haalpulaar*, which means: those who speak *Pulaar*. They are sedentary farmers, fishermen and small merchants, each of them benefitting in one way or another from the river's riches. When the river floods in August, the lower parts of the river banks overflow and the flood-plains on both sides of the river get inundated (see box 3.3). Between Matam and Podor the width of the flood-plains averages 25 km. Fish need the calm and nutritious waters in the flood-plain to multiply and fishermen profit by putting their nets in creeks and river-arms. In the flood-plains, called *waalo*, the *Haalpulaar* farmers grow sorghum and *niebe* (beans) after the floodwater has withdrawn. The withdrawal of the water equally permits the cultivation of corn, potatoes and vegetables on the river banks. This cultivation area is called *faalo*.

The rainfall in this area is low and irregular (box 3.4 and 3.5). Rainfed millet is still important near Matam, but loses its significance further downstream in the middle valley, where the *Senegal* almost touches the desert. The agricultural cycle in the middle valley is related to the hydrology of the *Senegal* and the climatic seasons: the short rainy season, the cool dry season and the hot dry season (box 3.6).

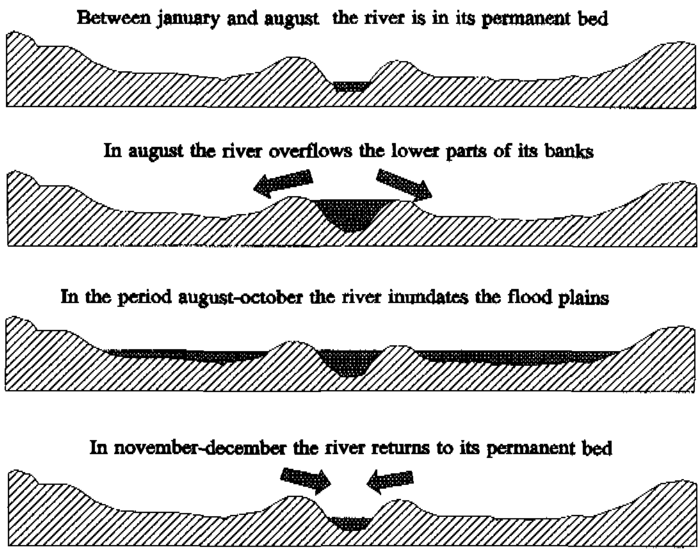
The flooding season starts in august, two months after the beginning of the rainy season. When the river floods, the water reaches such high velocities in its permanent bed, that only course sand particles can be deposited here. As a consequence, one finds sandy soils on the river banks: *fonde* according to the *Haalpulaar*. In the flood plains further away from the river's permanent bed, the water is stilled and here one finds the accumulation of clay sediment. This clay soil is named *hollalde*. The soil type in between *fonde* and *hollalde* is called *faux hollalde*, a combination of *Pulaar* and French: 'false' *hollalde* (see box 3.7).

Downstream from Podor, the river reaches the lower valley, leaving *Haalpulaar* territory. Here live the *Wolof*. The ocean is not far away any more and the climate becomes cooler. Salt intrusion in the end of the hot dry season - when the river was low - was not exceptional here. It even reached the middle valley. But in 1985, in the delta, a dam was constructed to prohibit salt intrusion definitively and to store sweet water for irrigation purposes. Near the coastal town Saint Louis, 1700 kilometres downstream from its source, the *Senegal* flows into the Atlantic Ocean.

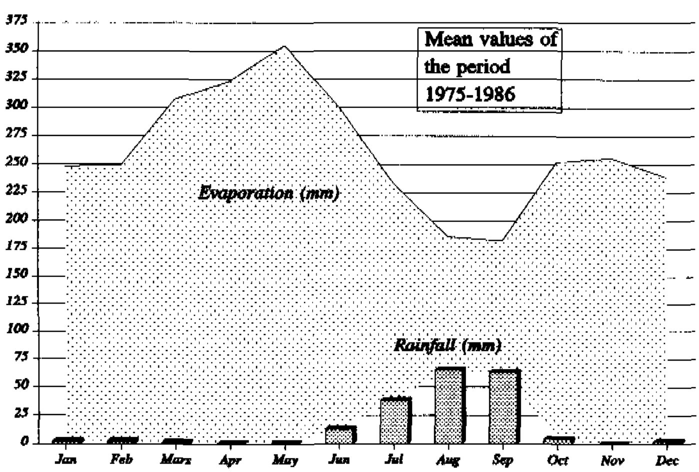
Drought

The notorious drought that started in the seventies (see box 3.8) and the rapid population growth in the middle valley had clear effects on the environment. Where the vegetation used to be more or less dense, savannah-like, with forests along the river, overexploitation and drought have now resulted in scarce vegetation and soil degradation. The few surviving forests have to be protected. Especially near Podor degraded desert-like plains with only dead trees and tree trunks can be occasionally observed. They remind of the more humid period before.

In the drought period also the river floods diminished. As a consequence, the area of the *waalo* cultivation decreased. The reproduction cycle of fish was rigorously hampered and fishermen lost their living. This was a severe blow for the *Haalpulaar* who are fond of eating rice with fish. From then on, they were forced to buy sea-fish from St Louis or



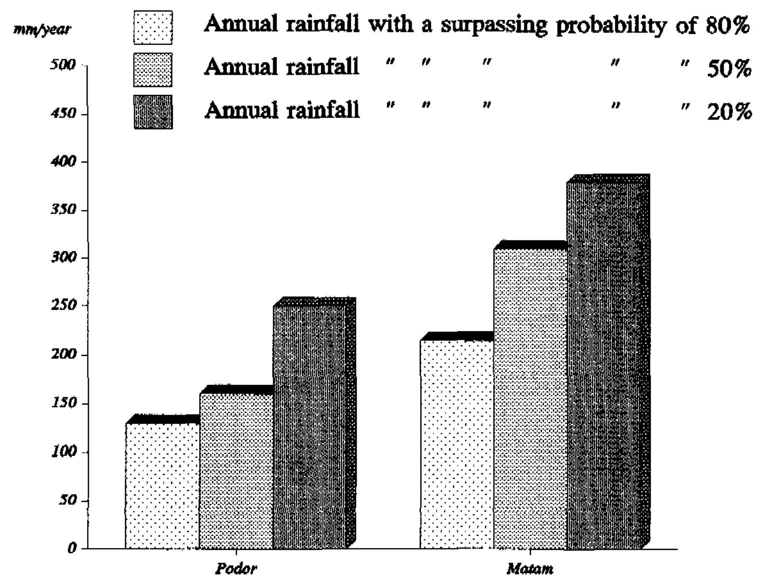
Box 3.3 The process of flooding



Source: AGRER/SCETAGRI (1987)

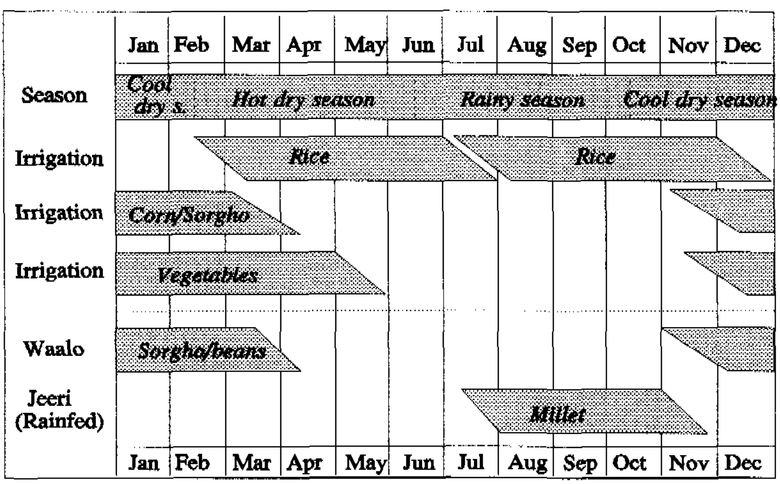
Box 3.4 Rainfall and potential evaporation in the middle valley (Podor)

(The figures are based on the years 1970-1987)

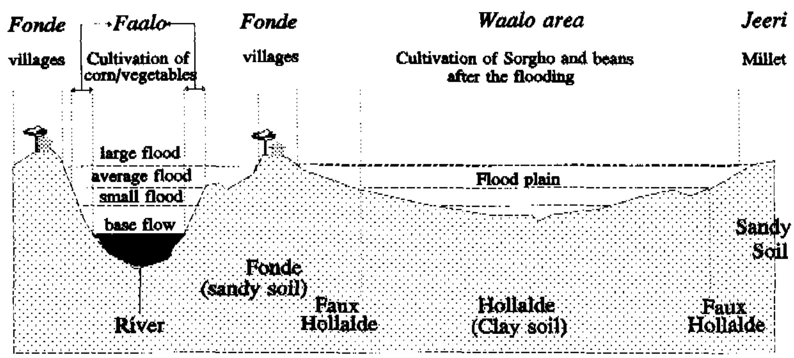


Source: Euroconsult/RIN (1990)

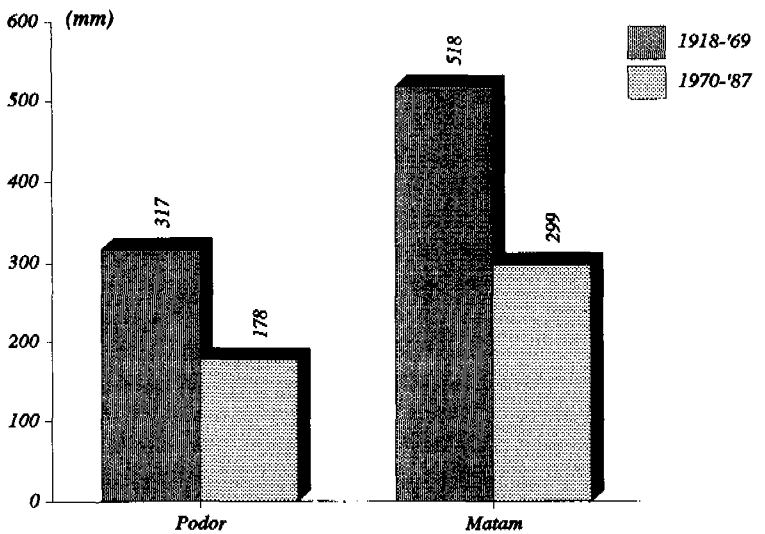
Box 3.5 The variability of rainfall



Box 3.6 Seasonal and agricultural calendar



Box 3.7 Land use and soil types in the middle valley



Source: Euroconsult/RIN 1990

Box 3.8 A comparison of annual rainfall before and after 1969

Dakar. The drought also resulted in a scarcity of grains in the middle valley and made donors willing to put their money in irrigation projects while farmers were induced to assimilate the irrigated agriculture in their way of life - the changing natural environment had caused that the *Haalpulaars'* original *practices* did not suit reality as well as before and somehow new *practices* needed to be developed. As a result, the irrigated area in the middle valley has been growing rapidly since 1974. Nowadays numerous sets of diesel motor-pumps, *Groupe Moto-Pompe (GMP)* in French, float on pontoons on the river and almost every village has one or several village irrigation schemes. These *Périmètres Irrigués Villageois (PIVs)* generally cover 20 hectares and can be found on the river banks near the villages. Recently, larger irrigation systems have been constructed in some floodplains in the middle valley. Their number is still limited, but as we will see in the next paragraph, the government has eager plans to increase it rapidly.

3.2 Turning the valley into a granary, a government's wish

In the centre of Senegal, the groundnut production has been stimulated from the second half of the nineteenth century onwards. Its expansion often took place at the expense of traditional food crops (During and Wester, 1993), forcing Senegal to import rice. To increase the grain production, the French colonists turned their eye to the *Fleuve* area. In 1935 a commission was asked to carry out hydrological, pedological and agronomic research and to make propositions about the construction of irrigation facilities (Diemer, 1990). An experimental farm near Richard Toll, which was to grow into a privately owned sugar-cane plantation (7000 ha), was created in this period. Equally, some experiments with controlled submersion were carried out. By constructing small dikes it was tried to cultivate rice by extending the period of land submersion after the river would withdraw from the floodplain. After the second world war the attention of the colonial regime remained focused on the groundnut production, but they also carried on with their efforts to increase the senegalese rice production with controlled submersion. After Senegal achieved independence in 1960 the agricultural policy remained relatively unchanged. The new regime also acknowledged the huge water potential of the *Senegal* and the *Fleuve* area was seen as a useful granary for the towns and the Groundnut Basin.

But still a lot had to be done before the valley could be transformed into the granary of Senegal. The government made different laws to change the land tenure in the valley. The law on the 'national domain' (*La loi sur le Domaine National*) of 1964 made expropriation of land from its traditional owners possible. The expropriation depended on whether or not the owner made productive use of the lands. The law on Rural Communities (*La loi relative aux Communautes Rurales*) of 1972 was a gesture to the traditional land owners, who were afraid to lose control of their lands. It was decreed that a rural committee (*conseil rural*), composed of elected local people, should decide whether the land was used properly. The formulation of the law is not clear with regard to the definition of 'productive use' and the combination of the two laws creates ambiguities, but it contains the germs of a radical change in the valley (Lavigne-Delville 1991).

The importance of the river's resources was also recognized on the international level. In 1964 the *Senegal* river states Guinea-Conakry, Mali, Mauritania and Senegal signed a convention in which the status of the river was stipulated. In 1972 Mali, Mauritania and Senegal decided to found the *OMVS* (*Organisation pour la Mise en Valeur du fleuve Senegal*), in order to come to a joint management of the river's resources. Apart from the production of electricity and the establishment of all year-round navigation on the river, the *OMVS* had to coordinate the development of irrigated agriculture in the *Senegal* valley. According to plan the construction of the two dams *Manantali* and *Diama* was to allow Senegal to irrigate 240,000 hectares by the year 2030.

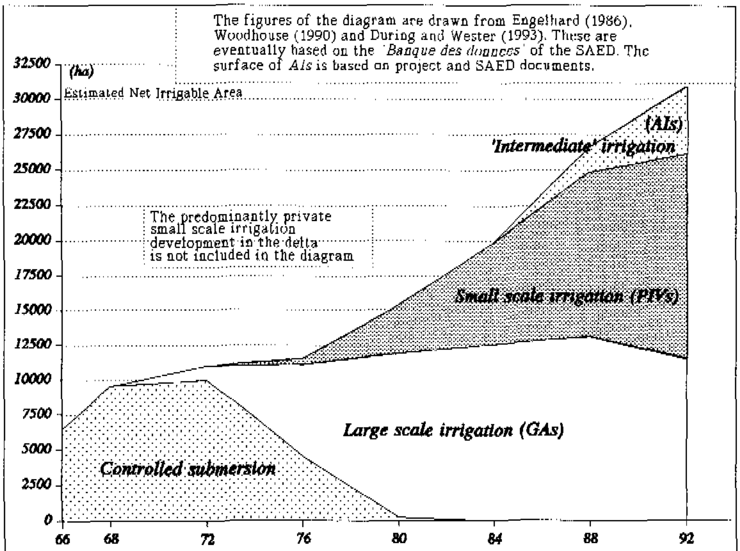
With the announcement of the *Nouvelle Politique Agricole* (New Agricultural Policy) in 1984, the role of the *Fleuve* area as a granary was underlined. A *Plan Cerealier*, which followed from this policy, aimed at eighty percent self-sufficiency in the year 2000. To reach this aim, the government wanted to develop 5000 hectares of irrigated agriculture a year.

Recent irrigation developments in the valley

After Senegal achieved independence, the attention remained focused on the controlled submersion technique for many years. In 1965 the government replaced the existing organisation by the *SAED* (*Societé d'Aménagement et d'Exploitation du Delta*) to guide and implement the construction of irrigation works. By 1972 it became clear to the *SAED* that the controlled submersion technique would not be successful. The concept was abandoned in favour of a concept allowing for water control between intake and plots, by means of pumps, canals and distribution structures. These large scale irrigation schemes were called *Grand Aménagements (GAs)*.

In 1974 the *SAED*'s activities were extended to middle and upper valley. The state-organization's name now stood for *Societé d'Aménagement et d'Exploitation des terres du Delta et de la vallée du Sénégal et de la Faleme*. While the *SAED* was oriented towards *GAs*, most of which were situated in the delta, the news of a successful small scale *FAO* initiative near Matam spread quickly. Many farmers requested such a system for their village. Senghor, the president of the republic of Senegal decreed in 1975 that the development of *PIVs* was to be supported. Surprised by the farmers' insistence on the development of *PIVs*, the *SAED* hastily formed teams of technicians and agronomists to construct them (Diemer 1990). After this, the development of *PIVs* went fast (see box 3.9).

In the beginning of the eighties it became clear that the expensive *GAs* were not successful because the rice production remained far below expectations. Moreover, in the



Box 3.9 Evolution of the irrigated area between 1966 and 1992

mechanisation, operation and maintenance of the *GAs* the *SAED* was heavily involved and had to subsidize *GAs* far more than *PIVs* (Engelhard et al, 1986). The *PIVs* were more successful. The operation and maintenance was done by the farmers, and the production per hectare was surprisingly high: twice as high as in the *GAs*. Besides, the construction costs of *PIVs* were considerably lower per hectare. However, from the government's point of view it was an important handicap that the rice production in the *PIVs* was locally consumed and - in contrast with the *GAs* - did not become available for the towns.

Again, a new concept seemed to offer a way out for the *SAED*: Design engineers came up with an 'in between' concept of an irrigation system. This concept got the name *Aménagement Intermediair (AI)*, intermediate system. It was hoped that this concept could combine the high productivity and farmer management of *PIVs* with the surplus production of *GA's*. The first *AI* in the middle valley was not to be constructed until 1986.

Between 1984 and 1990 the implementation of new irrigation schemes (some 2000 ha/year) progressed slower than expected. In addition, in 1990, 50% of the existing irrigation infrastructure was in a bad condition and needed either improvement or entire reconstruction (GERSAR et al 1990b). Therefore, it remains to be seen whether the ambitious goals of the government will be reached.

3.3 Disengagement of the SAED and turnover of the irrigation systems

Although the *Nouvelle Politique Agricole* was a renewed justification for the *SAED's* existence, it also foresaw in a structural adjustment programme, aiming at a decrease in the state expenditure on agriculture. Consequently, the *SAED* had to begin a programme to terminate many of its activities and to turn these over to private operators and peasant organizations. The role of the *SAED* would have to become coordinative and advisory. The *SAED* went through several reorganizations. It had to face its reduction - many agents were dismissed - and at the same time, a decentralisation had to take place. Extension officers had to change their role from giving purely technical recipes to providing broader messages and supporting the creation of independent farmer organizations.

The continuous threat of being dismissed or removed to another area lasted for several years and created an atmosphere of protest and passive resistance among *SAED* workers. Donors could not count on anticipated *SAED* support and in negotiations on any level the main issues centred around the question: Who pays? In this uncertain and changing situation, a reduction plan did not exist. The *SAED* suddenly stopped credit facilities and pesticide supply without preparing the farmers, which led to a serious yield reduction. Probably the farmers also had difficulties in obtaining fertilizer and fuel (Woodhouse 1990). In addition, in 1991, the *SAED* abruptly dismissed mechanics in the departments of Matam and Podor, informing the farmers only several days before.

By 1991, the organizational capacities of the *SAED* probably did not suit its task, which was huge: the organization had to reorganize substantially while at the same time it had to implement an ambitious irrigation programme in the valley. On top of this, it had to coach farmers in the process of turning over the irrigation infrastructure and its management to the population. The *SAED's* resources were limited and foreign financing was needed to provide a way out.

External funding

The availability of external funding is the principal factor to determine the implementation of the rice policy in the *Fleuve* area (Engelhard et al, 1986). Senegal succeeded in being popular among donor countries and donor organizations. In 1991 Senegal received about 100 USD of development aid per capita. One reason is that Senegal is a member of the *CILSS*, an international organization with Sahel-member states aiming to counteract desertification and starvation in the Sahel. The member states are supposed to implement the *CILSS* policy. Another reason of Senegal's popularity among donors is its good reputation concerning human rights and its political stability.

Donor organizations and countries intervened on the basis of *CILLS* directives. Their strategies differ with regard to farmers' participation, *SAED* involvement, agricultural input level, subsidy level, target groups, specialization etc. There is hardly any co-ordination between the various donors on national and local levels. Many donors are active in the valley. In 1990 at least 8 bilateral or multilateral irrigation projects existed in the Senegalese part of the middle valley. Besides, 47 non governmental organizations *(NGO's)*, equally operating on the river's left bank, were reported by GERSAR et al (1990b). Local *NGOs* are a minority. Of the 23 *NGO's* that are active in the department of Podor and the delta 17 come from Western Europe and the United States. Seven *NGO's* are directly involved in irrigation. Despite the existence of two (!) umbrella organizations, in practice no deliberation takes place in the field. In this chaotic situation, neither the state nor the *SAED* appear to be able or willing to play a coordinative role.

Chapter 4

HAALPULAAR FARMERS, THEIR FOYRES, VILLAGES AND RELATIONS WITH THE OUTSIDE WORLD

4.1 A first acquaintance with the Haalpulaar

Thirty years ago, travelling by boat on the *Senegal* river was the easiest way to visit *Haalpulaar* villages in the middle valley. Nowadays in the *jeeri,* south of the *Senegal,* a tar road exists, connecting St Louis with Bakel. Farmers leaving and visiting their villages and relatives travel by *taxi brousse,* a 'bush taxi'. But in the rainy season and during the flooding period, most villages in the middle valley are difficult to reach. Leaving the road in this period, one faces inundated or muddy tracks and is often forced to roundabout the flood-plains (*waalo*) to reach a village. Sometimes a village can only be reached by *pirogue* (canoe).

The villages are situated on the high parts of the river bank, sufficiently safe from the flooding. Often two types of houses can be found: the older houses made out of banco, and the modern houses made out of bricks and sheet iron. The modern houses are often financed with money that is earned with migration work in Dakar, Nouakchott, Gabon or even France. Each house may be the house of one *foyre,* this is the Haalpulaar word for fire place. People who are member of one *foyre* eat from the same pot. In its most simple form, the *foyre* consists of husband, wife and children. When a man has married more than one wife, all wives and children are part of the same *foyre.* When a son is abroad for a long time, his family may be part of his father's *foyre* (Diemer, 1990). The houses are grouped in compounds, called *galle.* Several *foyres* may be located here. The people who live here are part of one extended family and its members are the descendants of one father or grandfather. The oldest man of the oldest generation in the *galle* is the head of the family. Still bigger family groupings often live in the same part of the village. Small villages consist of 50 *foyres,* large villages count as much as 500, which coincides with about 4000 inhabitants.

The Haalpulaar society is a complex whole originating from different population groups like *Serer, Soninke, Wolof, Malinke* and *Peulh.* Every Haalpulaar village is populated by a variety of classes, castes and categories, settling in the same place in the course of history. The caste of *Pullo* were herdsmen who used the flood-plains for grazing after the flood water had withdrawn. They used to be nomads, but are now often sedentary farmers. The *Toorodo* (nobles), who actively spread the Islam, came later and used the flood-plains (*waalo*) for agricultural purposes, leaving their land for the *Pullo* who grazed their cattle on the sorghum stalks in the dry season. The *Cuballo* were fishermen who used the same flood-plains for fishing and started to use the *faalo* lands for agriculture.

The *Ceddo* were the warriors. Ceddo and Cubalbe started to cultivate *waalo* lands as well. The castes were interdependent, exchanging resources and services, acknowledging the same traditional rights, that developed through violence, magic and probably negotiation. Equally, a caste of artisans arose. They provided services like carpentry, weaving, forging and singing. Finally, a category of slaves existed. Their descendants formed about 22% of the population around 1960. Nowadays, the influence of class and caste differences is declining, but in some cases it may still be important.

4.2 The *foyre*, the Haalpulaar household

Men and women

Although the *foyre* is a unity of consumption, men and women have their own production activities and responsibilities. Men are in charge of the household. They are traditionally responsible for filling the granary. Consequently, when irrigation was introduced, the rice production automatically became the command area of men. Women engage themselves in cooking, growing vegetables and taking care of the children. Although they may have a small income from selling vegetables, they are financially dependant on their husbands and sons. In addition to this, their inheritance rights are greatly limited. Irrigation plots are given to the heads of the foyre. So, women who work in the rice field do this for their husbands who are to decide what to do with it. This marginal economic position of women discords with their important role in agricultural production, not only because their men often work elsewhere, but also because they tend to work harder. However, from a religious perspective, it is considered just that women follow their husbands. Their position is generally not perceived as marginal by the *Haalpulaar* women and men. It seems to be slowly changing. Recently, women get more attention of donors and may possess their own plots in vegetable gardens. They start to organize themselves, but for this they depend on the consent of men (Gaudet, 1988).

Production activities

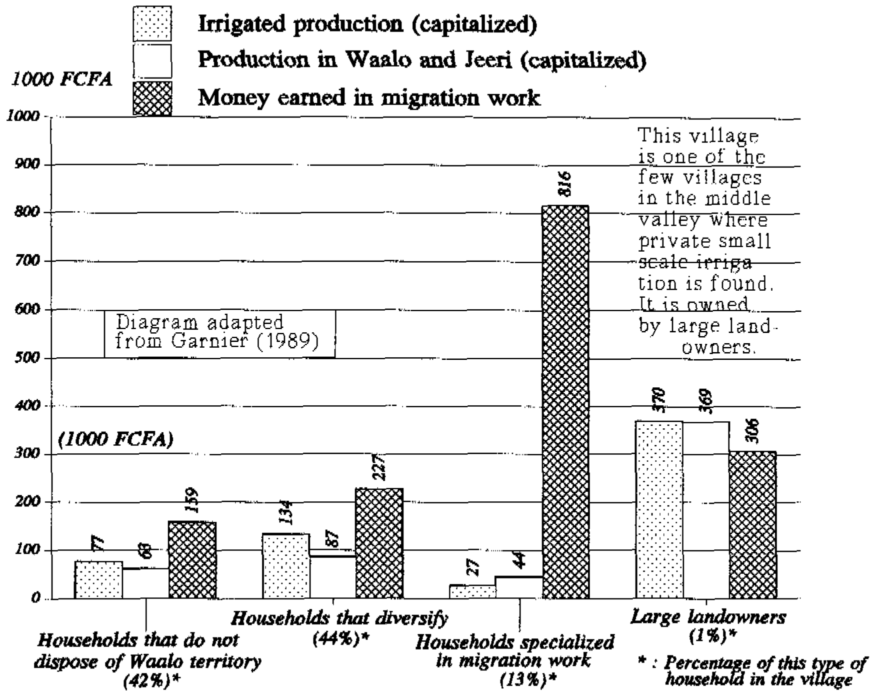
In the middle of the nineteenth century, the Haalpulaar economy was based on agriculture, commerce, home industry and fishing. Migration labour used to be an incidental activity, but became more structural as years went by. While factories evolved in urban areas most of the house-industry activities declined. The recent drought reduced the revenues of fishing. In the same period, irrigated agriculture was introduced and acquired an important place in the household economy. Currently, three vital production activities can be distinguished. Firstly, traditional agriculture (rainfed, *waalo* and *faalo*) plays a significant role in many foyres, supplying grains and beans. The label 'traditional' should therefore not be interpreted as rendered out of date. Secondly, irrigated agriculture supplies grains to the granary, but requires more labour and financial inputs than traditional agriculture. And thirdly, migration work supplies the indispensable cash money to the household economy. The importance of each of these activities varies from one year to another, since traditional agriculture depends on the amount of rainfall and the river's regime. But also the character of households and villages may vary strongly with regard to the significance of each activity (see box 4.1 and 4.2).

For some farmer families, artisan activities or small money making activities are important. Livestock tending is a wide-spread activity and carries a social value, because meat is a must for marriages, baptisms, funerals and religious feasts. But livestock is also used as a capital reserve: in prosperous periods one buys goats or sheep, and when cash money is needed one sells. In between buying and selling the animals may multiply. The activities of the Haalpulaar economy do not aim at a maximal profit, but jointly support a strategy of risk minimization (Engelhard et al 1986, Lavigne-Delville 1991) and the interaction between subsistence and cash-earning activities determines the households dynamics to a large extent (Diemer and Huibers, 1991).

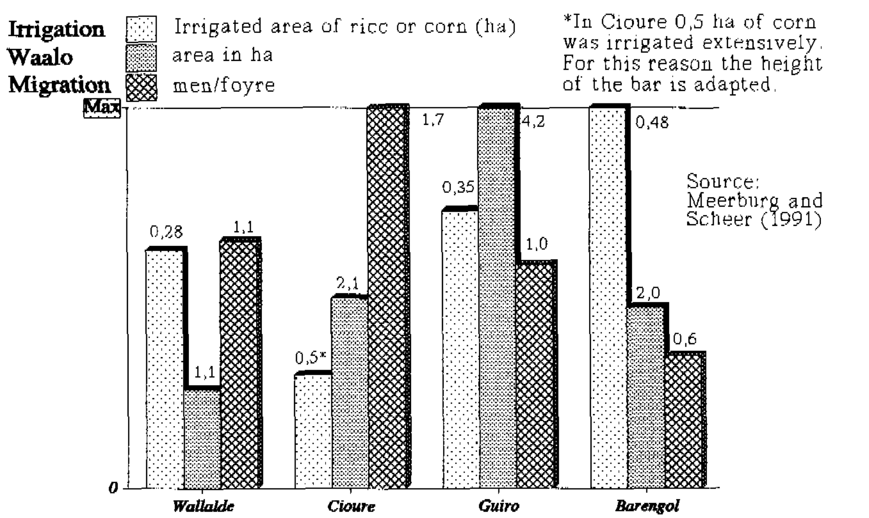
Migration work

To earn money, young men travel to city agglomerations in Senegal or to capitals of other West African countries. They also travel to Western Europe, especially to France. From an individual point of view, they often want to earn money to become more autonomous (Garnier, 1989). But also the *foyre* may stimulate the search for a job, because it needs the cash that is sent home by son or husband. Cash money is often scarce and can be used for buying medicines, clothing, inputs for the irrigated agriculture, sugar, fish, tea, livestock and rice. It is not easy to estimate the importance of the migration income and estimations vary, but all indicate its importance. In Ndoulomadji Dembe (department of Matam), for instance, the average income of the households was 281.000 FCFA/year (about 1200 USD)(Garnier 1989). This is two to three times more than what a farmer with an average plot (some 0,4 ha) would get when he would sell his total rice harvest of one season, the result of a 'full time seasonal job'. In Cascas (department of Podor) the money that reached the households via the post office in 1985 was 65.800 FCFA (Dia and Fall, 1989), but probably even more will have reached the village through returning migrants who bring letters and money from colleague migrants.

The pursuit of work is not easy. It not only depends on having the right contacts, but also on fortune. A lucky few get rich, some find a steady job and others may find seasonal migration work. Unfortunate men, however, cannot do much more than stay with their relatives in urban areas: searching, waiting and hoping. Finally, they often have to return to their home village with nothing to offer. Whether or not the members are successful in finding jobs determines the strategy of the *foyre*. People who benefit from a steady migration income may lease or even give *waalo* and *faalo* lands to other families, but in foyres with less migration income the accent will forcibly remain on agricultural activities (Garnier 1989). The migration labour and the search for it causes a large part of the adult male population to be absent from the village for long periods of time.



Box 4.1 Household categories based on different production activities within one village (Ndoulomadji Dembe, department Matam)



Box 4.2 Differences between villages with respect to the average household

Traditional agriculture

Within the risk spreading economy the traditional agriculture is of great value because it does not require any financial input. Its food crops, sorghum, millet and nutritious melon seeds are eaten during dinner, sometimes with milk. A good harvest, not unusual before the drought period, may last for two years in the granary. Bad years result in no harvest at all. Risk spreading within the traditional agriculture can be realised by combining rainfed agriculture in the *jeeri* with flood-land agriculture, because the amplitude of the flood is independent from the rainfall in the middle valley. However, although every one has access to the spacious *jeeri*, families without access to the smaller and more productive *waalo* and *faalo* lands cannot spread risk in this way. The same is true for Haalpulaar near Podor, where the potential for cultivating in the *jeeri* is very low, due to a lack of rainfall. These *foyres* need other activities to spread risk (cf box 4.1). *Foyres* that dispose of abundant *waalo* and *faalo* are few in number and have an advantageous position because they can increase their stock, leasing their lands to others and subsequently claiming an important part of the harvest.

Irrigated agriculture

Irrigated grain production is a supplement to non-irrigated production. In some villages the schemes' grain production meets over 90% of subsistence needs; in other villages irrigated production contributes only marginally. Such differences are related to alternative opportunities for production that are influenced by climate, topography and access to land (Diemer and Huibers 1991). Irrigated agriculture is risky because, contrary to the traditional agriculture, it requires a financial input. When the crop fails because of grasshoppers, birds, diseases, input supply deficiencies or breakdowns of the *GMP*, the money is lost. But in combination with the other production activities it proved to be risk spreading, because of its independence on rainfall and river flooding.

Before the switch to irrigation, the major part of the migrant money was used to buy grain to meet the households' grain requirements. Today, part of this money is used to meet irrigation expenses (Diemer and Huibers, 1991). The main irrigated crop is rice, of which the harvest is generally not sold, but used by the head of the household to fill his granary. According to Garnier (1989) rice is not sold as long as a *foyre* has liquid money. The reason is simple: If one sells and later on has to buy rice, one buys hardly a third for each kg one has sold before. This unfavourable ratio is partly due to the fact that farmers are obliged to sell low on the parallel market, because of delays in marketing and payment of the official price by the *SAED* (During and Wester, 1993). For a given area, rice cultivation calls for a labour investment that is much higher than is the case with traditional agriculture. It may be four times as high as *waalo* cultivation, but the labour input per kilo of grain seems to be about the same (cf SAED/DGIS/UAW 1988 p23, p37). The ploughing, sowing, irrigating, transplanting and weeding is generally done manually and requires at least 240 man-days per hectare for a season. Labour peaks occur in times of ploughing, transplanting and harvesting. The labour requirements are such, that a plot size of 0,4 hectares is about the maximum for an average household, provided that all men leave migration labour. Variable costs that go with it (fuel, fertiliser, pesticides and herbicides) would be around 30.000 FCFA. If the complete harvest would be sold at the official rate, the head of the *foyre* would get some 120.000 FCFA, so his gain would be 90.000 FCFA.

Households attach to a sufficient rice production, but hard work is avoided, if possible, although a higher labour input seems to be the best thing to do from a pure commercial point of view: in many cases it would raise the production per man-hour (Eychenne 1991). The lack of liquid money and the wish to reduce labour efforts make it understandable that a village often decides to cultivate corn or sorghum during the cool dry season, with a low input of labour and money. This implies that fertilizer and pesticides may not be used at all, and fuel-costs are reduced to a minimum, although these necessarily have to remain relatively high. In such a case, the grain harvest is low, often a third of the average rice crop (Meerburg and Scheer, 1991), but corn and sorghum stalks are gratefully used for the animals.

When the rice production has reached a certain level, a *foyre* may prefer to cultivate other crops than rice, such as tomatoes, onions and cabbage, especially near Podor and Matam. In remote areas women often sell onions and cabbages piece by piece on the local market. But the rapid increase in the cultivated area all over the valley causes prices to drop. As a result, these crops are only commercially interesting for the villages that have good access to towns and the tomato factories near the delta.

4.3 Social and political relations within the village

Dependencies

Diemer (1990) states that the most important distinguishing characteristic in the Haalpulaar society is the degree to which one person is dependant on an other person. The *toorodo* (nobles), *pullo* (herdsmen), *cuballo* (fishermen) and *ceddo* (warriors) are *freeborn* people, whereas the *slave* descendants are seen as dependent. The *artisans* have an in-between position. However, the ideological emphasis the Haalpulaar attribute to these dependencies appears to be less important in the actual relations and, through time, the contrasts between the classes have become smaller. The changing relations can be illustrated with the asymmetric master-slave relationship (box 4.3). Still, most Haalpulaar marry endogamous, within classses and *freeborn* generally possess the political power, especially the *toorodo*. This elite consists of religious leaders, Koran teachers and traditional 'heads of the land'. They often combine these functions with the presidency of the local party-cell and are members of the *conseil rural*. On village level another important distinction is found between men and women. Village politics are the domain of

The decline of the slave-institution started with the penetration of the French into the valley between 1860 and 1880. The emergence of migration labour was a second step in the emancipation process of the slaves. It enabled them to get their own income and they started to buy their freedom, or left the middle valley definitively. The participation of slave descendants in irrigated agriculture is a next phase in the process. The relatively equal division of plots permits them to become economically independent from the *freeborn* without leaving the village (Diemer 1990). But differences still exist. The master-slave relation changed into a patron-client relationship, with the character of an *asymmetrical friendship*, on which Diemer states: "*When he travels, the slave descendant will look after his (freeborn) friends' house, he will praise his name in the company of others, will inform his friend about the plans of his rivals, will repair his fence or house, will mediate for his friend in amorous relations. (......) The freeborn will provide his friend with material for a new boubou, will give him waalo fields to cultivate, will lend him money and grain without asking it back, and will allow him to join the meal. The freeborn may help his friend to solve problems at the ministry of home affairs and assists him for instance to get passports for his sons who wish to migrate (Diemer, p109).*" .. "*Also freeborn women have friendship relations with slave descendants. A woman of slave descent will draw water for her 'friend', will wash her clothes and the clothes of her foyre, will stamp grain, will treat the walls of her house with water resistant clay, will braise her hair, etc. (....) In exchange for these services her freeborn friend will give her material to sew clothes, and grain from her granary.*" (p110, own translation)

Box 4.3 Changing practice: The asymmetric master-slave relationship

men. Women are excluded from important village meetings. Nevertheless, the relation between men and women is dynamic and irrigation may again play a role in the process of change (cf box 4.4).

Landrights and land use

Each of the different freeborn castes settled the land use with the institution of a *jom leydi* (the head of the land). The *jom leydi* has the duty to administer and preserve the land for future generations. He has to deal with the interests of farmers, herdsmen and fishermen. In practice, most freeborn casts have the right of use of certain parts of the waalo land in certain periods of the year. Slave descendants, artisans and politically unimportant freeborn can only cultivate these lands in share cropping (*rem peccen*). Slowly but inevitably, the state becomes involved in the land tenure. As long as it has not been proved that productive use is made of the lands, they are owned by the government and administered by the *conseil rural*, the local council. Its members, elected by the farmers of the area, decide whether the land should be made available for government purposes.

Women farmers themselves often prefer to reply outsiders, when they ask about their irrigation practices: "*Don't ask me, irrigation is a men's business*", even when they actually do have irrigation experience. In this atmosphere, it would not be easy to hand over *PIVs*, or even plots, to women farmers. Such proposals could well be jeopardised by men in village meetings. Still, two engineers in the *Ile à Morphil* project wanted to give attention to women and proposed a concept to the women with which they could irrigate small plots of vegetables by means of watering cans. Watering vegetables in this way was already sometimes done by women near wells or in the *faalo*, near the river. In the proposed irrigation system, the water could be taken out of several concrete reservoirs, receiving water from a subsurface distribution network that was provided by a pump. In the eyes of the designers the advantage for the women would be that they had flexible irrigation turns: They could irrigate any time during the day, whenever their other activities allowed them to. The women agreed to the proposition of the engineers.

The introduction of these vegetable gardens was combined with a course for women on "*how to operate and maintain a pump*". Although many were suspicious - the operation of pumps was the domain of men - some women volunteered for the course and succeeded. Women became accepted pump attendants and were no longer dependant on men for their operation. A small revolution.

Despite the enthusiasm and the motivation of women, the gardens were not successful in many respects (De Fraiture, 1991). It became clear, for instance, that the capacities of the pumps were lower than expected and, as a result, the advantage of flexibility could often not be guaranteed: people often had to wait until the reservoirs - especially the far-off ones - were filled. Women started to ask for their own gravitational systems, something they would probably not have done before their irrigated vegetable-garden experience. Indeed, after four to five years men handed over land to women and the project started to construct gravitational systems for women. Now women own larger plots and even started to grow food crops (corn) and have become not only informally but also formally involved in water distribution.

Box 4.4 Changing practice: men, women and irrigation

The conseil Rural often consists of toorodo. They have to weigh local communal interests and the existing land tenure in their decision. In the ideal case, the *jom leydi*, *conseil rural* and the *SAED* agree about the destination of the lands. In the past, it was relatively easy for the *jom leydi* to hand over lands for the construction of *PIVs* in the interest of the village. In general, as the number of *PIVs* increased and became situated on the better soils, this became more difficult. In the often highly valued waalo territories where the *AIs* will be constructed, problems that stand in the way of consensus are likely to occur: on the site where an *AI* is implemented, land users (fishermen, cultivators, herdsmen) not necessarily originate from the same village. Their traditional rights of use are not always translated into rights of access to the new scheme. Until now, decisions tend to fall in line with the government's wish. According to a *SAED* official the *conseil rural* may be easily convinced by the *SAED* or the state, once high investments are at stake.

The irrigation brought about changes with regard to land tenure, because the *SAED* interfered in the plot distribution, proclaiming that each *foyre* should have equal access to irrigated plots. I checked on the plot repartition in two villages. In the first village I found that the local elite found ways to bypass the SAED regulations, but still the repartition was more or less equal. Some people who could not be present during construction, due to migration work, were able to buy extra plots that were reserved for this purpose. Equally people who participated in the first *PIV* were allowed to get two plots in the new *PIV*, while the few newcomers of other nearby villages only got one plot. In the second village I have not discovered any inequality in the distribution and women who had participated in the construction were allowed to get a plot as well. With regard to the equality of plot distribution, some contrary viewpoints can be found in literature. According to Diemer (1990) and Horowitz et a (1990) the access to irrigated plots is relatively equal for freeborn people and slaves. However, Boda et a (1991) state that the existing inequalities of the Haalpulaar society are reproduced in the repartition of plots in the irrigation schemes. This statement seems to be confirmed by the figures of Garnier (box 4.1). It can be concluded that the equality of plot distribution varies from village to village.

Leadership and Organization

Traditionally the village delegates authority to the head of the village. He always originates from one particular freeborn family, although most other freeborn families influence the decision who will be the village leader. When contacts with the *SAED* or the donor are required, the village leader represents his village. Other *Haalpulaar* organizations are age groups, savings associations and "youth" associations in which people between 15 and 45 years of age take part. Sometimes sister associations of those youth associations exist in Dakar or France. These organizations may occupy themselves with projects in the village, varying from watering tree-seedlings to raising money for building a mosque.

The political and organizational dispositions of the Haalpulaar were useful to fulfil the new irrigation cooperatives' tasks, such as management of the *GMP*, maintenance of canals, water distribution, assurance of inputs, coordination of activities like sowing, transplanting and harvesting and maintaining relations with banks (Diemer 1990; see box 4.5). However, it is remarkable that the irrigation organization is more egalitarian than one would expect from the hierarchical relations in the village. The irrigation organization is horizontal, with a small directing core consisting of two or three persons (Diemer 1990). Large differences exist in the organizational capacity of villages. On the one hand,

- The authority of the collectivity (e.g. a village) is represented by someone to whom the authority is delegated (e.g. the village leader)
- This representative has to be treated respectfully
- Only a special category of the collectivity members can represent the authority
- The authority of a representative can be taken away any moment
- When important decisions have to be taken the representative has to consult informal leaders to jointly formulate a proposal that has to be presented to the collectivity
- No one can ignore decisions that have been made collectively and anyone who disregards them can be fined heavily
- Descendants of slaves have to keep a low profile in the political arena
- Women don't play a role in the political arena
- Treasurers have to be controlled regularly

Box 4.5 Organizational dispositions of the Haalpulaar (Diemer 1990, p99, own translation)

organizational problems occur, often having their roots in rivalry between different influential families of a village. As a result, the village may be divided in two political factions of the government party, called '*tendences politiques*'. Conflicts between these can severely hamper the decision-making of the village. A farmer of such a village complained to me: "*Everything your own tendency says is right, even when its wrong. Everything the other tendency says is wrong, even when its right*" and an extension officer told me about this village: "*The only project for this village is...... two projects*". On the other hand, some villages have strong accepted leaders who play an important role in the development of the village. Due to these clear differences many development workers and design engineers in Senegal tend to blame the organizational capacity of the village, whenever a project that has succeeded in one village, does not succeed in another village.

4.4 Relations with the outside world

In the Haalpulaar society, the political process takes place on village level. The villages are autonomous and do not easily trust leaders of other villages. However, they are dependent on mechanics, input suppliers, banks, transporters, SAED and donors to keep their irrigation systems functioning. The traditional representatives of farmers usually maintain the relations with the outside world. Consequently, these representatives are also the ones who encounter the design engineers. To facilitate the contacts with banks and commercial agents farmers are organized in a juridically prescribed organization, a *GIE*

(*Groupement d'Interet Economique* in French). A *GIE* consists of a president, a vice president, a secretary and a treasurer. Generally they are local elite as well, often elderly men who are supported by young people who can read, write and calculate. Equally, the supportive role of the extension officer is important.

Extension officers live with their families in *SAED* houses in some of the larger villages and have 10 to 30 *PIVs* in their extension zone. For farmers, the extension officer is the *SAED* representative who is easiest to reach. They often ask him to take messages, to transfer demands to the *SAED* office or do them another favour. Being dependent on the farmers in his zone, he will probably try to do this. After all, productivity figures of the extension zones are still used to evaluate an extension officer, so it may depend on his relation with farmers whether they will act according to his extension message. Moreover, farmers who are not satisfied with their extension officer may complain about him to superiors and influential farmers can make life very hard for extension officers. Women extension officers are not common and are always attached to donor programmes or projects. Their activities are generally focused on vegetable farming.

Several extension zones belong to one *SAED* base, where the higher *SAED* officers, like design engineers, animal traction specialists and local *SAED* directors are based. Several expatriate development workers may be stationed here as well, being part of a bilateral or multilateral project. It is interesting for farmers to create or maintain good relations with them, but that is not easy, since a *SAED* base may comprise more than 5.000 farmer families.

Haalpulaar farmers often present themselves as being dependent on government and donors. This behaviour seems to indicate a *dependency* disposition (box 4.6). A history of twenty years of *PIV* construction, improvement programmes, *GMP* gifts and rehabilitation appears to have led to the idea that new projects will always emerge. A regional *SAED* director found that even the most dynamic and best organized villages knocked on the *SAED*'s door for help, even in case of the most simple problems. Lavigne-Delville (1991) refers to farmers using a 'blackmail strategy' by making use of the fact that the *SAED* and donors need the farmers to reach their goals. In this case the farmers' representatives may play political games with the *SAED* and donor, games they often win. However, villagers in Dodel for instance lost 60 hectares because their representatives demanded either a hundred hectares, or nothing at all. Once they settled for the 60 hectares the donor had terminated its activities. In general, the Haalpulaar are smart politicians, a characteristic for which they are known among the Senegalese. The *dependent-* and/or the *blackmail* disposition of the *Haalpulaar* has often paid off. Many examples can be brought up to demonstrate the benefit of having the right relations with *SAED* and donor.

Farmers in the middle valley often asked me for material help. Pumps for irrigation, fences to protect their irrigation system from donkeys and goats, mechanized support for canal maintenance, courses for pump attendants, new irrigation infrastructure, but also medicaments for the medical post, pesticide and herbicide products, etc. As a white design engineer I was sometimes not able to convince that I had nothing to offer. *"Why do you always ask me for help, in spite of my negative answers?"*, I sometimes asked. *"Because you are in the village"*, someone replied. It indicates how normal it is to see foreigners as people who give (material) help. It seems to be beyond discussion.

When I insisted that I had nothing to offer, people might reply: *"You are experienced. We, farmers, we do not know nothing. If someone like you passes by, who wants to cooperate and help* [something I just had denied, S] *we can only be satisfied. If you do not dispose of means, but can only help us with your experience we are grateful as well. You can show us the way. We have told you our problems. As a doctor you can give the solution"*. If people did not ask for help explicitly, they often informed me extensively about their problems.

These 'rituals' happened, whenever I visited a village for the first time, but regularly happened again. On my turn, I found it tempting to do something for them, even if it were only to look up some information. The fact that I could dispose of a car implied that I could help them, which I often did. Once I 'helped' them they would flatter me the next time, saying for instance: *"If it were not for you, we would have been lost, because ......"*. Others might come to me and carried my shoulder bag before I knew it. In presence of others I was praised for my deeds. Some might even lower themselves, comparing their village with *"An empty bag that cannot stand by itself"*.

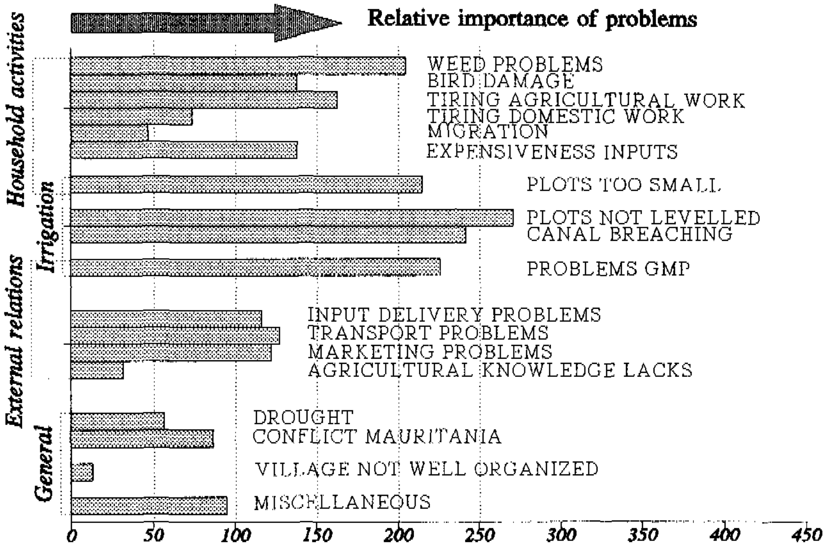
In my view, many Haalpulaar have a tendency to initiate a sort of 'patron-client' relationship (compare box 4.3) with development workers. I often observed the same rituals in the relation between farmers and *SAED* officers. One could state that this is the Haalpulaar 'dependency disposition' at work. One way or the other, farmers like to present themselves as dependent on the project, or the *SAED*. The most indicative statement of a farmer I found, was the reply of a farmer representative during a meeting with a Dutch extension specialist, who asked why the farmers always left the initiative to the project. *"Because we are the children and you are our father"*, he said.

Box 4.6 The *dependency* disposition

4.5 Ranking of problems by farmers

The diagram in box 4.7 indicates how farmers ranked different problems in the order of importance and illustrates the relative importance of problems. Problems related to the irrigation infrastructure receive the highest priority. In my experience, farmers reacted in a frank and natural way when I showed them the drawings that represented their problems. Nevertheless, one has to be very careful with the interpretation of the classification. In the diagram the priority to irrigation is probably overestimated, since farmers knew I was an irrigation engineer. This seems to be confirmed by Horowitz et a (1990), who indicate that irrigation may be less important than other activities of the household. 47 people in one village in Matam were asked why they had abandoned their two *PIVs*. In most of the cases a lack of money (49%), a lack of labour force (43%) or the wish to work elsewhere (34%) were mentioned as the most important reasons for leaving the *PIV*. Plot levelling problems (23%) and bad canals (23%) followed in the sequence. Other causes received less than 10%. On the other hand, these figures of Horowitz et a cannot be simply compared to the diagram, because they concern *PIVs* that have been abandoned. If one considers the fact that the repair of a *GMP* is often the immediate cause to abandon a *PIV* the high percentage attributed to 'lack of money' can be explained. In the case of my interviews, the *PIVs* were still functioning and a lack of money is less relevant. As we have seen, the 'lack of labour' and 'wish to work elsewhere' differs per village and if these factors are important in a particular village, people are more likely to abandon a *PIV*.

Problems related to the activities of the *foyre* received the second priority. With regard to this category it is interesting to note that 'hard work' receives a higher priority than 'lack of money'. 'Tiring domestic work' has no high score, but it is important to note that only four groups consisted of women. To each of these women groups, the tiring domestic work was regarded as a more important problem than the agricultural work. Subjects associated to relations with the outside world were ranked thirdly. A lack of knowledge about cultivation is hardly perceived to be a problem. In general, problems with regard to the village organisation were not mentioned to be a problem, receiving lowest priority. This may very well be a distorted image, since farmers appear not to wash their dirty linen in public: Even villages that are notorious for their tendency problems maintain that they are *"all one"*. Fundamental problems, like the drought, received a low priority, probably because these problems are not easily solvable and therefore taken as a given.



Explanation

After determining, in a first phase, what kind of problems farmers generally saw, these were translated into drawings (See for example some of the boxes in chapter 9). In a second phase I presented these drawings to 42 groups of farmers' representatives, who represented 29 PIVs and 13 UAIs (tertiary units of AIs). In this way I covered 7 projects and 25 villages - 13 in the department of Podor and 12 in the department of Matam (May, June 1991). I asked the groups to give their opinion on the drawings and to classify them in the order of their importance. The cumulative importance of the above diagram is determined by attributing 10 points to the most important problem, 9 points to the second, etc. The least important problems received minimally 1 point.

If the subject of the drawings was not regarded as a problem, it was put aside and no points were attributed. The drawing representing the village organization was put aside in 76% of the cases. The lack of knowledge was considered to be not relevant in 45% of the cases and the input delivery problems in 40% of the cases.

The majority of drawings was selected by more than 80% of the groups. The drought, the bird damage and the weed problems were selected in 100% of the cases. In some cases farmers came up with problems that were not represented by drawings. A drawing was then quickly made and subsequently used in the classification. These problems are represented in the bar 'miscellaneous'. No large categories of problems can be distinguished here. Examples are: disagreements with the project or the SAED, lack of drinking water, health problems.

Box 4.7 Farmers' problem priorities (in 1991)

Chapter 5

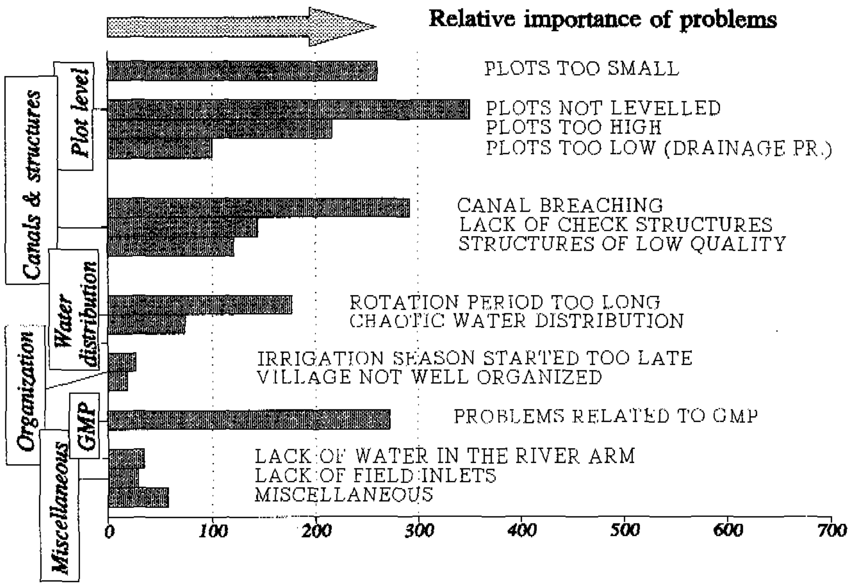
THE HAALPULAAR FARMERS AND THEIR PRACTICES IN IRRIGATION SCHEMES

5.1 The *GMP*: *"The father of the canal"*

These words a farmer attributed to the *GMP*, when it finally functioned again after a four days' breakdown. They reveal how fundamental the *GMP* is for the *PIV*. This delicate piece of technology is the most vulnerable part of the irrigation system and requires competence to operate and maintain it, and a specialist to repair it. The operation and maintenance is executed by a village pump attendant, who has been trained by *SAED* or donor mechanics. Such maintenance is limited to the changing of oil and filters. The skill of the pump attendant is of critical importance for the lifetime of the *GMP*, but whatever his skill is, the moment real defects occur, often once or twice during an irrigation season, villages are totally dependant on external support from mechanics. It may take one or two days to repair the *GMP*, and much longer when special spare parts are needed. In this case, the only chance for a village may be to borrow a *GMP* from the *SAED* or donor. This is often not possible. For these reasons it is not surprising that the *GMP* received high priority in the farmers' problem ranking (box 4.7 and 5.1). A sudden defect of the *GMP* may not only cause a loss of harvest, but may also stop the village from starting a new irrigation season when the required reparation is considered too expensive. Despite the critical role of the *GMP*, the job of pump attendant is often not valued. Frequently he is criticized by his peers and his job is low paid.

The *GMP* is not only vulnerable, but also expensive. Apart from its operation and maintenance, making up more than 50% of the variable costs of cultivation, the repair and depreciation costs would augment the total costs with a same amount (Meerburg and Scheer 1991). Although the *SAED* and donors tried to convince the farmers since long about the importance to save money, they prefer to live by the day (Meerburg and Scheer 1991), and think about a solution only when the *GMP* is defect. This strategy was generally successful and it is probably for this reason that farmers do not want to depreciate the *GMP* but seem to prefer to optimize contacts with *SAED* or donor.

In the technical sense, the *GMP* is a black box to the farmers, but their knowledge of its vulnerability and value has profound implications for their perception of irrigation. As we will see in chapter 9 and 11, frequent expressions like *"the pump is too strong"* or *"the pump is tired"* refer to its central place in the *practical logic* of farmers about water flow.



Explanation

The length of the bars are determined in the same way as before (box 4.7). However, the number of selections in this case was 48 instead of 42, because general problems were often perceived as the same for every one in the village, while this was not the case with regard to irrigation, since one village often has more than one PIV.

The following PIVs, UAIs and villages were visited:

AIs:
Ndoulomadji (Matam) 4 UAIs of Ndoulomadji Dembe; 2 UAIs of Seddo Abbas
Diomandou (Podor) UAIs (men) of 5 villages (Diomandou, Thialaga, Dodel, Diamy Mbaila, Diouwa) and 3 UAIs (women) of Dodel, Thialaga, Diomandou
Donaye/Diatar (Podor) ITs (units) of Donaye and Diatar

PIVs:
Matam: Bow I, II and III; Thialy I, II and III; Sadel VII; Somono; Nguidilone VIII; Navel I, II and III; Ordobore I and III, Ndoulomadji, Diamel III and IV
Podor PIVs of Donaye and Diatar, Mboyo I, II and VI, Diama Alwaly, Guede Ouro I and II, Abdalla I and II, Dioude Diabe I and II, Boki I and II, Fonde Elymane.

Box 5.1 Farmers' problem priorities with regard to irrigation

5.2 Water distribution

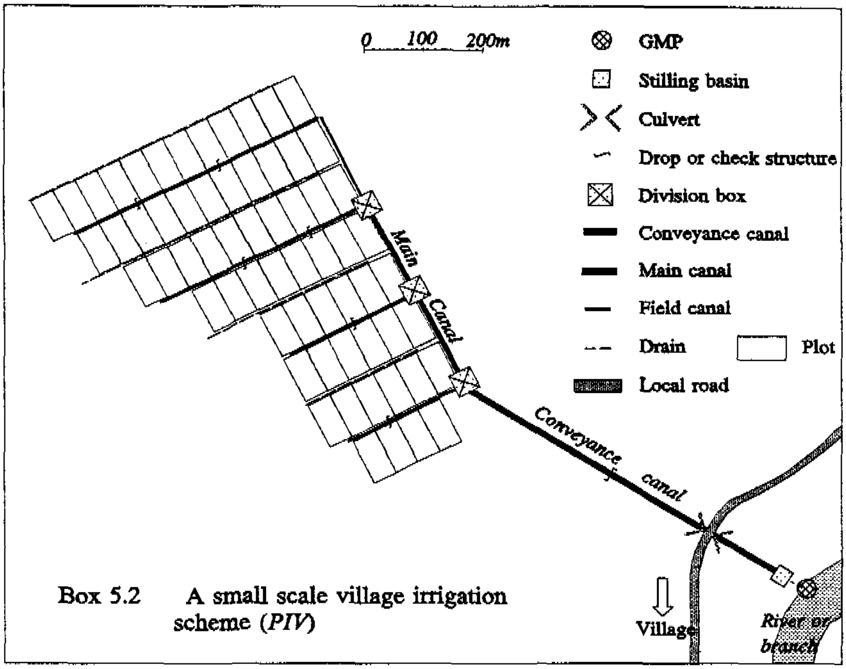
An irrigation day starts when the pump attendant turns on the *GMP*. The water flows in the stilling basin, slowly fills the *conveyance canal* and then reaches the *primary* and *field canal* (see box 5.2). The water flows past several concrete structures that serve to cross roads, diminish erosion risks (drop structures) or distribute and check the water flow. The distribution and check structures can be opened and closed by slides (see box 5.3). It may take one or two hours before the first farmer can start the irrigation of his or her plot. Often two to four plots are irrigated at the same time. The rotation period varies throughout the season, from 8 up to 20 days, depending on the water needs of the farmers. In some *PIVs* with highly pervious soils it may even last up to 30 days.

The *PIVs* in the middle valley are small and simple (box 5.2). Nevertheless, the organization of water distribution requires close collaboration and tuning. The water distribution of the *Haalpulaar* is remarkable (cf Huibers and Speelman 1990, Meijers and Mollinga, 1991). It is efficient and can cope with the inevitable variability of water needs of the farmers, each of them having a plot with its own specific soil, topography and elevation. In general the water distribution passes smoothly and no theft occurs. Farmers generally gave problems relating to the water distribution a low priority (see box 5.1). The basic rule is that every person can take as much water as he or she wants, but only when his or her turn has come. The irrigation sequence is fixed and follows the logic of the geographical positions of plots and canals. The actual water distribution can be regarded as the outcome of communication processes within a constantly changing group of actually irrigating farmers, the *irrigating group*.

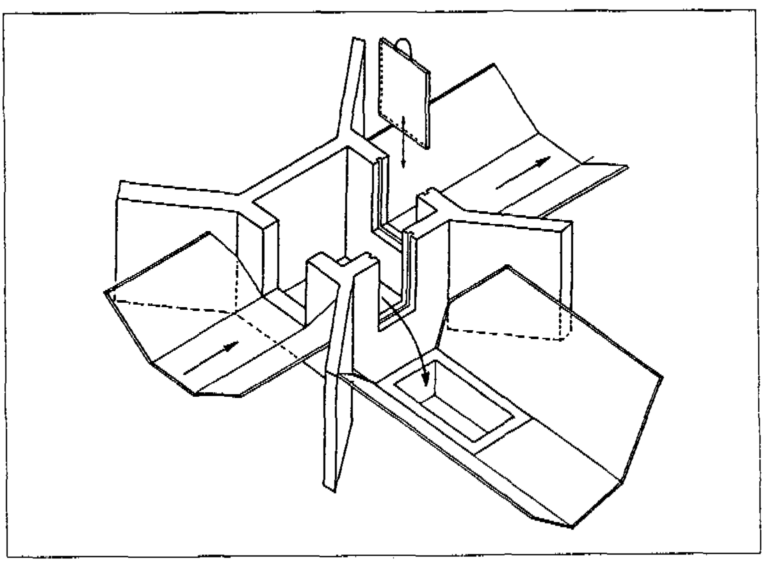
Although the regulating core of the *PIV*, often consisting of the president and the vice president of the *GIE*, has the authority to take strategic decisions, the organization of the water distribution is decentralized (Meijers and Mollinga 1991). The pump attendant, who is always present near the stilling basin, may have an important role in the organization. The water distribution mostly depends on interaction between the actually irrigating farmers and the farmers that are next in the sequence, waiting to irrigate. In the special case that a farmer faces water scarcity he or she can ask the *irrigating group* for an incidental change of the sequence. Most often his or her wish will be granted. If not, he or she may ask the regulating core for help. In accordance with the characteristics of the farming system, these water distribution rules are risk-spreading and enhance the equality between *foyres*.

Irrigation beyond the small scale PIV

In the chapter 7, attention will be given to irrigation infrastructure on a larger scale. These are called *AIs (Aménagements Intermédiaires)* and vary in scale from 30 up to 1000 hectares. With regard to water distribution the most important difference with *PIVs* is the



Box 5.2 A small scale village irrigation scheme (*PIV*)



Box 5.3 Division box (source: Meijers & Mollinga 1991)

extra level of water distribution, a consequence of its larger scale, requiring a different organization. The *UAI*, (*Unité Autonome d'Irrigation*) is the smallest rotation unit of the *AI* and its scale can be compared to a *PIV*. Often, the plot size in the *UAI* is larger and the number of farmers smaller, so the organization within an *UAI* is easy and the water distribution principles are the same. But on the overall level, perhaps fifteen *irrigating groups* operate simultaneously in one *AI*, sharing one primary canal. Another level of communication is needed: communication between villages who are not used to co-operate, and who do not easily recognize the authority of other villages. Not only the water distribution, but also the agricultural planning has to be tuned. This implies that organizational obstacles may come in between the *UAI* and the pump. In most cases, the intaking of a larger or smaller quantity of water by one *UAI* has consequences for the water distribution. For instance when an *UAI* needs a long rotation period due to sandy soils or irregular surfaces its members have to plan and negotiate on other levels instead of acting directly. Equally, when a canal breaches and the intake of water has to be stopped, this may influence the water distribution. Although these problems can be avoided to some extent by adapting the technical design (cf chapter 7), it is not certain whether or not the Haalpulaar are capable of coping with the higher water distribution level. In the *AIs* I observed the organization still depended on the support of the extension officers.

5.3 Maintenance of the canal network

A farmer coming from the village to affirm his irrigation turn may walk along the canals, checking weak spots in the canal bunds in order to see where the water overflows or nearly overflows. Once he belongs to the *irrigating group*, it will be his responsibility to prevent the bunds from breaking and overtopping, but then he may be too busy to notice such problems. When a canal breaches the damage may be considerable; a large gap, requiring time-consuming reparation, may result. In many *PIVs* two or three curative actions a day are no exception. It is not easy to find proper earth (not too wet and not too sandy) nearby to fill the gap. As a result the canal will often be left weaker than before. Avoiding canal breaches requires regular checking of the canals and the fact that canal breaching, as a problem, receives high priority (see box 5.1).

According to the *SAED*, the maintenance of the irrigation infrastructure is the responsibility of farmers and to a researcher who passes by, farmers pay lip service to this. But it may be questioned whether everyone attaches the same meaning to 'maintenance'. When observing their practices, one has to conclude that their perception of maintenance, comes closer to the *curative* than to the *preventive*. This may be an indication that maintenance as design engineers know it, (preserving the system in its original state) is not a known concept to the Haalpulaar. Therefore I will call the maintenance a *curative maintenance*, which, despite its inner contradiction, reflects how farmers look at it. Superficial *preventive* actions are only taken in the beginning of the growing season, when the canals are full of sand. The conveyance and main canal usually are collectively maintained (see box 5.4). In the field canals people do the maintenance in front of their plot. Curative action is taken during the season, which means that farmers only act when problems become acute. In the first generation of *PIVs*, where distribution structures were lacking and the canal bunds are small, the maintenance of canals is in fact automatically done, because farmers constantly use the soil from the canal bottom to secure the bunds. Only in the second generation of *PIVs*, canal siltation becomes apparent.

Before the season starts, the president fixes a day to collectively maintain the *conveyance* and *primary* canal. The maintenance often remains limited to clearing the canal from weeds. Every *foyre* that owns a plot has to send a grown-up man to do the maintenance. People who are too old, are ill or do migration labour are pardoned and women usually do not work in the maintenance either. In principle, others who do not come have to pay a fine. If they refuse to pay they will formally receive no water, but fining *free riders* appears not always to be possible in practice. I observed 6 communal maintenance actions in 4 villages, and I found that the number of people varied from 20 up to 50% of the number of plots. The communal actions often took place during 2 or 3 mornings.

In the *field canals* people are organized on canal level. Generally the plot owner is obliged to do the maintenance in front of his plot. One of the farmers, the *chef de secteur* (head of the sector), controls these actions.

Box 5.4 The organization of canal maintenance

Farmers do not relate maintenance to a long term stability of the *PIV*. When I asked the farmers why the canal maintenance was important, they did not mention long term stability reasons, but always responded in the following sense: 'When we do not maintain properly, there will be a loss of *production*'. Their arguments against a lack of maintenance were:

- It takes too much fuel,
- The water takes longer to reach the plots,
- The rotation period will be longer,
- There will be a loss of water (because of the canal breaches),
- The irrigation will be tiresome, taking a long time for each plot

These explanations are the same as those of the extension officers, which is probably no coincidence. It can be concluded that maintenance is connected to *short term* production rather than to the *long term* stability.

With the above mentioned maintenance standards and the notion of maintenance, some *PIVs* have been functioning for ten to fifteen years, which is in obvious contrast with the badly maintained sophisticated infrastructure in the delta of the *Senegal*. But in some other *PIVs*, laxness resulted in a rapid degradation of the system.

For maintaining the primary and secondary canals of *AIs* machines are indispensable. In general, the maintenance of *UAIs* can be compared to the maintenance of *PIVs*.

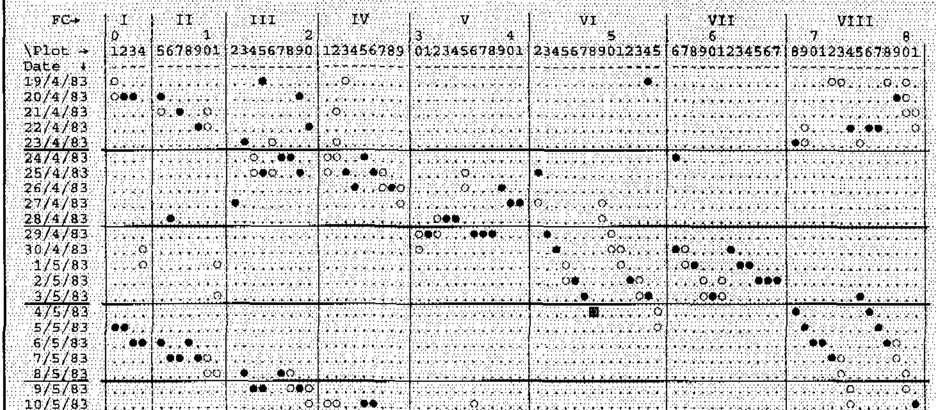
The influence of maintenance practices on water distribution

Around the weak spots that remain after the repair of canal breaches, *practices* of water distribution evolve. It may for instance be the case that, due to former canal breaches, the capacity of some part of the field canal is not sufficient and the entire water quantity cannot pass without causing frequent canal breaches. One way of coping with such a low canal capacity is to diminish the speed of the *GMP*, which may lead to a longer rotation period. The problem can also be solved by only irrigating the plots downstream of the weak spot while upstream plots are irrigated at the same time, because in this way only part of the water quantity passes the weak spot. By increasing the number of canals and/or the number of farmers irrigating simultaneously, problems may be avoided as well. A farmer for instance said *"...whether a canal breaches or not depends on the irrigating group and on the way they irrigate,* [for instance] *do they irrigate with two or five persons at the same time?"*. Generally a lack of maintenance, causing low canal capacities and a high risk of canal breaches, is compensated by changing the pattern of the water distribution. In this way the water distribution, based on simple rules, communication processes and a changing physical situation of the canals, may seem chaotic to a visiting *design engineer*, but a study of box 5.4 will make the reader realize how sophisticated the water distribution may be.

The weak parts in a *PIV* are familiar and may either be found in sandy parts, or in parts that are problematic because of the topographical situation, such as low areas (depressions) or other areas that only allow for small longitudinal canal slope. Canal breaches may also occur in parts where design errors and/or construction errors have been made. Farmers refer to the weak spots as being caused by construction errors or soil problems. If a canal often breaches, farmers may say: *"The GMP is too powerful for the canal"*, indicating that the canal capacity is not proportionate to the *GMP*.

5.4 Irrigating the plot and plot oriented knowledge

In most *PIVs* plot levelling is not done at all, or only superficially. This causes the irrigation to be problematic, because the higher parts are difficult to reach while the lower parts are difficult to drain. The rice plants will not have an equal layer of water, causing part of the plants to suffer from excessive water, while another part may suffer from



○ = Plot partially irrigated
● = Plot totally irrigated
FC = Field canal

Source: Meijers and Mollinga 1991

The *PIV* consists of 8 field canals and 81 plots. The original table (Meijers and Mollinga, 1991) covers the complete irrigation season that lasted from March 6 until July 18 in 1983. The first plot was irrigated between March 6 and June 27, the last plot between March 20 and July 18. In this table, the period between April 19 and May 5 is chosen to illustrate the farmers water distribution practices of a *PIV* in the middle valley. A study of the table reveals the underlying principles of water distribution, as well as its flexibility for the individual user.

A design engineer, paying a short visit to the scheme, might perceive the water distribution as chaotic. April 25, for instance, 10 plots are irrigated in 4 different field canals! Only a longer stay would make him note the orderly character.

Box 5.5 Pattern of water distribution of a *PIV* in the middle valley

drought, especially in the beginning of the season. To compensate for this, farmers may take measures by creating compartments in their plot, but dislike the hard work. Therefore they consider the plot irregularities to be the most important problem (box 5.1). Less important problems were the tiresome irrigation resulting from elevated plots and drainage problems (box 5.1).

The water that reaches a farmer's plot directly affects his own grain production, and although farmers respect the rules of their community they are obviously oriented towards their own plot. Their knowledge of the *PIV* as a whole is limited and only the pump attendant and the president or vice president may have a clear overview. However, every farmer is familiar with the water track between the *GMP* and his plot, the distribution structures that can be found in between, the parts where the water appears to be hampered by obstacles and, of course, the weak spots in the canals. Every one can tell what to do when such a weak spot breaches: closing one slide and opening another, opening field inlets upstream, or, if necessary, the pump attendant has to be told to stop the *GMP* as quickly as possible. But the latter has no quick result. Moreover, if the *GMP* has to be stopped frequently, the rotation period increases considerably.

People directly deal with the members of their *irrigating group*, often plot-owners nearby. They recognize the effect of irrigating with too many (the irrigation will take too long) or with too few (the water level in the canals will rise, causing canal breaches), and act accordingly. The elevation of plots of each member of the *irrigating group* differs, and someone with a lower plot will have a larger water flow towards his or her plot than the other. Other farmers may have a pervious soils and will have to irrigate longer than others, applying a larger quantity of water which will last until their next turn. The *irrigating group* is flexible enough to cope with these individual differences.

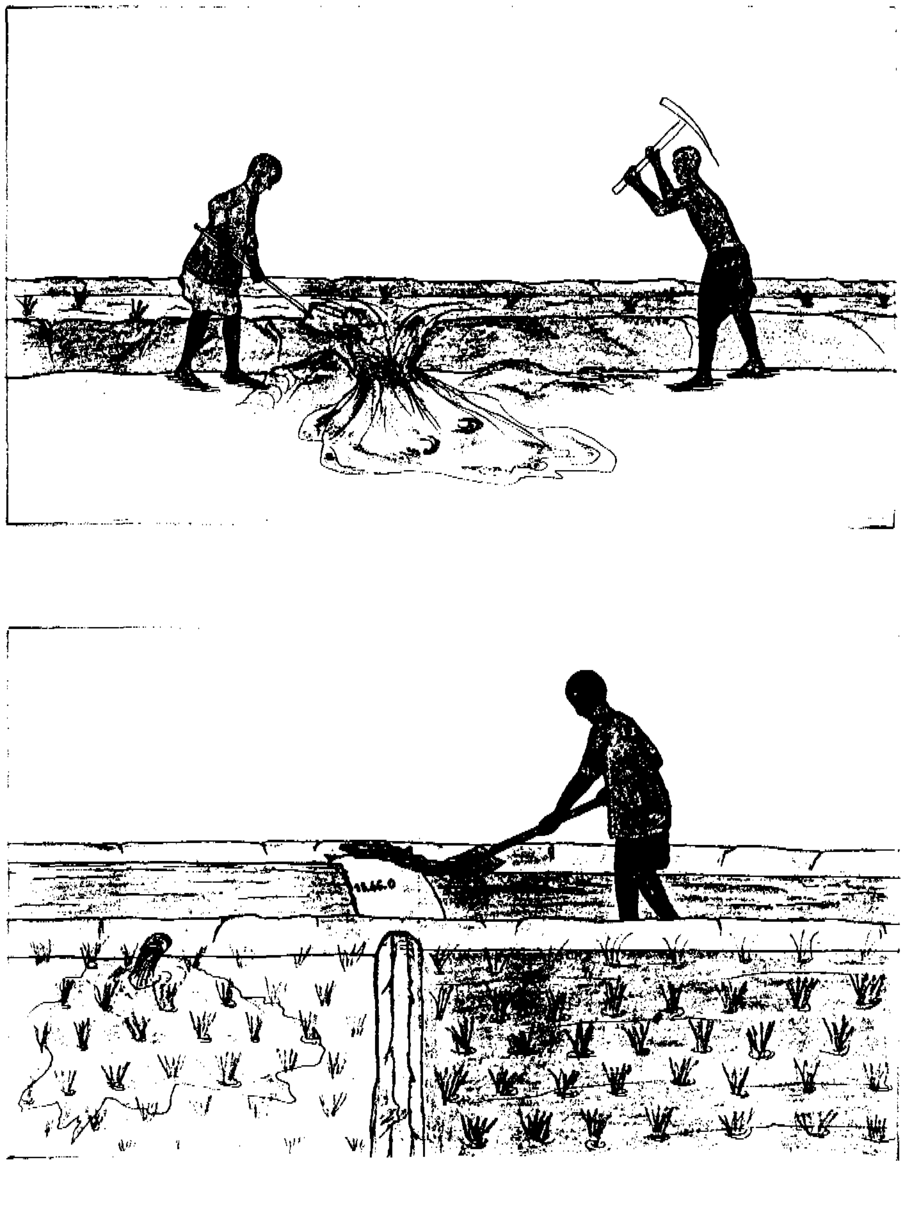
Plots are assigned by lot to an individual owner. In their eyes, Allah has given them their specific plot. This, together with the social rule that any member can take as much water as he or she wants when the turn has come, made it more easy for people to accept a plot with difficult physical qualities, to the extent that they do not change it even if they could, referring to Allah.

5.5 Adaptation of collective practices to the physical environment

It is pointed out that every individual has his or her specific practices. The same holds for every *irrigating group*, composed of communicating individuals. The irrigating group has collective practices, that are always adapted to the specific areas in the scheme where the group 'belongs'. As the composition of the irrigating group slowly changes with each member that stops or starts to irrigate, the nature of the collective practices changes as well. Some groups have to deal with drainage problems, whereas others have to face sandy soils. This does not alter the fact that some practices are more or less 'universal' in the scheme. Over a period of 15 years, starting with some basic rules, the community, as a whole, went through an impressive learning process during which the most important new practices sublimated into rules. Most of the rules have been drawn up by the farmers and are the outcome of discussions in a general assembly of the village. But the fixed nature of rules is constantly compensated with the flexibility of the practices, most of which are not put down in rules, but have grown into habits. The learning process and the emerging technical knowledge is dynamic and well adapted to the local physical environment.

5.6 Adapting the irrigation infrastructure

Farmers often complain about construction errors and in many cases they are right, because these are common in the *Senegal* valley (Boda et a 1990). In the case of a poor quality of a scheme, farmers may start to look for solutions within the *irrigating group* and the community. But often they start the problem solving process by asking for *SAED* support. If they do not succeed, farmers have to improve the physical qualities of their *PIV* themselves. They may adapt the system by removing or building structures. They may also improve the system by lining erosive stretches or constructing field-inlets. The most radical modification is effectively changing the design by lengthening, diverting and creating field canals, which results in new plots and structures. Before implementing a design, farmers discuss what they will do. After implementation it may appear that the result is not what they expected, e.g. the slope in a new canal is too steep, or the plots appear to be too elevated. Learning from the direct feedback, they may think of other ways to solve their problem. In this way, they design by trial and error, proceeding carefully. The adaptations they apply to the scheme can be seen as a tangible response of farmers to the design of engineers. In some cases, design engineers react on the changes of farmers (see part III). In other words, the *hardened history* of a *PIV* reflects a specific 'communication process' between design engineers and farmers: whether they are conscious about it or not, they communicate through infrastructure.



Box 5.6 Two examples of drawings I used when discussing with farmers. The first (above) shows canal breaching, the second represents a lack of concrete check structures.

Chapter 6

THE DESIGN ENGINEERS' EDUCATION AND POSITION

6.1 Introduction

Irrigation design engineers originate from different countries and cultures. In that sense, they cannot be considered as a group with a similar background, like the Haalpulaar farmers. It can be questioned whether all design engineers have a similar habitus and whether differences between them can be reduced to '*only a matter of personal style*'.

When we consider their knowledge on hydraulics, hydrology, soil mechanics, agronomy and the like, the answer to this question may be positive. They certainly share a common sense. "*Water flow cannot be opposite the laws of gravity, can it?*" is 'common sense' to design engineers and part of their practical logic. Checkland (1989) gives the following description of how design engineers make sense of their world: "........... *A specification is produced which gives a careful description of something which is required, whether a physical object (for example, a particular kind of valve or oil rig) or a complex system (for example, a petrochemical complex). The professional skill of the engineer is then used to meet the specification in the most efficient, economic and elegant way. Finally the finished object or system has to be described - often in 'manuals' - in ways which enable others to use it*" (Checkland 1989, p273). Engineering is applied science and generally irrigation design engineers are inclined to give solutions for certain problems. Their question is: "*How* are we going to do it". In other words, design engineers occupy themselves with future situations. Maybe for this reason, they like to use maps and to often can be seen drawing maps, even in the sand when they have to, because maps make the future present (cf Wood 1992). These characteristics of design engineers indicate that they share certain dispositions, originating from their similar technical education.

Another homogeneity in the conditions of existence of engineers can be found in their working environment. Contrary to most farmers, the position of design engineers is close to (other) planners in government and donor institutions. They depend on these institutions for their income and their career. Farmers are no part of the design engineers structural environment. Besides, no design engineer in the middle valley has a Haalpulaar farmers' background. But because they know that their product, the irrigation scheme, will be used by farmers, their ideas about them are relevant.

In this chapter, the education (6.2) and the position (6.3) of design engineers will receive attention. Subsequently, I will describe their attitude towards farmers (6.4).

6.2 The education of design engineers

Physical and social dimensions of the irrigation system

Traditionally, the irrigation infrastructure evolves by means of a design: a whole of plans, drawings, calculations and analysis, integrating the knowledge and skills of a large number of disciplines. These disciplines mainly originate from civil engineering and agronomy. The design of canals and structures is based on theories and empirical data from the fields of civil engineering, hydraulics, hydrology, construction engineering and soil mechanics. Characteristics of water use on farm level are covered by disciplines like soil science, soil physics, soil-hydrology and plant science. In the process of designing, considerations on efficiency and economical considerations have an important role (Horst, 1992, p2, own translation). This 'traditional' design is the professional heartland of irrigation design engineers. Often, social and economical subjects are part of their education, but these subjects have no central role. The *irrigation system* is a key-notion in their training, because it is through this system (system in the broad sense) that a design engineer may hope to contribute to society.

A design engineer creates a design with the building-stones of other disciplines and, in this sense, he or she has no important 'own' discipline. For this reason, the profession has interdisciplinary aspects (Horst, 1992). It is beyond doubt that the design of irrigation schemes has non-technical dimensions as well. Exclusively designing from a technical perspective would imply that certain social, economical, cultural and other wishes, demands or constraints are known or - more often - presupposed (Ubels ed. 1990). An irrigation system can only be sustainable when non-technical perspectives are also taken into account so that the system not only is technically consistent, but also acceptable from social, economic and other viewpoints. But this thesis focuses on the technical dimension of the design. In such a *technical design* a system is developed with which it is physically possible for users to adequately supply crops with water.

Education on irrigation design

Although educations at other universities or schools are not particularly studied in this thesis, the author's observation of design engineers' practices in the *Senegal* valley indicate that the technical part of the education at the Wageningen Agricultural University (*WAU*) can be easily compared to other educations. This part of the education starts by treating basic subjects such as plant water requirements, hydraulics, hydrology, soil science and - mechanics, field irrigation methods, land surveying, etc. Equipped with this basic knowledge and a topographical map, a chart of soil characteristics, climatological data, a known water source, some technical handbooks and assumptions about socio-economic as well as other constraints and demands, the technical design procedure can start. According to the anthropologist, who works now for over 10 years at the department of irrigation in Wageningen, the typical design assignment is to conceive a certain area for the irrigation of rice, sugar cane, tomatoes or cotton. "*In the assignment one focuses on the physical qualities of the location (.....) and combines it with the physical qualities of the crop or crops like the evapotranspiration and the root depth. With the crop choice or the crop calendar as a given the designer calculates the water requirements from which he determines the maximal water requirements that prevail in the agricultural season. Subsequently he designs a network of canals, with which the crop water requirements can be matched.*" (Diemer 1990, p5, own translation)

The design procedure requires skill and, according to Meijer, a technical engineer and former teacher at the *WAU*, generally follows the same principles, regardless of social, economic or other dimensions. It can be explained by using Meijer's three-step model in technical design (Meijer 1989).

According to Meijer, a designer may start to design at the field level (the first step of the procedure). At this level, he or she determines the irrigation requirements of farms, usually calculating the crop water requirements from agronomic, climatological and pedological data. Then a certain irrigation method is chosen depending on crop, topography and soil. Usually a rotation period is established between a group of farmers. The water volume depends on the size of the plot and the irrigation time. In Wageningen it is preferred to situate relatively small rotation groups in one physical, so called tertiary unit. In each tertiary unit a certain volume of water is received and distributed among the farmers of the unit. They are supposed to irrigate in a fixed sequence and the size of the unit can be calculated, depending on rotation and water delivery characteristics.

Subsequently, the attention is shifted from the field level towards the primary level and the water source of the irrigation system (the second step in the procedure). The water availability is known or can be determined from hydrological data. Then, the type and position of the water source or intake is chosen and decisions about the scale and the location of the scheme are taken. Before drawing the preliminary outlook of the lay out, the contour lines of the topographical map are interpreted. The highest parts of the land are reached by irrigation canals. The lowest parts are connected by drains. The required capacity of drains is calculated from rainfall and run-off data. Most often, the drains require a higher capacity than irrigation canals and require more earthwork. Since the amount of earthwork has a strong impact on the construction costs, the depressions determine the rough outlook of the lay-out.

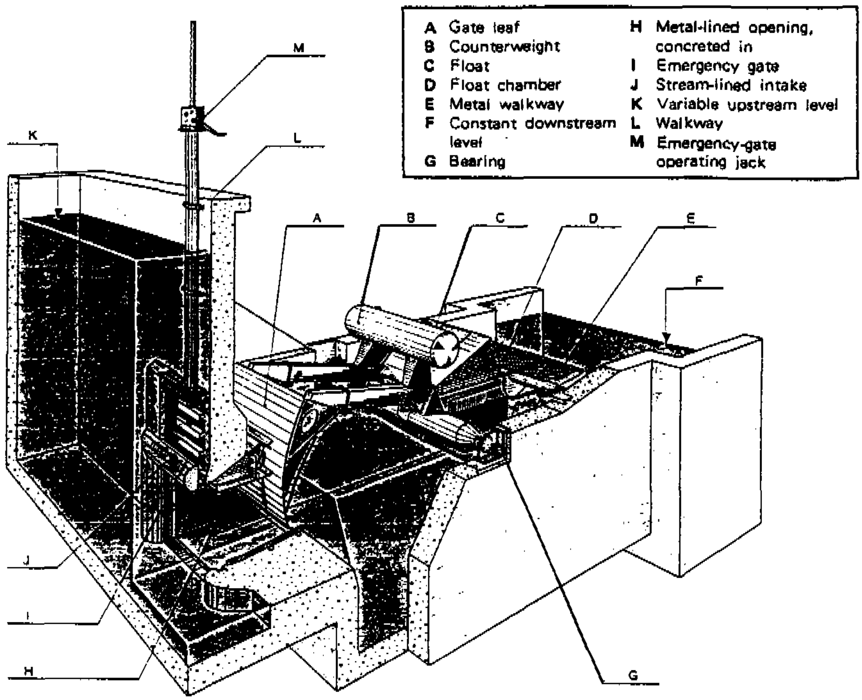
The first step and the second step of the process lead to different perspectives which are often conflicting. A third step is needed in the procedure to make them compatible. In simple terms, the design engineer has to connect the two perspectives by designing canals and structures in between. The tertiary units are fitted in between secondary and primary canals. Between the intake and the plot, gravity- and hydraulic laws have to be respected when calculating the water levels in all parts of the system. The right structures should to be chosen, because structures determine the conditions for water distribution and have their own specific influence on the downstream and upstream water level. Not only do these distribute the water, they also regulate the water flow velocity and the water levels in the canals. These water levels should be sufficiently elevated to create the required water head for the highest cultivation areas. When the outcome of 'fitting' the field level to the primary level and the water source leads to unrealistic or too expensive solutions, the first two steps are to be reconsidered. The three-step procedure is repeated several times, until a satisfactory final plan is achieved (Meijer 1990). This iterative process is the most creative and difficult part of the technical design process.

Finally, design engineers may describe the operation and maintenance requirements of the scheme in manuals. Equally, a plan for the rotation sequence and the irrigation period may be made, informing the farmers or the extension officers when to irrigate. The planned water level allows for the smooth irrigation of even the highest plot. Maintenance is crucial to keep the system in its original state. A proper maintenance keeps the water level within the required limits and guarantees that the water distribution can remain as planned.

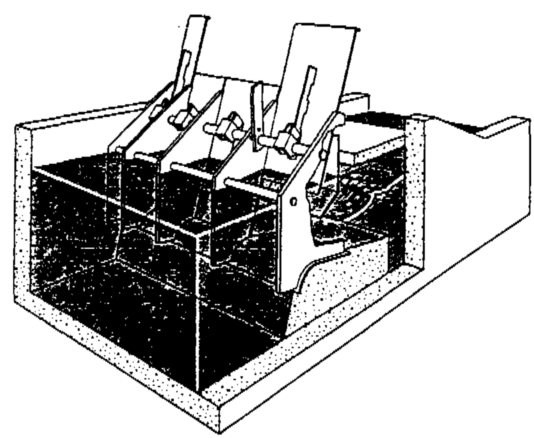
In the process of designing, handbooks are commonly used by design engineers to calculate crop-water requirements, to determine the optimal plot design and irrigation methods, to choose distribution, regulation and other structures, to select the appropriate canal roughness factor, maximum and minimum flow rates, etc.

Irrigation schools

Different irrigation *'schools'* of design engineers can be distinguished. These originated in the colonial period, but still persist. Consultants from these former colonial powers are active in the developing countries and are still applying designs of their own "*school*" (Horst 1983). In Wageningen, for instance, it is preferred that the water distribution is surveyable, easy to understand and easy to operate by farmers. Fixed diversion weirs that cannot be manipulated and elementary structures that can either be opened or closed are promoted (cf box 5.3). The *PIV* concept can be considered as an example that would fit this school. Another irrigation school has French origins and prefers more sophisticated solutions. This school prefers a system where flows are regulated automatically when water levels in the canal change (see box 6.1). When they are properly maintained and operated, these downstream control structures raise flexibility downstream and tertiary units become more autonomous. Small irrigation units receive water through "*modules à masque*": structures with several slides to regulate the volume of water (box 6.2). The *GA* concepts in the *Senegal* delta are an example of the French school. Many Senegalese design engineers had French teachers, and French handbooks are frequently used. The sophisticated structures used are theoretically more efficient than simple structures. But supporters of the simple structures suppose that the sophisticated structures are practically not so efficient. Although design engineers of different *schools* may quarrel about different solutions and options, the core part of the design process is the same.



Box 6.1 Lay-out of a downstream control structure (source Neyrtec (undated [a]))



Box 6.2 *Module a masque* (source: Neyrtec (undated [b])

6.3 The design engineer's position

In exchange for a salary design engineers provide a service to their employer. Some Senegalese design engineers work for the *BEC* (*Bureau d'Etudes et Control*) in St Louis, a subdivision of the *SAED*, some for the *SAED* at department level (see box 6.3). Others are employed by Senegalese consultancies. As for the European design engineers: they work for a donor organisation or a commercial consultancy, doing a short term mission or fulfilling a two to three year contract (box 6.4). They all have in common that their careers depend on the satisfaction of their employer and, at best, maybe indirectly on the satisfaction of the farmers, who can only try to compel a design engineer through pressure on the government or donor. As we have seen, the government aims at transforming the *Senegal* valley into the granary of Senegal, supported by donor organisations. The relation between design engineers and their superiors is laid down in their "terms of reference" (*TOR*), in which their tasks are described. The emphasis is often put on constructing a certain number of hectares a year.

Since design engineers are inclined to give solutions - asking themselves "*how* this can be done" - they need goals. For a long period it was simply supposed that a design engineer would serve the goal of society, the government or his employer, which made things clear for the design engineer. However, in the water management discussion, which is described in chapter 1, the question shifted from '*how* should it be done' towards '*why* should it be done, and *for whom*?'. At the Department of Irrigation and Soil and Water Conservation of the *WAU*, both the *how* and *why* perspectives are current to roughly the same extent. But in my experience the ratio between '*how*' and '*why*' of design engineers in developing countries - including the ones who studied in Wageningen - is clearly in favour of the "*hows*". Although many design engineers know that reality is complex, they prefer to *do* something once they are in the field. They probably did not chose to be engineer to discuss and talk. A Senegalese design engineer perfectly illustrated his preference to leave the *why*-question to others: while we were watching the news on television, he compared the empty shelves of a bulgarian supermarket with an irrigation system he designed: *"Look, this is the problem of us, engineers. It is easy to construct the system, but you see: it does not depend on us whether there will be something* ***inside****"*. The joke was highly appreciated by all design engineers present.

The wish to solve problems and the need for goals may turn many design engineers into the natural ally of the donor. Those who doubt these goals, generally are tied to their *TOR* and are not easily allowed to change the planning by questioning identified projects. In this way, technical norms may easily outrule farmers' wishes in a design (box 6.3, second example). In practice some margins exist in the conditions put down in *TOR* (box 6.4, first example), but it may be more easy to find justifications to follow the path of the least resistance. Although design engineers certainly may have their own objectives and their own view on "*what's best for the farmers*", it may be concluded that they most often

Senegalese design engineer, *BEC/SAED*, St Louis. He is stationed in St Louis and works for the *BEC* (*Bureau d'Etudes et Controle* in French), a subdivision of the *SAED* that is concerned with project acquisition. The *BEC* is *maitre d'oeuvre* until the first water gift of *GAs* in the delta and *AIs* in the middle valley. The *BEC* participates in discussions about feasibility studies and supervises the contractor. He is only involved in the "*technical part*" of the design processes. According to him, the sociological part of the design process is the responsibility of the *SAED* on delegation level. He says that it is important to "*....involve the farmers when decisions have to be taken, because we work for them. After all, they are experienced in irrigation*". But this appears to be lip-service, because when I ask him, wether he means all decisions, he clarifies that they have to be involved "*to a certain extent*", but hardly about technical issues, since "*There is not so much to talk about; the existing physical conditions lead to a certain logical design*". Later on he says that farmers were informed during one meeting, *to prepare them for the socio-economic field research*. He is not sure about the success of the disengagement policy: "*We are still remote from the situation where farmers maintain the irrigation system themselves*".

Senegalese design engineer, *BEC/SAED*, 'borrowed' to the *SAED* delegation of Matam. He admits, that he is one of those *design engineers* who used to make designs without controlling them in the field. "*Now, the situation has improved because we work with contractors. It is more easy to be hard on them, than on colleagues*", he says. According to him farmer participation in site selection is important, because they know about the soil suitability, the land rights and the required number of plots. Participation by farmers in the technical design, for instance in the choice of distribution structures, is out of the question because "*their precise dimension requires a certain calculation*". When he saw that farmers changed the design of a second generation *PIV* he called them "*pirates*". In an other case he did not agree with an initiative of farmers to change the scheme. When I asked him why not, he said "*One should only apply the proper norms*".

Two Senegalese design engineers (*SAED*, Matam). After having worked for the *SAED* in Cascas, one of them now designs a new generation of *PIVs* in Matam and supervises the contractors who implement them. He is used to communicating with farmers, for instance when he checks out their complaints in the field, when supervising improvement programmes or in the case of site selection. He has the opinion that the Haalpulaar farmers are politicians, trying to reach their goals by playing off the one donor against the other. According to him they will do anything to avoid work. But he takes them seriously and is clear about farmers' participation in decision making: "*one has to make clear to farmers that they are involved in the decision making, otherwise they will say "no" in advance*". His colleague, who has a similar position, does not agree. He thinks communication with farmers is only important once the system has been constructed and they have to learn how to use it.

Box 6.3 Cases of design engineers: their position and their opinion about farmers' participation

Belgian design engineer working as a consultant for the *SAED*, supervising the contractor during the construction of the *AI* of Salde Wala. The original design, the soil study and the topographical plan of the Salde Wala scheme were of such a low quality, that he doubts wether the *design engineers* ever visited the locality. He proposed to do the study once more, and suggested to wait another year before constructing. This was not accepted. However, he could adapt it, creatively profiting from the slow construction rhythm of the poorly organised contractor. He managed to 'save' still functioning *PIVs* from total deletion, by changing the design. The farmers respected him for this. The *SAED* agreed to his proposition to change the structures, because the soil was more erosive than expected. In addition, after having read sociological reports, he decided to change the limits of the units, so that the cattle could easily pass through. Furthermore, he changed the lay out of the 50 hectare units, making a subdivision of two equal units, so farmers could irrigate in accordance with the *practices* of the *irrigating group*. He does not oppose to farmer participation, but doubts whether their participation in the technical design is useful, since the viability of a scheme simply depends on the farmers' motivation to work in the scheme. It is more important to him, that the system is technically sound: *"...when the system is technically sound, the degree of adaptation to the scheme will be relatively high for motivated farmers"*.

Dutch design engineer in Cascas (department of Podor), working as the project manager for the *Ile a Morphil* project. The project manager has a design engineer's background, as well as experience in contract-work. He is not often in the field. He reasons that some distance is required to manage the project, and leaves the contacts with farmers during the design process to another dutch design engineer. The project leader wishes to influence the design process, possibly because his heart lies with his former profession. Sometimes he would prefer to be design engineer instead of project manager: *"Then you can easily measure your production"*. In a context of diminishing project means, he strongly supports the efficient use of machines. He gave the push to quit with farmers' participation in excavating canals, when he saw that their work in the heat did not progress. *"I have to implement hectares. We are already behind schedule"*, he argued.

At first, the **Dutch design engineer of the above mentioned project** is not so eager to change the principle of farmers' participation in construction, arguing that the farmers could have done the work before the hot period, if only they would have been more motivated. However, later on he agrees to use machines for the work that the farmers used to do before. He prefers working with his *équipe* (construction team) above working with farmers anyway.

Box 6.4 Cases of design engineers (continued): their position and their opinion about farmers' participation.

turn out to be the solution-minded "natural allies" of the state or the donor organization. In this way, the *AI* concept offered the state and donors a way out of the stalemate caused by the failure of large scale irrigation development in the delta (see next chapter).

6.4 The design engineers' relation with farmers

Most design engineers I met in the Senegal middle valley (only men) want to help the farmers in one way or another. Many of them seem to assume that both the government and the farmers are helped out by constructing irrigation schemes. The design engineer's position enables him to give 'material help', for which he is paid by government or donor. In his *TOR* the nature of his contacts, if at all, is only vaguely mentioned. He is more or less independent from the farmers for whom he designs and communication with them most often has no priority. This allows, but most often forces him to remain at a distance from farmers. Design engineers who are in touch with farmers often use their potential material assistance as a tool to negotiate with them. In exchange for the 'material aid' they want to be paid back in organizational efforts and participation by farmers. Many design engineers stress the importance of farmers' participation in design and construction, whatever they mean by it, and the argument '*the more farmers participate, the more responsible they will be*' can often be overheard. Farmers' participation in decision making is limited, as will become clear in the next chapters. In other words, the design engineer remains in control of his material 'gift'. Solutions that are not ideal from his point of view, are only accepted when farmers insist, for instance, when they threaten not to use the system. Some examples of the attitude of design engineers towards farmers are presented in box 6.5.

As a rule, the assimilation of a dialogue with farmers within the design process depends on the constraints of *TOR* and on the personal wish and efforts of the engineer to integrate the demands and the wishes of farmers into his design. In box 6.6 this is illustrated with an overview of the practices of all design engineers that have been interviewed during my research. Besides, some representative cases of their opinion about farmers' participation can be found in box 6.3 and box 6.4. Other examples are described in part III of this thesis.

Remaining distant from farmers

A Belgian design engineer who had to implement 1000 ha a year: *"Maintaining contacts with farmers is the task of extension officers, since, in the end, a scheme has to be constructed. But if farmers have questions we can always try to find a solution".*

Studying, coaching and convincing farmers

A Senegalese design engineer involved in the implementation of AIs: *"It is always important to integrate preoccupations of the farmers into the design, but this has to be done during the feasibility study. From technical and social criteria, the project design can be derived. For instance: Small plots or large plots? To what extent do the farmers participate in the management of the scheme? ..... In the first three years after the construction of the scheme the farmers have to be taught how to use it. ..... Then the role of the design engineer is a coaching one,....... to convince the farmers.*

Behaving like a school master

Dutch design engineer, involved in design and implementation of *PIVs* in Cascas: *"As [my predecessor] already pointed out, unfortunately it cannot be avoided to speak to farmers as a school teacher, when something has to be done".*

Helping farmers out (a and b)

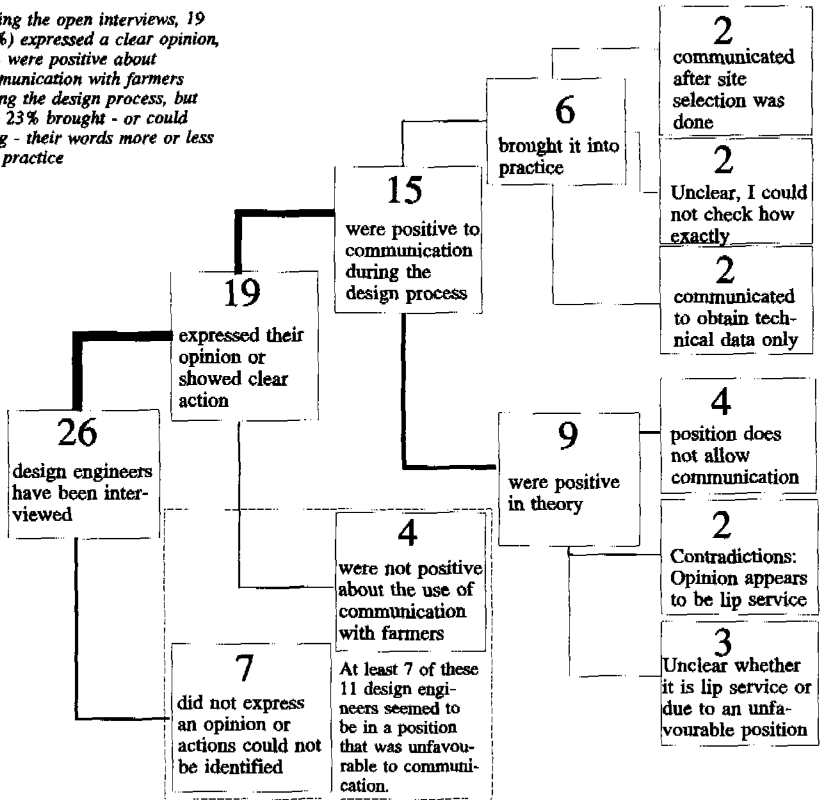
a: **A Senegalese design engineer working in Cascas**: *I proposed the farmers to make a list of workers for each working day and encouraged them to make clear how many days a worker is allowed to be absent. The others would have to be fined. They accepted my proposal. I put it down on a piece of paper and asked the president to sign it".*
b: **A Dutch project leader in Cascas, former design engineer**: *"Shouldn't I, for the farmers, construct as many* PIVs *as possible? They keep nagging... so I tell them: We will implement 1000 hectares, full stop! And we will have to meet that promise."*

Negotiating and using 'material aid' as a tool for it.

The above project leader:
"If they have not fabricated the number of bricks we agreed on, we will - for the time being - blow off the construction of their scheme and continue elsewhere." and: *"We just need one or two examples of the project's withdrawal from the construction site, and then they will work."*

Box 6.5 Examples of the attitude of design engineers towards farmers.

During the open interviews, 19 (74%) expressed a clear opinion, 58% were positive about communication with farmers during the design process, but only 23% brought - or could bring - their words more or less into practice



Box 6.6 An inventory opinions and practices of middle valley design engineers, with regard to communication in the design process

Chapter 7

HISTORY OF IRRIGATION DEVELOPMENT AND DESIGN ENGINEERS' PRACTICES IN THE MIDDLE VALLEY

7.1 The first *PIV* generation

After the introduction of the first *Périmètre Irrigué Villageois (PIV)* in 1974, irrigation development became widespread in the middle valley. In the early years, emphasis was put on a rapid and cheap construction of *PIVs* to reach all villages as soon as possible. Sustainability was not the primary aim of the *PIVs*. The *SAED* regarded them as 'irrigation schools' for the farmers, in expectance of large scale irrigation development in the middle valley. Technically, these *PIVs* are simple (see box 5.2) and in the beginning, neither concrete structures nor drainage provisions were made. The *design process* was elementary as well. Only one design engineer was involved, no soil survey was done and the land survey was straightforward. Farmers played an important role in the site selection. They provided information about soil suitability and water availability in a certain part of the river in the dry season. Discussions about the site selection often focused on land tenure problems. For the farmers it was out of the question to discuss the design. *"We did not know about irrigation. Therefore we supported the plans of the design engineers"*, one of them would say later. Farmers participated in construction intensively, by clearing the land from its original vegetation and digging the canals by hand. They provided a list of villagers who would participate, and extension officers made sure that the list was according to the *SAED* regulations (every *foyre* one plot).

Once the site was selected, a topographical brigade surveyed the land, often supervised by a design engineer. Subsequently their measures were processed into a contour-map, on which the design engineer drew a concise plan. He then indicated to the farmers where they had to dig the canals and, if necessary, adapted his original plan in the field. After the farmers had completed their work, the motor pump (*GMP*) would be installed and for the first time water was supplied as a final test for the quality of the *PIV*. Then the design engineer explained to several farmers - chosen by their villagers to see to the water distribution - how they could distribute the water and irrigate their plots. He gave them simple rules for water distribution and maintenance. After this the irrigation was left to the farmers, which was part of the ideology of these first years: too much interference would only create dependent farmers (personal communication Hoevenaars, 1994).
During the construction process the local extension officer often was present to control the farmers and to assist them, for instance with the division of plots. The extension officer had an agronomic background and was mainly concerned with the introduction of the rice crop. After becoming experienced, through working with the design engineer in

already existing *PIVs*, he could also explain what rules to follow in water distribution and maintenance.

Although most farmers were motivated in the beginning, their enthusiasm to participate decreased after a few years (Versteylen, 1982). Farmers complained about the hard work and begged for mechanical assistance. In some cases, to ease their work, they hired a tractor or a grader that happened to be in the neighbourhood. In the same period, certain technical shortcomings in these first generation *PIVs* started to become clear. Being constructed on sandy soils near the river *(fonde)* they caused high percolation losses. This had serious drawbacks for the farmers, because each drop of water required fuel. The better soils, further away from the river, could only be reached with longer conveyance canals. By that time, design engineers had observed that the existing canals easily overflowed and that the maximum water level in the canals was too low to domain the higher parts of the non-levelled plots easily. Therefore, the higher plots were often abandoned. This may be one of the reasons why design engineers came with plans to construct larger and more stable canals, provided with concrete structures.

For the design engineers the time became ripe for a new generation of *PIVs*. Under their influence, slowly, the *SAED*'s ideology of leaving the construction entirely to the farmers and to only construct very simple systems started to decline (box 7.1).

7.2 The second *PIV* generation

The new generation of *PIVs* evolved in the beginning of the eighties. Their emergence was not abrupt, but differed per project and area. In 1984, an effort was made to standardize the design and construction of *PIVs* (box 7.2). Longer and more stable conveyance canals were to be constructed to reach the fertile soils further away from the river. Depressions and a more difficult topography called for an increasing number of check structures. Design engineers not only started to use machines for the construction of canals and protection dikes, but also for plot levelling and the construction of plot bunds. Although the farmers' participation in the construction decreased, it remained substantial. They still had to clear the land, work the canals and were given cement and supervision of a *SAED* mason to construct the structures. These were simple division boxes that could be opened and closed by slides (see box 5.3). The construction time of the *PIVs* varied from one month to more than one year. The construction costs remained relatively low. In the end of the eighties these were estimated on 840.000 FCFA/ha, excl. *GMP* (3000 USD) (Bastiaansen 1988).

Despite the norms of land survey and design, the *SAED* made many mistakes in various phases of the design and construction process. Three types of mistakes can be distinguished. Firstly, the topographical brigade did not correct their own errors that were made in the field when collecting data, due to a lack of the required built-in checks. The data that

The ideology of the first years was to keep the *PIVs* as simple as possible, so that farmers themselves could easily maintain and repair the infrastructure themselves, without the need of mechanical assistance. The ideology came under pressure because design engineers in the field saw reasons to change the construction method. Where in the beginning a simple drum was used as a stilling basin, it was soon replaced by a concrete stilling basin because the drum did not work, and where, in the beginning, the number of distribution structures remained limited to the absolute minimum, their number started to increase as time went by. This made the water distribution more easy. More and more, the farmers were helped out with the most difficult works during construction: tree trunks were for instance pulled out with a tractor, provided the farmers paid the gas oil. In some cases farmers rented machines from contractors who happened to be in the neighbourhood.

The principle not to use machines during construction was further undermined in the project *Ile a Morphil*, where a bulldozer came to the scene to construct a protection dike to prevent the lower parts of a *PIV* from excessive run-off water. Once the bulldozer was there, it was used to reinforce a weak part in some conveyance canal, or to rip (loosen) the soils before the farmers would dig the canals. Slowly a situation evolved, where the mechanisation became part of the construction method. At first, the *SAED* strongly objected, claiming that the project should respond to the standard construction method, but finally agreed, realizing they lacked the means to finance the project themselves (Boersma 1992). The *SAED* was afraid that bigger investments for construction would become a new standard and farmers in other project areas would claim that new *PIVs* would have to be constructed accordingly. Later on, in 1984 and 1985, farmers in the area South and East of the project indeed totally rejected *PIVs* which were less solid and demanded more participation in construction by farmers (cf AGRER et al 1987). They referred to the standards of the *Ile à Morphil* project.

Box 7.1 The design engineers' role in the change of the construction method of *PIVs*

incorporated these mistakes were processed by others, making a contour map far away, in St Louis. By using faulty technical design criteria in the design the second type of mistakes were made. Friction losses were for instance neglected when calculating the water heights, or the lay out of an earlier designed *PIV* - often an easy square form - was simply copied to the new entirely different topographical map (cf Roodenburg, 1988). Thirdly, once the lay out was drawn on the contour-map, it was often decoded into *real* infrastructure in the field, without again checking whether the design fitted reality.

In this way, one error was superposed on the other and, as a result, many of the second generation *PIVs* were of low quality, whereas the responsible individual could not be tracked. The problems of this period are now generally accepted by design engineers of

In 1984, during two seminars in which design engineers and other technicians participated, an effort was made to standardize the design and construction of *PIVs*. This resulted in a document in which a methodology of design and construction of *PIVs* was laid down (*CNAPTI*, 1984). These standards implicated that distribution and check structures, protection dikes and simple drainage provisions became a norm and the use of machines became generally accepted. Although not all of the propositions were actually followed in practice, most design engineers subscribed to the general idea of the document. Some of the proposed design norms are:

- The natural slope of a site should be less than 1% in order to be selected, if not, the departmental *SAED* director should give explicit permission
- Superficial levelling and land-clearing may only be done mechanically if the departmental *SAED* director gives his consent
- Conveyance canals may not exceed 1 km, unless the departmental *SAED* director decides differently
- The soil type needs to be *hollalde* or *faux hollalde* for the cultivation of rice
- The surface of a *PIV* must be adapted to the capacity of the *GMP* (80 l/s); in practice around 20 hectares
- With regard to the topographical study at least two durable mark stones should be placed in the area
- The slope in the canals has to be limited (0,05-0,08%)
- One uniform canal dimension for 80 l/s canals (Conveyance canal, primary canal and secondary canal) and 40l/s canals (field canals).
- The distribution structures are provided with adjustable metallic slides and can be used for an "*All or Nothing*" distribution (cf box 5.3), but may also be used for splitting the water volume in two equal parts. The distribution structure may also be replaced by two check structures in the ongoing canals, enabling the supply to the one or the other canal.
- Plot intakes for rice cultivation are PVC tubes with a 200 mm cross-section

Box 7.2 Propositions for the standardisation of norms in the design process of the second generation of *PIVs* (CNAPTI, 1984)

the *SAED*, who were in control of most of the surveys and designs. According to one of them "*...the problem was that the people who constructed the works and the people who had to control it were part of the same organisation [*the *SAED*]." Some projects like the *Ile à Morphil* project were relatively independent from the SAED and had their own topographical- and construction team with one single responsible design engineer. In this case, fewer mistakes were made and flexibility to adapt the lay out to farmers' wishes remained possible, even throughout the construction process. However, even in these cases mistakes could not always be avoided.

Rehabilitation and improvement programmes

As a category, design engineers benefitted from their mistakes, because the bad quality of *PIVs* called for rehabilitation projects and gave them new work to do. It should be noted, that a lack of maintenance had led to deteriorated *PIVs* as well. As a result, in the eighties, not only new *PIVs* were designed and constructed, but also existing *PIVs* were occasionally integrated in improvement or rehabilitation programmes. In these programs, plots were levelled, weak parts of canals were reinforced, etc. In july 1985, for instance, 3.290 hectares were implemented in the zone of Podor (excl. the *Ile à Morphil* project), 1400 hectares of which would be rehabilitated before 1987 - while many other *PIVs* had to be improved by means of levelling plots, stabilising canals, new slides or total reconstruction of structures (Greppi, 1986).

Also in the *Ile à Morphil* project and in the department of Matam rehabilitation and improvement programmes were necessary. It can be questioned whether design engineers and planners could adequately determine what causes had led to the deterioration of each *PIV*, as the distinction between 'construction error' and 'lack of maintenance' was not always easy to make in quick surveys. Certainly many technically sound systems have been rehabilitated. In some rehabilitation projects, the procedure was almost standardized and every village obtained a new *PIV*. In this way, it was avoided that farmers who properly maintained their *PIV* were 'rewarded' for this by *not* getting any mechanical improvement, while farmers of a neighbouring village who did not maintain their *PIV* would obtain a new one.

7.3 The 'improved' second generation

From the beginning, the goals of the construction of *PIVs* had been shifting from food aid for farmers and '*schools* to learn to irrigate', towards sustainable infrastructure and independent farmers who would have to pay for all costs. By 1990, this shift gave firm ground to the opinion that farmers should have technically sound systems. Higher investments per hectare, one of the major taboos in the seventies and the eighties became acceptable. Some design engineers and many others even claimed that more expensive irrigation infrastructure might be less expensive to maintain by farmers. Probably for these reasons, a new generation of *PIVs* was developed in the beginning of the nineties, in which the construction method and the design changed anew. Contractors constructed the whole scheme, due to the disengagement process of the *SAED*. With regard to the stability of canals, in the department of Matam even scrapers were used for transporting soil of good quality for raising the stability of the conveyance canal, which was often a problem in existing *PIVs*. In the Podor rehabilitation project, the conveyance and primary canal profiles were very high and broad, based on the observation of engineers that existing canal capacities were low and canal breaches were frequent. Plots were levelled with precision, structures were no longer constructed by farmers and their participation got reduced to site selection. These *PIVs* were more expensive than the second generation (5000-9000 USD per hectare). But it should be noted that these were sometimes constructed on relatively unfavourable sites, because all the favourable sites already were occupied by older *PIVs*.

The effect of this new construction method on the quality of control seems to beneficial. The contractors could construct the *PIVs* quicker because of a total mechanization. They did not have to adapt their rhythm to the farmers' organization. Due to the reorganisation of the *SAED* the design process became more locally based. Fewer mistakes were made in coding reality in contour-lines and decoding the technical design into reality. The construction rhythm was much higher than it used to be, especially in Podor. Although in the *Ile à Morphil* project no contractors were employed, the efficient construction method of the Podor rehabilitation project nearby was partially copied. Only the structures still were made by the farmers. In this project, during the design process, even through the construction phase, farmers could still influence the design.

As a conclusion, after 20 years of *PIV* development, one can say that technical problems - even if caused by their own mistakes - were resolved by design engineers, by constructing ever more solid and expensive systems. However, the basic concept of the design still is simple: one simple unit with limited drainage provisions to reduce costs. Only the construction method changed substantially, especially the farmers' investment in the construction diminished. Whereas the engineers occupied themselves with rehabilitation and improvement programmes, they left the water distribution and maintenance to the farmers and extension officers.

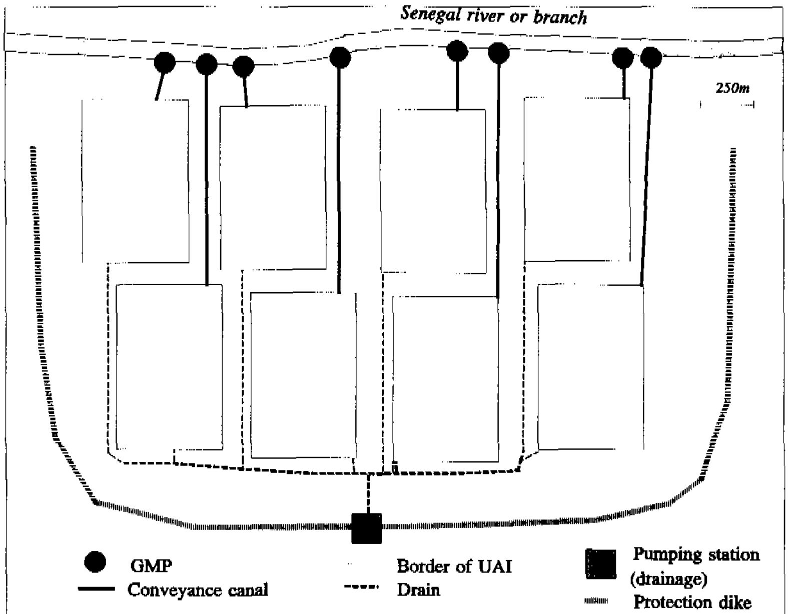
7.4 The *AI* concept

A third PIV generation?

Right from the beginning of the *PIV* development, planners, design engineers and others discussed how the transition from these *PIVs* to large scale irrigation systems (*GAs)* should be made. However, the negative experience with *GAs* in the delta and the success of *PIVs* led to the concept of the *Intermediate Irrigation Scheme* (*Aménagement Intermédiaire (AI)* in French). These *AIs* (varying in scale from 30 up to 1000 hectares) were to be developed in the flood-plains, the *waalo* territories, where the fertile *hollalde* soil could be found. Consequently, a large protection dike would be needed to protect the system from the river's flooding.

The major difference of *AIs* with the technical concept of *GAs* is the inclusion of several so-called independent irrigation units (*UAIs*). Compared to *PIVs* the concept differs because it often requires an extra level of water distribution. Diemer and Huibers (1991) mention other differences that distinguish *PIVs* from *AIs*. They state: *"For intermediate* *schemes, the planners envisage major works to develop water sources and primary canal systems, serving schemes several hundreds of hectares in size"* (p47-48). Furthermore, *"The concept of the intermediate scheme is based on the use of large plots, which it is hoped will lead to adequate production to meet subsistence needs, cover operating costs, and provide a marketable surplus"* (p48). Another importance difference is that the land users of a *waalo* area - the site of the future schemes - often do not belong to the same village.

Design engineers developed three different technical concepts of *AIs*.



Box 7.3 *AI* composed of large *PIVs* grouped together

First alternative: Large PIVs grouped together

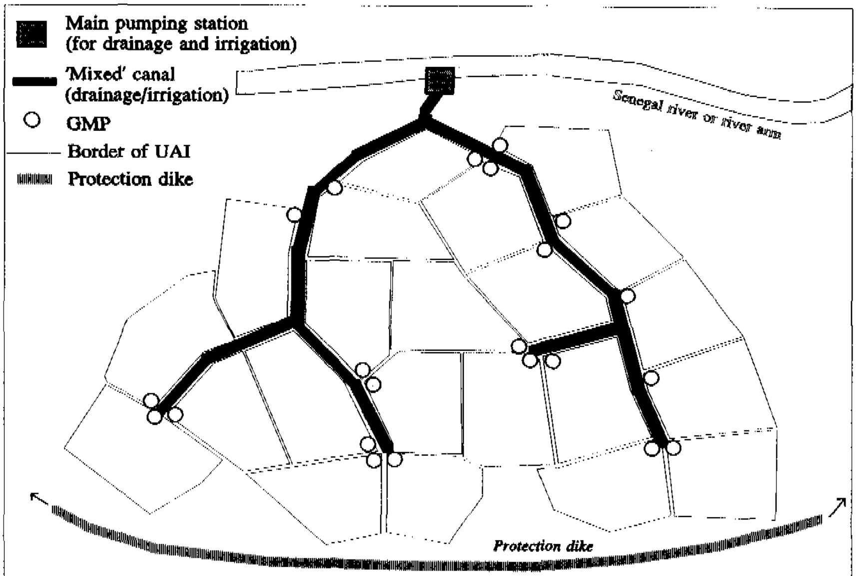
A first concept can be compared to a group of large *PIVs*, called *UAIs*, with conveyance canals that are often relatively long (box 7.3). It is necessary to group the *UAIs* together, to spread the cost of the protection dike over a larger irrigated area. To limit the costs per hectare, one is inclined to construct in topographically less favourable areas within the dike as well. The concept is more expensive than the *PIV* concept. The first example of this is the Salde Wala project, of which the construction ended in 1989. Each conveyance-canal provides water to 50 ha units, consisting of two tertiary units. Plots were levelled in precision and structures were of high technical quality. Drainage provisions, including pumps, were important in the topographically unfavourable area. The costs were at least 9000 USD/ha. The total irrigable area in Salde Wala equals about 600 ha.

The second example is an Italian project near Podor. The units were 30 ha. Between 1985 and 1989 ten of these were constructed on the Senegalese side of the river. Unlike the units in Salde Wala, the *UAIs* had no communal drainage system and therefore were more autonomous than in Salde Wala. The Italian design engineers elegantly made use of the favourable topographical condition of the location. In this system no distribution- and check structures were required because all irrigation canals had one horizontal level. As a result, the canals had to be elevated (up to 1,50 m) in some parts of the *AI*, which means that canal breaches had to be avoided at all costs. Due to the single water level, the large irrigation canals can serve as a water reservoir to which each plot always has immediate access, by means of syphons or flexible buses. In this 'on demand' system the pump attendant knows when to start and to stop the *GMP*, by checking the water level in the canal reservoir nearby. The plots were levelled in precision, but unlike the Salde Wala scheme the drainage system hardly got attention. The costs were about 7000-8000 USD/ha.

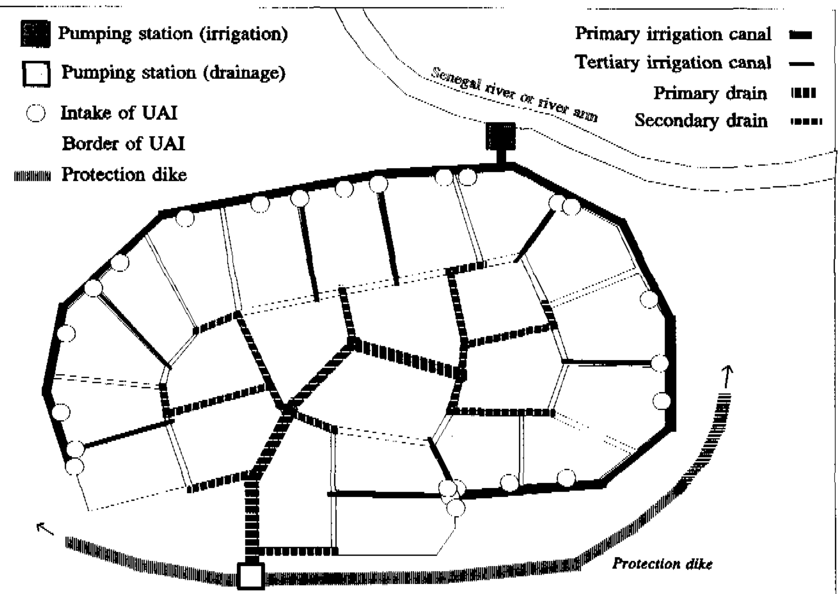
Second alternative: The "Low Water Level" concept ('low concept')

In this concept (box 7.4), the existing natural watercourses that flooded and drained the flood-plains are adapted so that they can be used as a primary irrigation canal and as a drainage canal at the same time. From this 'mixed canal' (*chénal mixte* in French) simple *PIV*-like units *(UAIs)* pump up the water in dry periods, and drain into it in the case of excessive water. The mixed canal has a low water level and is horizontal, so no distribution or check structures are required and, like the above mentioned Italian system, it equally functions as a reservoir from which the *PIVs* pump the water on demand. Despite the elegance of the idea to use the existing water-courses, the implementation of the idea is more expensive than it seems, since the required groundwork remains substantial. Moreover, the mixed canal is not low enough to have permanent access to the river water. Therefore, a second pumping installation is required between the river and the low canal. This second pumping level implies that farmers of different villages have to manage one single pumping station. In some cases the pumping station has to be used to drain excessive water from the mixed canal.

A first scheme of this type is said to be constructed near Richard Toll in the lower *Senegal* valley in the beginning of the eighties, but this was a special case: the scheme profits from the pumping installation of the sugar-cane plantation at Richard Toll, and commercial farming is favourable in this area. However, the success of Ndombo Thiago was seen as an argument in favour of the *"low"* concept. In the end of the eighties, the first 'real' schemes of this type were constructed in the department of Matam. Initially, the *UAIs* were supposed to be constructed with a high level of farmer participation, but as we will



Box 7.4 The *AI* with a low water level primary canal (the 'mixed' canal)



Box 7.5 The *AI* with a high water level primary canal

see in chapter 8, farmers rejected this and the *SAED* gave in to their demands. Three of these *AIs* were constructed by 1991 in the department of Matam, totalling almost 1300 hectares. The costs of this type of *AI* vary from 10.000 up to 15.000 *USD* per hectare.

The third alternative: "High Water Level" concept ('high concept')

This concept (box 7.5) did not make use of the natural waterways and originated later. In a feasibility study in 1985 it was preferred to the *low* concept. Arguments against the *low* concept were that two pumping levels were required, parts of the mixed canal would have to be lined and finally, the *low* concept was said to have been evaluated too optimistically by using the case of Ndombo Thiago, the only case available at that time. The choice for the *high* concept is remarkable, because it has more features in common with the *GA* concept than the *low* concept: contrary to the *low AI* it does not try to guarantee autonomous units by giving each unit a *GMP*.

However, it was argued that the three *GAs* (Nianga, Dagana, Boundoum) in the middle valley were functioning satisfactorily. Therefore, it was supposed that this concept would do well, provided a good institutional framework (*encadrement*) was set up (AGRER et al 1987). The decision to construct a *high* concept was probably strongly pushed by the European Development Fund *(EDF, FED* in French), who had negative experiences with the development of low budget *PIVs*. These had been rejected by farmers, partly because of their bad quality, and partly because the simple schemes required a high level of participation in construction. The farmers argued that they wanted the same mechanical support as farmers in the *Ile à Morphil* project nearby (AGRER et al 1987). In the *EDF* project their participation in construction was not demanded at all. The plots were completely levelled and the tertiary canals and structures were made by the contractor as well. Canals were solid and compact. Four of these schemes were to be constructed, totalling 3000 hectares in the Podor region.

The first of these *high water level AIs* was constructed in 1989 in the department of Podor. Their construction costs are high, between 15.000 and 21.000 *USD* per hectare.

The *'high'* primary irrigation canal receives water from a pumping station. It surrounds a *waalo* depression and domains all parts of the floodplain. Several automatic downstream control structures were placed in the primary canal. In the case of the *EDF* project, secondary canals and extra distribution structures are designed to reach all *UAIs* (cf box 10.3). The design of this secondary level may be less costly, but creates a water distribution that is more complicated. This could have been avoided (cf van Driel 1990, see also chapter 8).

The tertiary units in the *EDF* schemes were provided with *modules à masque* (box 6.2), specific intake structures. These units were still considered to be autonomous. This seems to be based on the assumption that the intakes can be used to measure the quantity of water, flowing into the *UAI*. This implied that the opening and closing of the slides would require a precise registration by the farmers. Later on, it appeared that the farmers would not do as assumed. As a result, it was not possible to convert the effective water use of each *UAI* into proportional costs.

Which concept to chose

As we have seen, different *AI* concepts were designed. From a comparison of feasibility studies it appears that design engineers do not always use similar arguments to underpin their choice for a certain concept. Nevertheless, in all these cases engineers managed to sell different technical concepts to planners, by manipulating technical variables in their own way (see box 7.6).

7.5 The design process of *AIs*

As a rule, the design process of *AIs* clearly differs from the design process of *PIVs*. In general more design engineers and planners are involved in the process and the whole process takes much more time. Besides, the design process is enacted still further away from the locality. The first phase of the design process of all *AIs* started in the second half of the seventies, more than ten years before the first 'real' *AI* in the middle valley was constructed. The technical track of the design process went along with the socio-economic track. The socio-economic reports were marked by an implicit optimistic assumption of the farmers' capacity to transform into commercial farmers. In addition, the studies gave the impression that the traditional agriculture is quickly declining and that farmers would leave their migration activities once the scheme was constructed. The existing interrelation between traditional agriculture, migration work and irrigation was rarely taken seriously. As a result the importance of irrigation for the household strategy was easily overestimated. In addition, the number of *foyres* that were involved in the *AI* was seldom known before the construction had started. However, these studies did justify the production goals of the *SAED* and cleared the way for design engineers to present their solutions.

For the middle valley two masterplans were made, one in the department of Podor (GERSAR, 1983) and the other in the department of Matam (SATEC et al 1980). Compared to *PIVs*, the gathering of information during site selection followed a different procedure: where in the *design process* of *PIVs* farmers were consulted about the aptitude of a site, in *AIs* aerial photographs made in 1954 were a major source of information. In the 1956, these were used as a base for topographical charts (1:50.000). Later, between 1969 and 1973, the photographs provided a base for soil-charts as well. With the help of these the sites were selected, using criteria such as: soil quality, distance to the river and its branches. Sites that did not require a large protection dike got priority. The sites that were found in this way amounted to 28 in Podor and 49 in Matam. In 1983, based on

Design engineers use different arguments, motivating their choice for a certain concept. For instance, they chose for *'low' AIs* in Matam and for *'high' AIs* in Podor, despite technical conditions that were roughly the same. Engineers in favour of *'low' AIs* designed mixed canals without lining, but supporters of *'high' AIs* use the argument that *'low' AIs* would be too expensive, because the mixed canal should be lined. This does not alter the fact that the supporters of *'high'* did insist on lining 'their' huge primary irrigation canal! A second argument used by the engineers who were in favour of *'high' AIs* was based on the 'success' of the *GAs* in Dagana, Boundoum and Nianga where a 'good institutional framework' (*encadrement* in French) was available (the disastrous developments in the delta with comparable technically sophisticated systems were only shortly mentioned), but later on the three *GAs* that were mentioned appeared not as successful as they appeared: e.g. maintenance and improvements of the physical infrastructure of Dagana cost 400-500 USD/ha a year. Their argument against *'low'* was that its chances for success were based on a comparison with the success of Ndombo Thiago, which they deemed an unjust comparison.

A supporter of *'low' AIs* in Matam, saw 'his' alternative as the only real example of an *AI* and it went without saying that the case Ndombo Thiago was a just comparison. The *'high' AI* in Podor, however, would not be sustainable: just like similar *GAs* in the delta it would have to be rehabilitated within several years. Suppositions of the above-mentioned *'high'* supporters about the farmers, having to measure the quantity of water flowing past *modules à masques*, were not explicitly mentioned, which is strange because these are important operational requirements. It is interesting to note that a comparable *'high'* concept was not chosen in Salde Wala, since "*the water management could not be done by the farmers themselves*" (OMVS 1986).

Another example: In Matam, the hydrological situation of two *'low' AIs* remained unclear (SATEC et al, 1980/1984) until the construction process had begun and the contractor discovered an elevated natural threshold in the river arm. It was implicitly assumed that no third pumping level was required and double cropping would be possible once the *Manantali* dam was constructed. Both assumptions appeared not to be true and made new investments necessary to create a third pumping level, as well as new investments to excavate parts of the river bed. Had the design engineers studied the hydrological situation more carefully - like it had been done by their colleagues in Salde Wala - they would probably have known that double cropping could not be reached.

Most feasibility studies do not - or incompletely - quantify the expected maintenance costs of the system. Contrary to what many design engineers seem to believe, maintenance in *AIs* is more expensive than in first and second generation *PIVs*. It appears from GERSAR (1990b) that the depreciation of canals and structures in these *PIVs* would be 120 USD/ha, while *AIs* would require 200 USD. Small maintenance of infrastructure would be 17 USD/ha (*PIV*) and 50 USD/ha (*AI*).

Box 7.6 Plying technical arguments to underpin choices.

mainly demographic and - less obviously - political criteria the sites that should have priority, were selected. Later it would appear that the soil quality of many of these sites (for instance in Salde Wala, Ndoulomadji, Orkadière and Hamady Ounare) was estimated far too positive.

After the identification of favourable sites, projects were started. European and Senegalese consultancies were embraced to do feasibility studies and teams of design engineers, economists and sociologists gathered data in the field. Additional soil- and topographic data were gathered in the field in a few weeks. In some cases, the quality of the additional research was low: some design engineers who worked in subsequent phases even doubt that the original soil- and topographic data of the first phase were ever properly controlled in the field.

In this period, meetings were held with the farmers, with the aim to motivate them for the *AIs*. On these occasions, farmers' opinions were ambiguous: on the one hand, most of them expressed their wish to obtain better schemes than before, larger plots and mechanized cultivation and, on the other hand, a large part of them also made clear that they did not want to lose their *waalo* cultivation. In these meetings the design engineers' role usually remained limited to the presentation of the advantages of an *AI*.

Far away from the farmers the feasibility studies were proposed and served as a basis for negotiation between government and donor organizations. Planners, politicians, economists as well as design engineers discussed until agreement was reached. After the approval of the feasibility studies a detailed technical study was done. Tender documents were made and contractors were selected. This implied that there was no room left for important changes: contracts were strict and the contractors preferred to implement the plans as quickly as possible. During the construction, additional socio-economical and demographical studies were done in the field. In several cases, this was combined with the 'activation' of farmers (sensibilisation in french). During and after the construction it often appeared that mistakes had been made during the design. These were not corrected during the construction process. Frequently the soils were not as fertile as expected, and sometimes the topographical plan was so mistaken, that severe construction errors resulted.

Through time, one observes a tendency to design more expensive, more solid and technically more sophisticated systems, for which many different technical and economical arguments are used in the reports. These arguments are often not sound. Besides, the variables used appear to be pliable or are completely left out. To the exception of one case, mentioned in chapter 8, these reports never speak against project continuation, to the contrary. For the sophisticated schemes that result, a more efficient mechanized construction is necessary. As a consequence the construction method shifts from farmer participation towards total mechanisation. This process is similar to what happened earlier in the delta (Boda et al, red, 1989 p13): "*Almost all the irrigation infrastructure in the Senegalese delta is marked by a systematic degradation that repeatedly needs to be* *rehabilitated. The first difficulties were often 'resolved' by constructing ever more sophisticated and more expensive irrigation systems. Nevertheless, the results that were expected were not reached.*" Since the same development has been observed in *PIV* concepts, one may suspect to have touched upon practices that result from the design engineers' habitus.

PART III

SOCIAL INTERFACES, DESIGN PROCESSES AND TECHNICAL IMAGES

Chapter 8

DIFFERENT DESIGN PROCESS APPROACHES: TWO EXAMPLES OF SITE SELECTION

8.1 Introduction

In this chapter contacts between farmers and design engineers in the feasibility phase of the *design process* of Intermediary schemes (*AIs*) get attention. Two cases will be treated in which the site selection and - consequently - the traditional land tenure play an important role. I selected the cases because they are mentioned to be good examples of farmer participation and consultation. However, as we will see in both cases, a 'snake is in the grass with regard to farmers' involvement.

In one of the examples, the design process can be seen as a research process and was a joint effort of the *WARDA* (West Africa Rice Development Association), the *WAU* and the *SAED* to design an *AI* near Cascas. During this process, it was tried to improve the quality of the design through integrating farmers' social and economic conditions, using an interdisciplinary approach. However, as will be seen, the control of the process and the final decisions about the design remain in the hands of the planners and the design engineer.

The other example describes the design process of the *AI* of *Ndoulomadji* in the department of Matam. I took an interest in it while reading a preliminary version of the most recent masterplan of the Senegal valley. It stated the following about design processes in the valley: "*The concept is almost disconnected from the future user......, who faces the accomplished fact of* **"receiving"** *a ready-made product without consultation and without any social activation* ['animation' in French, S] *before the turning over. The two exceptions of Cascas (Dutch project) and of Ndoulomadji Dembe of the Matam III programme are famous, especially the second that indicates how important it is to go clearly beyond the familiar socio-economic interviews of the planner*" (GERSAR et al 1990a, p10). This suggests face-to-face contacts between farmers and design engineers and even, to some extent, a participatory design. The case is interesting because it indicates the 'state of the art' with regard to the ideas of planners about participation, illustrating the role of a distant design engineer and his relation with the other actors. I will start with this example.

8.2 The design process of Ndoulomadji

Socio-economic surveys and site selection

The design process of Ndoulomadji is part of the *MATAM III* programme, a bilateral project of Senegal and France. As a whole, it not only covers the design process of *AIs*, but also the design and rehabilitation processes of *PIVs*, as well as consolidation programmes of existing *PIVs*, extra programmes on animal husbandry, fishery, reforestation, artisanery and monitoring of the agricultural development in the department. The first phase of the Ndoulomadji design process is an example of a 'traditional' feasibility study. It begins in 1980, when the site was chosen as one of the 49 physically interesting sites in a prefeasibility study. The sites were identified by means of aerial photographs and related soil and topographic charts. The choices of the sites and the setting of priorities were done without consulting the farmers. Of at least 125 villages in the area, only 2 to 6 villages were selected to interview farmers on their opinion about irrigation (see box 8.1). It was stated that no time was available to do more research. In general, the socio-economic part of the study lacked precision. It was for instance assumed that the *waalo* cultivation would disappear after the construction of the *Manantali dam* and that the performance of *PIVs* would be less than in future *AIs* once farmers would obtain larger plots. In the study farmers were expected to behave commercially, but no serious analysis has been made to underpin this idea because, although all economic activities of the farming system are mentioned, no effort is made to analyze these beyond the level of reporting. Consequently, reader gets no insight in the local farming system.

> In less than 5% of the villages farmers were asked whether the irrigated agriculture was more beneficial than the *Waalo* and *Faalo* culture and whether they wanted extra plots, apart from the ones they owned in their *PIV*. To both questions a clear majority (70% and 84%) replied positive. The attitude of the farmers towards installing the irrigation systems on Waalo territories (66% positive), on sharing their lands with others (54% positive) and on receiving plots that were distant to their villages (60% positive) was tested in a similar way, but here the majority was smaller. The percentages varied clearly per village, probably because they differ in access to waalo lands. Only 13% would leave the existing irrigation schemes, if the normal rainfall should return (SATEC et al, 1980). Probably the farmers' answers had a significant opportunistic dimension (cf blackmail strategy and their dependency disposition).
>
> Box 8.1 The opinion of farmers in the department of Matam

Technical assumptions made in the beginning of the project appeared not to be valid in the end. Soil quality was worse than expected and of the 890 hectares net irrigable surface (SATEC et al, 1980) only 398 hectares were retained (SATEC et al, 1984), but not without the firm assurance that rice cultivation would be possible. Nevertheless, during and after construction it appeared that more than 25% of this remaining area was extremely sandy. Also from a hydrological perspective one may question the quality of the feasibility studies. It was true that figures about the expected situation after the construction of the *Manantali dam* did not exist, but then, the water availability was too easily supposed to be good: two crops a year were estimated to be possible (SATEC et al, 1980). But after construction it appeared that only one crop was possible, even after the construction of the *Manantali*. With regard to the topography no apparent problems have been observed in *Ndoulomadji*, but in two similar schemes that had followed the same procedure the topographical plan (1:5000) appeared to be full of mistakes and the construction process took longer and was more expensive than expected. These two other *AIs*, *Hamady Ounare* and *Orkadière*, were part of the same project, but had begun earlier. The design process resulted in a disaster and firm protests of the farmers, who rejected the infrastructure, especially in *Hamady Ounare* (box 8.2).

Communication pattern in Ndoulomadji

To avoid similar situations in the future, a pilot project started in *Ndoulomadji*. *'Sensibilisation paysanne'* was seen to be necessary, in order to turn over the scheme to the farmers. This implied in practice, that two extension officers and their direct supervisor had to inform, train and mobilize the farmers of seven villages, 22 *UAIs* and more than 1000 households. Additional surveys were done since the original study lacked precision. Field visits to *Hamady Ounare* and the site of *Ndoulomadji* were organized (box 8.3). However, the construction of the protection dike and the large mixed canal were well on their way and continued: the start of the rapid construction of *UAIs* coincided with the efforts to inform the farmers about the project. No design engineer participated in the meetings with the farmers, and the design made by them was not adapted, except for, in one case, the position of a tertiary canal.

During the meetings farmers strongly criticized the *SAED*, attesting that *".... they were exploited by her, whereas they would have preferred to be involved in the initiation and elaboration of the project, instead of being put before the accomplished fact of the project and the plot distribution* (*SAED* 1990). Farmers threatened to ignore two demands of the *SAED*, refusing to put money on the savings account and refusing to pay the money to constitute a *GIE*. An even stronger criticism focused on the landrights and the distribution of the project area between villages. All four villages with land rights on the site objected strongly to the repartition of *UAIs*: they demanded a larger surface. The *SAED* put pressure on the farmers, arguing that if they did not cooperate, they would not be able to cultivate during the first season. The atmosphere was tense: Extension officers mentioned that *"....criticism and claims harassed the meetings, some of them were even violent"* (*SAED* 1990). Particularly the village that had to abstain from the biggest part of its lands insisted on having more *UAIs* - even though they got a relatively favourable surface per *galle*. Their relation with the *SAED* was very tense, and they did not want to cooperate

Contrary to the expectations the farmers refused to dig the tertiary canals of *UAIs* themselves, arguing that they needed canals of good quality to be able to repay their loans. It became a political struggle, in which the farmers were supported by a deputy, who claimed the farmers should have mechanical support, like in an Italian project near Matam. When farmers discovered that the irrigation infrastructure would comprise two pumping levels they protested and refused to accept it, since it would be more expensive in their eyes. They even visited Ndombo Thiago, a project of which it was said that it had a similar concept, but concluded that no comparable project existed and threatened not to use the scheme. The SAED gave in, using bulldozers to construct the tertiary canals and helping the farmers out by initially paying for the first pumping level. However, half of the UAIs were not taken into cultivation because farmers still complained about the plot levelling. According to the extension officer the farmers who did not come also lived in distant villages and preferred to concentrate on rainfed agriculture, since the rainy season had been good [this indicates that the figures of farmers who were to leave the irrigation (13%; see box 8.1) in case of a good rainy season, are based on opportunistic answers indeed]

In Hamadi Ounare the farmers who did cultivate in 1989 could choose which *UAI* to adopt. When other farmers who started to cultivate one year later, they were left with the unfavourable parts. But they refused to accept these and claimed that their traditional land rights were not respected. Several villages got hostile towards each other. In 1991 two UAIs in *Hamady Ounare* and one in *Orkadiere* were still not cultivated for this reason. Besides, the farmers of several *UAIs* were still not organized to jointly manage the first level pumping station.

Many farmers refused to use plot-inlet tubes, arguing that it took too long to irrigate their plot. They irrigated their plot by breaching the canal. This resulted in a quick deterioration of many parts of the scheme. Unexpected drainage problems had to be solved by placing extra pumps, but still the mixed canal overflowed in a low part. On top of this, the sandy soils in many parts led to unstable canals and caused high percolation losses.

Water availability was disappointing. In order to warrant sufficient water a new project had to be formulated to create a dam with a pumping station (estimated at 1,500,000$). Additional costs were high and despite the privatisation goals the *SAED* still had to give mechanical assistance to cope with the worst problems until, at least, two years after construction. The extra costs for the construction of *UAIs* were some 2000 dollars per hectare. Still for some UAIs the machines were only available for a short period so that even the most fundamental construction problems could not be resolved.

Box 8.2 The farmers' rejection of the infrastructure and other problems during the first season in *Hamady Ounare*

While the *UAIs* of *Ndoulomadji* were being constructed to be finished before the rainy season of 1990, informative meetings were organized in seven villages around the *Ndoulomadji* site. Within three weeks the villages were informed about the project and their criticism and demands were recorded. Extension officers informed the farmers about the site and the concept of the scheme, using a simple plan. The farmers were explained which villages would participate and how many *UAIs* each village would obtain. The allotment of these was done by the *SAED*, using the number of inhabitants of each village and the land tenure situation in the area of the site as criteria. The meetings were also dedicated to, respectively, (1) the explanation of the required organization, (2) the necessity to open a bank account, and (3) to immediately start paying for the depreciation of the *GMP*. To avoid land tenure problems it was decided that eight of the fifteen originally adopted villages were left out of the scheme because these were too distant or had no valid traditional claims. Structured and semi-structured interviews about the history of the villages, its environment, the production activities and the farmers' opinion about the future development were part of the programme. But time was not sufficient to use the results for the distribution of *UAIs* or plots. The results could only be used for monitoring the project's impact after the construction. With the help of a computer several classes of households were identified. It was hoped that these could serve as a model for further irrigation development in the Matam department.

In may 1990 an excursion to *Hamady Ounare* was organized. Every *UAI* of *Ndoulomadji* was represented by 1 or 2 farmers. The *SAED* was also present. This may be the reason why sensitive issues were not brought forward. In the field two *SAED* representatives of *Hamady Ounare* explained how the water distribution and its management worked. Later on, in the *SAED's* office, the farmers of *Hamady Ounare* answered the questions of Ndoulomadji farmers. The spokesmen of the *Hamady Ounare* farmers supported the irrigation development.

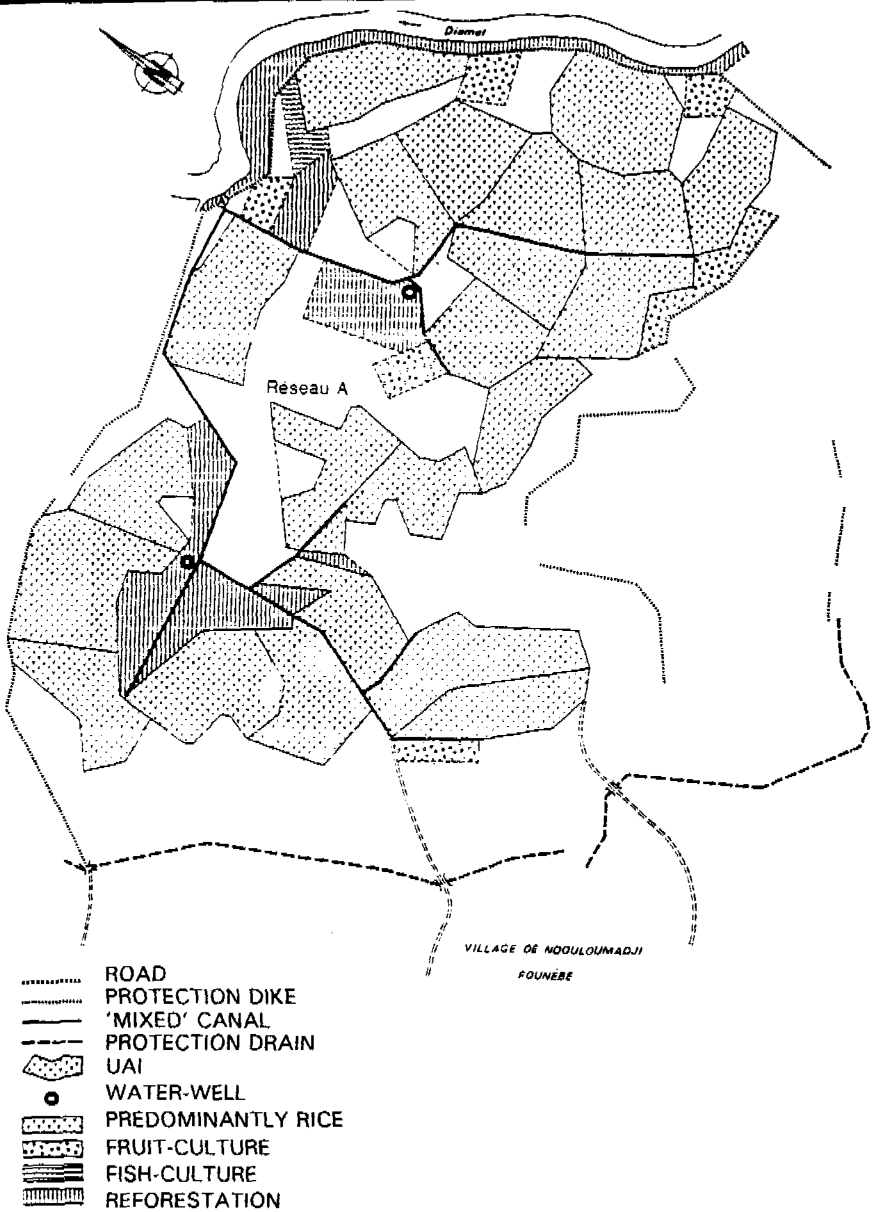
Besides, visits to the *Ndoulomadji* site were organized. On the one hand, farmers were impressed by what they saw. For the first time, they could leave the work to the machines. The large profiles of the *tertiary* canals looked more stable and the structures were of a better quality than in *Hamady Ounare* or any *PIV* they knew. Farmers reacted enthusiastically. On the other hand, during the construction, farmers of some *UAIs* complained about the quality of the soil, asking for other plots. Frequent complaints were made about the plot levelling. These were promised to be resolved, since the works were not finished yet. An extension officer reminded that in one case farmers claimed that one of the canals had a faulty direction. They proved to be right and the lay out was adjusted. As far as I know, this was the only influence of farmers on the lay out of the scheme.

Box 8.3 Meetings, interviews and field visits in the *Ndoulomadji* design process unless they got more *UAIs*. Extension officers referred to this village as a 'feudal village'. However, according to one extension officer, *"in the end, everything was sorted out"*, This does not alter the fact that, two years later, the farmers of this village were still rebelling against the *SAED*.

When it appeared that the number of families was higher than the number of plots, most farmers objected to the distribution of plots, but the *SAED* clung to its demand that each plot should have an area of 0,8 hectares in order to stimulate commercial farming. About the problems with regard to the distribution of plots within each village, farmers' representatives of Ndoulomadji Dembe said: *"We arranged that every one gets his share. We divide among ourselves. There are three families for one plot, because the number of plots is limited. It is possible to arrange this by drawing lottery tickets, so that one family may get it. Families may also decide to work together. One way or the other, the problem is arranged among families"*. The limited number of plots and the fact that only part of the area within the protection dikes was implemented (cf box 8.4) is contradictory to many farmers: *"A large area is not implemented"*, they said, and *"We agreed with the large dike, thinking: 'that is good', but now only a part* [of the area in between, S] *is implemented"*. Before the construction, they did not question the soil quality of the site and accepted the *SAED's* explanation that the site was good. During the informative meetings women groups and youth groups claimed their own plots. With regard to the women the conclusion was drawn that men had to be motivated to give land to them and they could participate in other activities (animal husbandry, painting, tailoring). However, the men were not eager to give land. The idea was put forward to look for special donor assistance for women. With regard to the youth groups it was concluded that they should try to participate in another development programme that existed in the Matam department.

It should be concluded that the *Ndoulomadji pilot project* is not a participatory design process at all: even farmer consultation about the design does not take place. Farmers remain excluded from making important choices like the site selection and - which is more important to them - user selection. Despite all the criticism, the local *SAED* functionaries succeeded in making the farmers enthusiastic about the new scheme and the exceptional part of the *Ndoulomadji* pilot-project may be found in the efforts of local *SAED* people of the Matam department, who tried to integrate the farmers into the ready-made project in a short period. Promises were made about the quality of the scheme, for instance about the plot levelling in the scheme. Box 8.5 indicates that the results are better than in *Hamady Ounare*. But a year after the construction, the *SAED* still is heavily involved in the scheme. It remains to be seen whether farmers *can* finance all costs of operation and maintenance themselves, as well as whether they *want* to do that.

Since no design engineers were involved in the "participatory" part of the design one cannot speak of an *interface* between farmers and design engineers. However, via their physical one-sided 'communication message' design engineers have left a particular impression to farmers and extension officers.



Box 8.4 The design of the *AI* of Ndoulomadji (source SATEC et al 1984)

Despite the enthusiasm of the farmers, the first year was not devoid of problems. All *UAIs* were cultivated, although some of them got yield reductions because of a delay in the installation of *GMPs*. A sudden dismissal of mechanics for reasons of privatisation gave rise to problems because it coincided with a high number of *GMP* defects. Unexpected levelling problems on the large plots hampered the irrigation. Later on, the farmers would receive mechanical assistance from the *SAED* to cope with the major problems.

It was a small success, that some *UAIs* even started to cultivate in the hot season. However, the water availability in the *Diamel* river arm was not sufficient and some of the *UAIs* had to abandon their cultivation and lost their investment.

In at least 25% of the *UAIs*, the soils were absolutely inappropriate for the cultivation of rice. Moreover, the stability of canals on these light soils was very low and they quickly deteriorated. These *UAIs* received extra mechanical assistance for plot levelling to compensate for the quality of their *UAI*. Despite the discouragement of the extension officers the farmers persisted in their wish to grow rice, although high pumping costs were involved.

Box 8.5 Preliminary results of the *Ndoulomadji* scheme

8.3 Views on the design engineers' role in the process

Farmers of Ndoulomadji about the design engineers' product

Although they do not know them, the farmers indirectly expressed their opinion about the engineers who made the design. It should be mentioned that most farmers I interviewed (1991) were positive about the quality of the infrastructure of their *UAI*, but generally they found that they should have been involved in the initiation and elaboration of the project. With regard to technical decisions they were negative about the idea of the two pumping levels, as well as about the plot levelling, that had been less thorough than promised, and the disappointing water availability. Besides, many farmers had the idea that something was wrong with the number of hectares that were implemented. With respect to the soils, farmers thought that better sites should have been selected. This does not alter the fact that they were easily convinced by the *SAED's* assurance that the site was of good quality - maybe as a part of their 'dependency disposition'. An extension officer said that farmers were familiar with the soil quality in the area and if the design engineers would have asked the farmers *beforehand* about the soil quality, they would never have selected such a bad site. Nevertheless, farmers do not blame the design engineer, but the *SAED* as a whole. It seems that, because of his distant position, they are hardly conscious of the specific role of the design engineers.

Opinion of the extension officers

The distant position of the design engineer was stressed by the extension officers. They came to the scene in march 1990 and were particularly dissatisfied with the top-down character of some technical decisions of the design process. According to one of them, the site selection, the two pumping levels and the soil quality had called for trouble. *"The farmers want to cultivate rice. How can all those researchers decide on this particular site, while next to it hundreds of hectares of clay ground are situated? Now, the danger exists that farmers will leave the scheme"*, one of them said. The other said that the infrastructure would deteriorate within three or four years, just like the schemes in the delta. It is not surprising, that the extension officers held a negative view on the design engineers. *"The ones who made the mistakes hide themselves"*, one of them said. The other said that extension officers do not have the position to do something about it: *"We have to deal with hierarchical relationships; we are only informed about certain issues"*.

The design engineers

Expatriate design engineers left the scene. Senegalese design engineers who were involved were not easy to trace. One of them justified himself, using arguments that contradicted the feasibility report. The answers of a design engineer of the *BEC* who was involved in the first phases of the design process justify the technical shortcomings of the infrastructure, but sometimes contradict the ideas expressed in the feasibility studies. About the soil suitability he said: *"It's a long story. There were many changes in the BEC, as well as in Matam. But originally, people used to think more easy about the soils: we had the opinion that farmers were free to chose: they may cultivate rice if they want. ... The actual problem is that farmers* [in sandy areas] *do not want to cultivate other crops, when some others* [with appropriate soils] *are allowed to do so"*. About the quality of the topographical study he said: *"In a survey of 1:5000, usually one makes mistakes. These should have been solved in the construction phase*. About the disappointing water availability: *"In the beginning, we had no intention to grow two crops a year"*. This surprised me because the feasibility studies were clearly based on the assumption that two crops would be possible. He justified what he said by stating that, at the time of designing, no clear figures existed about the impact of the *Manantali dam*.

He did not wish to blame the study for the problems in Matam. He changed the subject, judging that the general lack of maintenance of irrigation schemes is an important cause for deteriorating schemes. He blamed the extension officers to be not capable of explaining farmers about the maintenance. Stating this, he may have referred to the farmers of *Hamady Ounare* who breached the tertiary canals to irrigate (box 8.2).

The local design engineer working with the *SAED* in the Matam department acknowledged the technical problems in *Hamadi Ounare*, but the *SAED's* emergency programme, in which he was involved, did not have the means to undo all mistakes.

Therefore he had a difficult position. He frequently had to justify himself by telling the extension officers: *"I was not involved in the design process"*. Another design engineer in the Matam department, was more interested in the design and the construction the improved second generation of *PIVs*. He had no time to be involved in the *AIs*, and, since other design engineers designed and constructed it, he sees no reason for it either.

Planners

The planners' vision in the preliminary version of the masterplan about the design process of Ndoulomadji (cf quotes section 8.1) is illustrative for the opinion of the main-stream of planners involved in the *Senegal* valley about farmer consultation. In the definitive version of the masterplan (GERSAR et al, 1990b) attention to the involvement of the local population has become much smaller. The one section about farmer involvement says: *"It is clear that we are in favour of a consultation of the local population concerned and we judge that this is an absolute condition for the success of a scheme"*. However, it is stated that a site has to be selected *before* the support of the local population may be sought. The masterplan also provides a new inventory of sites all over the middle valley, but it is based on the same material as the masterplan in the beginning of the eighties (GERSAR 1983. Only the processing was different: topographical elements have now been projected on the soil charts of the FAO/SCETAGRI (1973). Engineers also re-used topographical charts of IGN/MAS (1956), but actualised these with images of the SPOT satellite and added extra variables on the irregularity of the topography. However, in the field it appeared that these studies are not very precise either: the extremely sandy soils that I visited in Hamady Ounare, were for instance classified as *hollalde*.

One of the implicit assumptions of the planners seems to be that *design engineers* do not have to be involved with farmers, not even in a 'consultative' way. They take his 'scientific' non-local feasibility studies for granted. If it were for the planners, the *design engineer* in the future can afford to remain distant from the sometimes hostile farmers and the local *SAED* functionaries.

8.4 The design process of the Cascas floodplain

Site selection and research during the feasibility study

The second example concerns a *design process* in which a relatively open atmosphere was created between the design engineer and the farmers. However the design process stopped without implementing a scheme. This may be the reason why the experience seems quickly forgotten by planners who are involved in the *Senegal* valley: the masterplan of 1990 (GERSAR 1990b) does not mention it.

The feasibility study incorporated an interactive approach and cost no more than conventional feasibility studies (personal communication van Driel, 1988). Instead of a number of expatriates of various professions who gather their field data over a period of a few months, now only one expatriate irrigation design engineer was involved during eighteen months. In the same period, a junior sociologist worked in the field, who was backstopped by a senior sociologist. Additional field work was done by Senegalese and Dutch students. The research was a collaborative *WARDA/WAU/SAED* effort to design an *AI*-system in a large floodplain situated near the village of Cascas, one of the sites envisioned in the *GERSAR* master plan 1983. A description of the experiment is given in Dia and Fall (1990) and in Diemer and Huibers (1991).

Taking the *SAED's* interest in the floodplain as their point of departure, the design engineer and the sociologist decided that it should be their first task to identify the part of the floodplain that would be most suitable from a physical point of view. Then, the sociologists were to determine which farmers owned land in the depression. However, after three months they had to decide to abandon the site, because of difficulties in the land-tenure situation. To avoid the risk of further delays and setbacks it was decided to reverse the procedure of site selection: the inhabitants of Cascas were asked where the scheme should be situated. After several meetings the villagers proposed a chain of five depressions nearby, totalling 452 hectares. This proposal met the *SAED*-requirements and was also acceptable to the design engineer (Diemer and Huibers, 1991).

During the subsequent feasibility study two approaches alternated. In the first strategy the design engineer asked the sociologist to gather information that could be directly related to certain design choices (such as the site, the organization of water distribution, crop choice in relation with soil quality, and so on). The sociologist was prepared to derive his study topics from the design problem at hand and not from a sociological theory. A variety of techniques was used to obtain this information in a limited period (see box 8.6). In the second strategy contacts between the design engineer, other technicians and the farmers were established. Subsequently, a dialogue was stimulated during which the sociologist and local interviewers served as intermediary actors. They noted the farmers' concerns and ideas, structured these and presented them to the design engineer. Informative and consultative meetings were carefully prepared by the sociologist and the design engineer. Again, the reactions of the farmers to these meetings contributed to the research.

The communication pattern

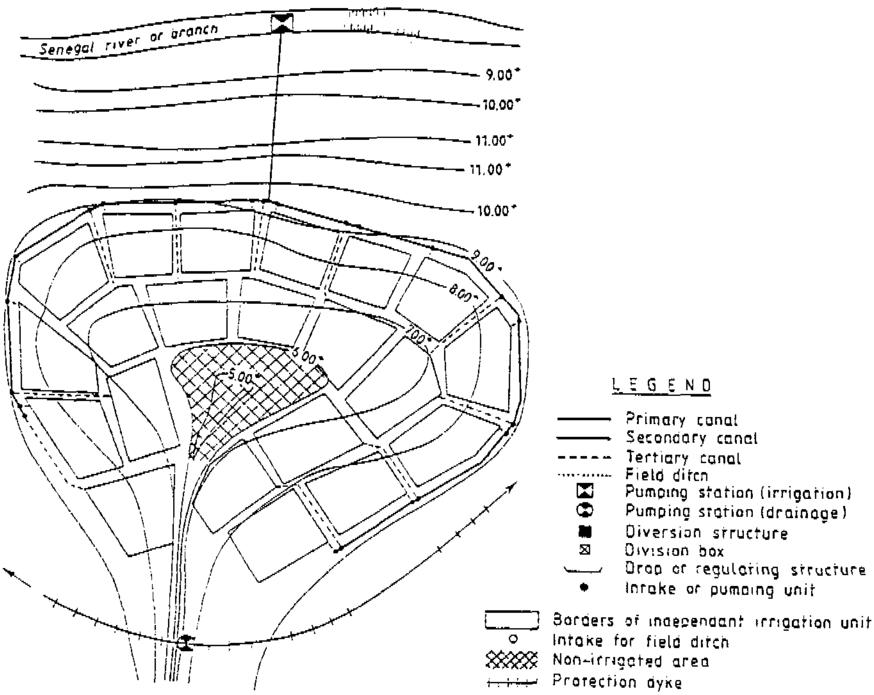
The inhabitants of Cascas and the surrounding villages expressed their satisfaction during and after the informative meetings. Once they saw that their comments were taken seriously, they showed eagerness to participate in the design process. According to the design engineer it was the growing enthusiasm of the farmers that resulted in the agreement that other villages could be incorporated in the design, although their plot size would be

"To identify the basic organizational units and relationships, semi structured interviews were held with the members of the rural council, with the village's informal leaders, with the board of the defunct village scheme, with the association for the improvement of the village, with the association of the village's migrants based in Dakar and with other groups. Topics included the villagers' view of the history of their village, the relations between the groups inhabiting it, the relations with (groups in) the village and (groups in) other villages, the rights of certain clans or individuals to floodplain land, and so on. Unstructured interviews were held at the household level. These exploratory interviews yielded some of the questions for a questionnaire that was subsequently administered to a sample of villagers. This questionnaire contained items concerning the importance that the head of the household attached to the scheme, his preference for certain crops and his opinion regarding the criteria for access to the scheme" (Diemer and Huibers, 1991 p56). In addition, farmers' comments during the topographical studies were noted by the sociologist and gave insight in relevant issues. According to the sociologist in the field the alternation of group interviews and individual interviews were important to distinguish between untrue opportunist or political information and true information. The long term character of the study, established a trust-relation and gave people time to think things over, and to discuss among themselves. The sociologists' work was dynamic and the planning was left open to allow time to research and discuss unexpected issues that could pop up. He discovered for instance how important it was to visit Cascas migrants who lived in Dakar. These people, who were used to send money to their kin in Cascas, even proposed to support the project by financing the mechanisation when the project would be implemented.

Box 8.6 Information gathering for the Cascas feasibility study

affected by this. Also women groups and the youth association could be incorporated in the design. Organizational and financial aspects of the management and maintenance of the primary level of the scheme got major attention during the informative meetings. The maintenance of the protection dike, the primary canals and the pumping station would require the reservation of large sums of money. Even meetings with the Cascas kin who lived in Dakar were organized to stress this, since it was discovered that Cascas migrants used to provide a large part of the cash inputs for irrigation. The non-residents also played an important role in the decision making about the mechanisation. At first, the design team favoured animal traction, but the initiative of emigrants to pay for the investment costs of mechanisation made them decide to introduce light mechanisation instead of animal traction.

During the meetings the farmers were informed about the physical concept of the scheme: the selection of the site and the boundaries of irrigated and non-irrigated area within the dike, the position of the protection dike and its effect on the flooding regime, the position and type of the pump (only one pumping level was necessary), the nature of the primary canal (which would be lined), the collective management and maintenance of the primary level infrastructure (pump, canal, dike), the distribution of independent tertiary units and soils over the various groups, the plot division within the units. In box 8.7 the design is represented. Despite the fact that the system was a 'high' *AI*, the *UAIs* were more autonomous than in other, now existing 'high' *AIs*, since all *UAIs* could directly obtain water from the primary canal and because the intake of each *UAI* was provided with water meters counting the water volume. As a result, no continuous control was required, but the values would be read before and after each season.



Box 8.7 The design concept of the *AI* of Cascas (source van Driel 1990)

The decision making on the technical design remained the domain of the design engineer: he asked and obtained information from the sociologist with whom he closely cooperated. He translated this information into design choices and informed farmers about his decisions. No systematic efforts were made to discuss the choices on a technical level with the farmers. The attention of farmers mostly concerned social and economical subjects and they posed few purely technical questions like: *"How can the water reach the floodplain over there, when the protection dike is constructed"* and *"How will the canal pass through this higher area?"*. These questions were gathered by the sociologist in the field and later on explained to the farmers by the design engineer. Nevertheless, many technical aspects (distr. structures, irrigation method, etc.) were not explained to them, because they were not considered to be relevant for estimating the feasibility.

Quitting the design process

Despite the growing enthusiasm of the farmers, the design engineer as well as the *WARDA* staff considered the design that emerged from the studies unsustainable. On the one hand, the investment costs were so high (more than 16000 USD a hectare), that these could not be justified by its expected economical benefits. On the other hand, the organizational requirements of operation and maintenance were not expected to be met by the organizational capacity of the village, which was divided by four political factions. *"The crucial elements here were the dike and the pumping station, since the irrigation units could only continue to exist if these were maintained. Maintaining the dike would have required frequent and considerable cash outlays. The costs of operating the pumping station would have to be met by each irrigation unit on the basis of its water use. This arrangement presupposed that any irrigation unit which refused to pay its share would be cut off. However, at the level of the village there was no agency with the authority to shut off one of the units"* (Diemer and Huibers, p62). The design engineer quickly elaborated other alternatives that were more feasible, but these were not considered to be sustainable either.

It goes without saying that, after having cooperated with the research team, this was a big disappointment for the farmers. The research period was over and neither money nor time were available to continue with the research of other possibilities. The design engineer and the sociologists were so busy writing reports, that even no last meeting had been organized, to tell the farmers the news and they had no opportunity to further negotiate. For them, the design process suddenly stopped and remained open-ended. Several years later (1991) they still asked "*Why?*". Why did we not obtain the scheme and why did other villages, like Diomandou or Ndoulomadji do so? Why, now that we have come so far? Later on, some farmers would suggest that they should not have cooperated with the research. Although the decision of the researchers may be scrupulous in the sense that they tried to judge the future situation adequately, in the end farmers were treated as usual: they had to deal with one-sided communication and were dependent on what the planners decided to do with their information. The design engineer and the sociologist were not happy with the situation either. *"But we had no time to talk to the farmers. The donor expected us to write reports"*, the sociologist said.

8.5 A comparison of the two design processes

In box 8.8 the design process of *Ndoulomadji* is compared to the one of *Cascas*. The processes have in common that farmers are highly dependent on what the design engineers and planners decide. In other respects, the design processes are different. With regard to many subjects, such as the site selection, the user selection, the attention to organizational and financial requirements of the primary level of infrastructure, the atmosphere between farmers and the design- and research team and the research quality the Cascas feasibility study seems the answer to the problems that were reported in the *Ndoulomadji* design process. It may for instance well be that a similar design process in *Ndoulomadji* had led to the choice of a more favourable site. The farmers probably would have objected to the two pumping levels beforehand and the scheme would probably not have been regarded as feasible. On the other hand, in the *Cascas* design process farmers were not involved in the crucial decision whether or not the scheme should be implemented. They probably would have preferred a traditional design process after all.

Ndoulomadji is seriously put forward as a positive example of farmer consultation. There is no reason to believe that other *AI* design processes will have more intensive contacts between farmers and design engineers than *Ndoulomadji*. The *Cascas* case was an example of an interdisciplinary approach and gives evidence that an alternative design process in early phases is not necessarily more expensive, whereas it obtains more viable information and succeeds in motivating the farmers in the feasibility phase. But also in Cascas the contact between design engineer and farmers remains limited, especially with regard to the technical design itself. However, the decision not to implement the Cascas scheme makes a comparison of construction and functioning of both schemes impossible. It is unclear how the final decision not to implement *Cascas* will turn out in the future, compared to a supposed implementation (which would mean a loss of *waalo* lands!). As we have seen in the case of *Ndoulomadji* and as we will see in the case of *Diomandou* (chapter 10) *AIs* are certainly not devoid of problems.

From the cases presented in this chapter it appears that especially the site and user selection are important in this phase. It is clear that communication about technical subjects is useful. In the case of Cascas, we do not know, whether the exchange between farmers and engineers about the technical design would have been sufficient. By presenting other cases in the next chapters, I want to give more insight in this question. Also the technical knowledge of farmers will be treated more elaborately.

Ndoulomadji (1983-1990)	Cascas (1986-1988)
Top down feasibility study; Social activation of farmers only during construction	Social activation and farmer consultation during feasibility study. Interdisciplinary design. No construction.
Farmers are informed about the technical design and do not agree.	Farmers are able to ask questions and do propositions with regard to the technical design.
Many different design engineers were involved in the process and no one can be held responsible for the mistakes. No contacts between design engineers with neither farmers nor local staff.	One design engineer is responsible for the design. Contacts between the design engineer and farmers exist, through intermediary of a sociologist in the field and several meetings.
Farmers criticize the fact that they had not been involved in decision making, for instance about the two pumping levels and site selection.	Growing enthusiasm of farmers and constructive propositions. Agreement on the design.
The site is selected on the basis of faulty physical data. Farmers' criticize the quality of the site.	The site is selected by the farmers and (physically) acceptable for the design engineer.
Refusal to admit other villages to one's own territory. Women and youth groups cannot be included, because of a limited area.	Willingness to integrate women groups, youth groups and other villages in the scheme, despite a limited area
No information to farmers beforehand, about the true maintenance requirements of the scheme. The first year, SAED pays the first pumping level and is still involved.	Clear information about the maintenance costs. Proposition of the migrants to finance the mechanisation themselves
The feasibility of the project is never seriously contested. Farmers are expected to behave as they are supposed to.	The project is considered unfeasible and farmers have no opportunity for negotiation.
In addition to the construction, emergency programmes and extra projects have to be formulated.	No construction at all.
In the first season farmers are generally enthusiastic and reasonably satisfied about the system.	Farmers are disappointed. They have a hangover since the project has ended suddenly.

Box 8.8 Comparison of the design processes of Ndoulomadji and Cascas

Chapter 9

IRRIGATION AND DRAINAGE REQUIREMENTS IN THE PIV ABDALLAH III

9.1 Introduction

The next example treats a design process of *PIVs*. In general, design processes of *PIVs* are less rigid than those of *AIs*. Probably, the original food aid objectives and the consequent focus on quick and cheap construction in the field made the design process of *PIVs* develop differently. Decisions to implement projects did not require voluminous feasibility studies. Although a certain construction rhythm was demanded by the planners, most *PIV* design processes have a flexible site and user selection, in which farmers can participate. But once the site has been selected, the design can often not be changed any more. The design process of the *Ile à Morphil* project is an exception to the usual procedure. In this project the contact between design engineers and farmers is the most developed and there is flexibility to the extent that, even during the construction phase of the *PIV*, plans can be adapted.

The *Ile à Morphil* is the area of intervention of a bilateral project that is funded by the Dutch government. The project started in 1977 as a reaction to the long dry spell in the early seventies. The construction of *PIVs* was the first activity of the project and has always remained the central activity around which other project activities developed. The project base is situated in Cascas, in the middle of the area. In 1989 the design engineer of the case here described started to work in the *Ile a Morphil* project. After a two weeks overlap he took over from his predecessor, an engineer who is known for his interest in participatory design. He lived for six months in a *Haalpulaar* village in the area, when he was a student. He knew the farmers *practices* well. His view on the design process is represented in box 9.1. The new design engineer was less interested in experiments with participatory design than his predecessor, but considered the project experience as a part of his professional job. He was not interested to conduct new experiments with farmer consultation, because, to him, (1) the technical quality of design and construction and (2) the fact that the *PIV*-concept only requires a limited organizational capacity are far more important factors to guarantee the success of PIVs. His interest lies with the organizational aspects of the design and construction 'team': surveyors, masons, bulldozer drivers.

"As regards the criterion of quality, up to 1986 specific attention was paid to the technical aspects of the schemes. (...). From 1986 onwards an attempt was also made to pay conscious attention to the quality of the structural process of scheme implementation. This because it appeared from preceding phases that in spite of an improvement of technical quality, some villages still had problems using their schemes, or that in an exceptional case, e.g., because of discord between two factions in the village, the farmers abandoned them altogether. In an attempt to avoid problems of this kind we have tried to incorporate consultation with the users in the framework of the design process, and to base the physical lay out on their contribution as well. The communication with the farmers took another turn and some steps were added to the design process:

- *Discussions with the future users during the preparation of a specific scheme in order to make an inventory of their ideas concerning the design and the future organization,*
- *excursions to other schemes*
- *presentation and discussion of some alternative designs, and*
- *a guarantee on the technical quality after the first growing season if adaptations prove to be necessary".* (Meijers 1990, p 3)

Some examples of adapting the design to the farmers' situation

- While making the design drawing, the design engineer makes use of information - e.g. about the village organization or land rights - that comes to him through extension officers, surveyors, masons, and/or bulldozer drivers: the "design team", according to Meijers. He may adapt the lay out of the *PIV*. In one case, a village appeared to be divided in two political factions, and consequently two conveyance canals were constructed in agreement with the farmers, although this required more work.
- During construction, canals may be adapted to the traditional land tenure or farmers preference for other soils, the wish to leave space for cattle, etc.
- Even after construction, the design is not over. Plots may be repositioned or added; dikes may be added or (partly) reinforced; drains may be changed into irrigation canals when the farmers want to; conveyance canals may be adapted to diminish erosion risks.

Box 9.1 The view of Meijers, design engineer on the *Ile à Morphil* river Island between 1986 and 1989, on the design process of the project

9.2 The example of Abdallah III; (first part: The general communication pattern)

The oldest *PIV* of Abdallah (20 ha) was constructed by hand in 1977 and rehabilitated in 1983. It is now used for the production of corn. The second *PIV* of 40 hectares is now used for rice cultivation and was constructed in 1983. The conveyance canal was ameliorated mechanically around 1988. The following example is about the design process of the third *PIV* of Abdallah, which took place in 1989-1990.

The example

In Abdallah, I interviewed the representing members of the GIE of the PIV and asked them whether they had talked to the design engineer before the construction. They told me the usual story: he comes and explains; they show him the site and he agrees, he is present to control the work during the construction. They also stated that the design engineer requested them in the beginning, to inform him when they had any ideas for the irrigation scheme. During the design process farmers frequently assured the design engineer they supported him and complimented him. He made the design on the site the farmers had indicated. However, during the construction it appeared that the scheme was partly situated on land claimed by the neighbouring village Wala. The design needed to be adjusted. After the construction the farmers made it clear that the lay out of the scheme had to be adjusted again (see part 2 of the example).

Farmers' perspective

The attitude of praising or pleasing the design engineer, assuring that they are 'all behind him' is a normal ritual during the design process. Later on, however, farmers come up with new information, or they start to make demands. In the *Ile à Morphil* project it often happens that farmers do not start to make their wishes known before the machines are present to construct the scheme. The major reason for this is that they are convinced that, when they demand more, the engineer, the state, or perhaps more neutral, 'something' may turn against them. Farmers' representatives in Abdallah told me that they did not tell the engineer about their wish beforehand, because ..."*if someone gives you something, you should not say 'this has to be changed' and 'that has to be changed' because there is a risk that you lose everything*". In general, farmers are careful about the information they give to the *design engineer* and for instance leave out information about land tenure that might make the site less attractive to the design engineer. In other cases, when they want him to choose another site that has their first priority they are only too eager to present a site as unattractive as possible. Thus, farmers consciously manage the information they have, because "...*he who implements decides*". In the next paragraph we will see, that another reason for their timing of requests is that they were mislead by the topographical markers in the field.

The design engineers' perspective

In the beginning, the communication remains limited to information gathering by the engineer about the site of the scheme. He says that he *does not like to behave like a school teacher* and, apparently, treats the farmers as grown-ups with their own responsibilities, by clearly requesting them to inform him about their ideas about the design. With the farmers' assurance they are behind him, he continues with the design and adapts it during the implementation when the boundaries of the site appear not to have been correct. Later in the *design process* he even adapts the lay out for a second time.

The farmers' idea "the bigger the better" pops up every now and then, and not only in the *Ile à Morphil* project. The plot surface can be considered as a general subject of negotiation. A reason for the farmers to opt for a bigger scale is that they want to preserve land for the village and family in the future since the national law on land-rights implies that irrigated land cannot be expropriated easily. Another reason is that they want larger plots, which is directly related to a larger scale, as the number of households is fixed. The idea of owning a bigger plot appeals to them and they may tend to ignore water scarcity problems. This is also illustrated by the problem priorities of the Abdallah farmers (box 9.3): even during the functioning of the *PIV* farmers in Abdallah consider the small size of the plots as a more important problem than the long rotation period (25 to 33 days). It appears that the concept of owning a plot is more appealing then the (short term) productivity of the plot.

Owning a large plot may also seem to fit in a risk-spreading strategy. But with regard to irrigation it is not always favourable to own large plots, since pumping costs are high. Farmers cannot always judge beforehand what design engineers mean with figures about the size of the plots and what these mean to their farming system. E.g. in *Diomandou*, farmers claimed 4 hectares during the design process of an *AI*. When many of them finally got a plot of one hectare, they were impressed by its size. Later, one of them would make jokes about the size to visiting farmers. "*The plot fatigues me very, very much*", he said, laughing.

Box 9.2 Motives to opt for large plots and large sites

9.3 The example of Abdallah III; (second part: communication about a technical issue)

The example of the *design process* continues:

After the adaptation that was needed to cope with the land rights problem, the design engineer made the design in such a way that he left out a lower part in the middle of the PIV that could not be drained, probably creating a production loss. But after the construction, a discussion arose about the lay out of the scheme. The farmers said there were too many sandy plots and wanted the design engineer to add the lower area to the irrigation system. Finally, the design engineer decided to extend the system somewhat to the lower part, but the lowest part remained as it was. He told me the farmers finally agreed to his supposition. Later on, Abdallah farmers had a discussion with the *topographer who stayed behind in the village. The farmers told him they had seen the markers of the survey and therefore thought that the whole area within was to become part of the scheme. The farmers told me that the topographer had explained them that there were two types of plans: a 'basic' plan and an 'additional' plan. They did not agree that the project returned with the 'smaller additional plan' and told the topographer: "If you come for what we want, do the whole surface. But if you come for what* **you** *want: leave it".*

Later, the design engineer gathered from his topographer that it was doubtful that the farmers would leave the lower area in its natural state. "The farmers told me they agreed with my supposition, but behind my back, they will probably irrigate the lowest parts too", he said. He asked himself whether it would be a good idea to take the farmers to Dounguel, where the consequences of drainage problems were apparent. However, other activities got his priority. In this particular case, he was for the first time conducting a precise levelling of plots, which required a new organization of the surveyors and engine drivers.

The design engineers' perspective

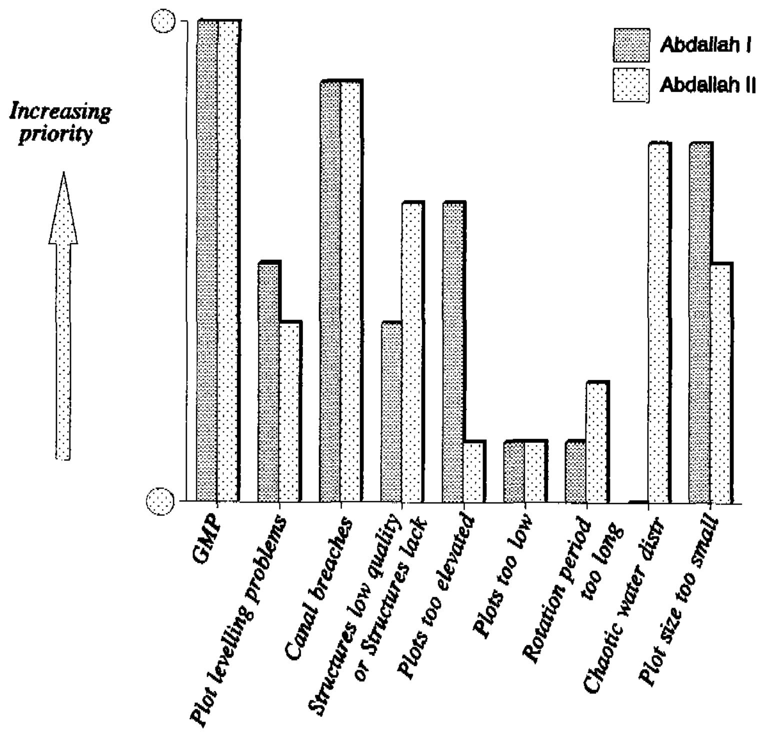
The design engineer acts on the basis of the technical knowledge he acquired about plant water requirements and drainage requirements. One of the most important starting points in design is that the water availability has to keep up with the water needs at field level. This starting point led to the rule of thumb that each GMP having a capacity of 80 l/s cannot irrigate much more than 20 ha of rice crops. This design norm is never questioned by design engineers in the *Senegal* valley. If the scale exceeds 20 hectares water scarcity results and the production will drop and even in a number of *PIVs* in the project area farmers have this problem, despite the fact the scale of their *PIV* is around 20 ha. Although the design engineer in this example adds some plots in the lower area, he sticks to his demand to limit the scale, by leaving other plots out of the design. This is not only in accordance with one of the most basic starting points in design, but it also seems to be in the interest of farmers from the viewpoint of productivity.

Another condition for design engineers is, that the irrigated area has to be drained. This condition is less rigid than the previous one because *PIVs* are often situated in sandy areas. Besides, it is argued that the *PIV* concept is not meant to be too expensive and only a simple drainage system can be allowed for. So when sites, being favourable from topographic and soil-perspectives, cannot be optimally drained this is not a major problem. Only when an area will face severe drainage problems, it makes no sense to plan the scheme over there. Nevertheless, the boundary between an acceptable and an unacceptable drainage situation cannot clearly be drawn. In the example the design engineer considered the area in the middle of the PIV too low and left it out of the scheme, but when the farmers did not agree with him he meets them halfway and decides to add some plots in the lower part of the scheme. From his professional viewpoint he considers it too risky to add everything. Besides, he is conscious about drainage problems that do occur and about which the farmers complain in other *PIVs* in the project area. He does not want the farmers of Abdallah to have drainage problems. The *design engineer* acts *for* the farmers, which is, according to him the best thing to do in this situation.

The farmers' perspective

The preservation of landrights and the idea of owning a big plot (*the bigger the better*) may orient the farmers when they talk about the site selection and the lay out of the scheme (see box 9.2). But although these motives are important, farmers also rely on their technical knowledge. From former experiences with crop husbandry in the area they know the soils better than the engineer and for traditional agriculture the best soils are normally found in the *lower* places. Farmers often prefer these for irrigation as well. Their preference for lower plots does not imply that the Abdallah farmers are ignorant with regard to drainage problems. To the contrary, they are familiar with these problems in the lowest parts of their scheme. Equally water-scarcity problems are well-known (cf box 9.3) and in the existing *PIVs*, especially the second one, the rotation period is considered too long. The farmers of Abdallah stated that the water scarcity first occurs on sandy - and often *higher* -plots, where *"...the water is gone within two hours"*. Their most important problem, however, is the functioning of the *GMP* (box 9.3). Farmers indicated that they were concerned about this, because both *GMPs* had been recently defect.

When one considers the farmers' technical knowledge only, it seems contradictory that they are not sensible to the design engineers arguments to limit the scale. Besides, they are not susceptible to his argument to avoid drainage problems. One is inclined to believe three things: (1) farmers wish to preserve their land rights, (2) they prefer large plots and (3) they want to use the traditionally fertile soils. A design engineer may reason that their socio-economic considerations simply turn the balance in favour of extra plots, taking water scarcity and drainage problems for granted. However, considering all aspects of their technical knowledge carefully, their wish to increase a number of plots in the lower parts of the scheme fits perfectly in a logic that counts with water scarcity, drainage problems as well as *GMP* defects. To understand this, it should be realised that the experience of water scarcity is part of their history, which probably already has been internalised as a second nature. Once water scarcity is perceived as a given, the perspective changes completely. Now, anyone would prefer the lowest plots, despite occasional drainage problems: the production loss will probably be amply compensated in periods of water scarcity, as these fertile soils remain moist enough. Besides, 'objectively', the Abdallah farmers may be right in regarding the water scarcity as a given fact because even in a *PIV* that does not surpass the 20 hectares limit, the *GMP* remains an uncertain factor liable to cause a long rotation period.



Box 9.3 A comparison of the old and the new PIV of Abdallah, with regard to farmers' irrigation problem priorities

Other examples also indicate that the farmers' wish to use the lower soils is often valid: in Cioure another village on the *Ile à Morphil* farmers chose to implement the lowest part of a site and did not regret it because, despite occasional drainage problems, their production was good. In Fonde Elymane (also on the *Ile à Morphil*) the people who complained about drainage problems admitted that they reached a better production than farmers in the same scheme, who had lighter soils.

The misunderstanding

Consequently, water scarcity and drainage problems are closely connected by the farmers. The design engineer, however, works with the practical logic that the two are relatively separated: Water excess is solved by a drainage system and water scarcity by an irrigation system. Moreover, for him the *GMP* is not such an uncertain factor as it is for the farmers.

In the design process of Abdallah, despite the discussions and a relatively open atmosphere, the farmers and the design engineer remained unconscious about each others' technical knowledge. The confrontation of the two logics is bound to give rise to misunderstandings. The design engineer thinks that the farmers want to have the lower plots because of their wish to preserve land rights and their preference for traditionally fertile soils. He assumes that farmers are interested in a system with no water scarcity at all, but overlooks their basic assumption that water scarcity is a given fact. On the other hand, the implicit assumption of farmers that water scarcity will occur - whatever a design engineer may propose - turns into a self-fulfilling prophecy, when they decide to add the lower plots, increasing the rotation period, causing water scarcity. Once water scarcity exists, farmers with the low plots may reason: "*You see, we were right!*"

Image about one another

With the outcome of the farmers' prophecy, the design engineer's knowledge will be judged negatively by the farmers. Farmers are not satisfied with the design engineer's behaviour, arguing: "*If you come for what we want, do the whole surface, but if you come for what you want, leave it*". They may think that they are fooled by the markers of the surveyors, that seemed to be the prelude to a large *PIV*. On the other hand, when the design engineer discovered he had not convinced the farmers, he concluded: "*Behind my back they will irrigate the lower plots anyway*". He did not like that they did not tell him that face to face. He may get the idea farmers cannot decide on this *technical matter* of water scarcity - since they want bigger plots or traditionally fertile soils anyway - and therefore, he has to remain in control of the design process. When I asked him about it, he confirmed that farmers in other villages often do not take his *technical knowledge* seriously either. In one case farmers told him they preferred a certain canal for '*technical* reasons'. However, from his own technical perspective, he could not agree with the farmers' proposal. Afterwards, farmers tried to force him with the help of the local SAED director.

9.4 The state of the art of communication between design engineers and farmers in the *Ile à Morphil* project

As we have seen, the knowledge of Abdallah farmers seems to originate from their existing experience, which is limited to their two older *PIVs*. This knowledge is not complete, and one may question whether it is appropriate for any new scheme. An excursion to another PIV could have broadened their view. The design engineer thought about it, but gave priority to other activities, and therefore we will not know whether Abdallah farmers could have been convinced by visiting the other *PIV*. His question to farmers to make explicit their wishes, his adaptation of the design during the construction phase, as well as thinking about an excursion, without actually organising it: these practices on the *Ile à Morphil* project illustrate the state of the art of the most developed interface of farmers and design engineers in the middle valley. Its design process comes closest to a participatory design, taking the farmers' knowledge seriously within certain limits, but still it cannot be considered as interactive participation (Pretty, 1994). But it would be interesting to know, how a more fundamental discussion about technical issues and assumptions could be stimulated. Unfortunately, from the remaining projects in the valley the reader cannot learn *how* to reach such a knowledge exchange either. He or she will only learn about other misunderstandings on the interface between design engineers and farmers. Nevertheless, these are interesting as well as useful for this thesis.

Chapter 10

STRUCTURES AND CANALS IN THE AI OF DIOMANDOU

10.1 Introduction

The third example is enacted south from the *Ile à Morphil*, in the floodplain of Diomandou, where a 468 ha irrigation scheme was constructed in 1988-1989. It is one of the four *'high' AIs* the European Development Fund (*EDF*, *FED* in French) wanted to develop in the period 1986-1991 in the region of Podor. The *EDF* project stands for integrated development, but irrigation is a central focus around which other activities are implemented. The development of the Diomandou scheme is part of the project and involves 5 villages. The design process of Diomandou is comparable to the one of Ndoulomadji in the department of Matam. The design engineer, the engineer who supervises the construction and the engineer who assists after the construction has finished are not one and the same, but three different actors. With regard to the decision making the emphasis lies on the earlier project phases, where the actors involved try to determine the design as much as possible. The design was essentially the work of the European consultancy *SCET/AGRI*, with the approval of the *SAED* and the *EDF*. Reports, written in Europe, served as a basis to negotiate with the planners, among whom the design engineers from the *BEC*.

10.2 Involvement of farmers during the design process

Before the construction started farmers' representatives were only asked their opinion about the size of the irrigation system and were solicited whether they wanted to cooperate with the surveys of *SCET/AGRI*. *"They asked us: 'Do you want a large scale irrigation system or a PIV?' The conclusion was, that in a PIV nothing remains for you, after having paid the inputs. You will not have a high profit"*. During this meeting questions were asked about who would be the users and farmers expressed demands, like the wish to have mechanisation and large plots. Others complained about the bad quality of *PIVs* and wanted the *SAED* to finish the work that still had to be done. A minority insisted on sparing the *waalo* lands.

Informative meetings beyond this only took place during and after the construction phase. During these meetings, farmers representatives wanted to negotiate about demands of the *SAED/EDF*, such as the criteria for plot ownership, plot size, the crop choice and crop intensity, the type of mechanization, the organization of the cooperative and the planting

1986 - Representatives of the *SAED* and a sociologist of *Agrer* discuss the irrigation option of the cuvette with the farmers of Diomandou and Thialaga. Equally, the Conseil Rural and the local administration are approached. They are asked to cooperate with interviews about land rights, and later on about demography, family composition, availability of labour, production activities, health, etc.

86/87- Interviews with 20% of the farmers in three villages.

1988 - In February 1988 the project and its objectives are presented to the farmers of Diomandou, Thialaga and Dodel. The farmers are asked to cooperate with new interviews. A discussion arises about the criteria of plot allocation. Later, the planners would decide to relate the plot size to the available labour in each household.

- From 7 to 31 March 1988 the *SAED* interviews all household representatives about their family composition. Diamy Baila and Diouwa, two 'Peulh' villages are now newly included. The users' choice is determined as follows: Every head of the family of each village has to be present, the Village Leader and a representative of the *Conseil Rural* have to check his answers to the questions of the *SAED*. Only households that payed their taxes in 86/87 are called for. In this way, the SAEDs' decision is manifested that people who have not payed taxes in the village itself, even *jom leydi*, will not get a plot.

- According to plan the construction work would have started from February 1988 on, but it did not start before June 1988. The farmers of the five villages concerned wanted to have priority in getting work, but saw to their dismay that the contractor took the workers he wanted. It nearly came to blows.

1989 - In January the *EFD* and the *SAED* present their plans in more detail in the presence of representatives of all villages concerned. They pose three new demands to the farmers: (1) they have to grow two crops a year, (2) they have to plant and irrigate trees and (3) they will have to use animal traction for the cultivation of their plots. The farmers especially dislike the demand of animal traction, since they had expected mechanized agriculture, saying they had been promised to get it. Only because of new promises about the ease and advantages of the scheme, the farmers accepted the demands.

- The highest official of the *EFD* in Senegal, "Madame *FED*", asks the farmers to give a piece of their land to their women for a vegetable garden. The farmers are reluctant, but the *Conseil Rural* agrees.

- After this general meeting, meetings on village level were organized, where extension workers helped them in forming *GIEs*. After this, the members of the *Union* were chosen.

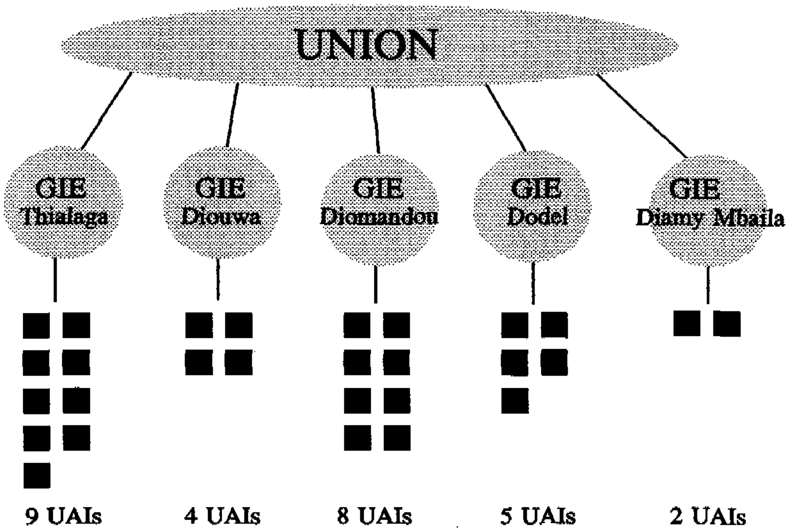
- In May a last general meeting was held. During this meeting, the farmers again questioned the earlier demands and they declared that they considered the plots too small: they wanted 4 ha instead of 1 ha. The farmers finally accepted the demands, after promises of "Madame *FED*" about the good technical quality of the scheme. The scheme is finished in July 1989.

Box 10.1 Farmers' involvement in the design process and irrigation of trees, but all these demands had to be taken for granted by the farmers, which they did reluctantly. They probably only agreed to it because the *SAED/EDF* repeatedly promised them a profitable and smooth irrigation. The two most important negotiation issues were the criteria for plot ownership and mechanization. The *SAED/EDF* wanted a scheme for 'commercial' farmers and therefore related the plot size to the available labour of each household. In this way, they wanted to avoid that land owners who lived in Dakar leased their land to share croppers, which implied that in some cases even *Jom Leydi* could not obtain a plot. *"We had too many discussions about this"*, a farmer remembers, *"because it is their land anyhow. How can you give this land to another person without giving it to them* [people with valid traditional claims]*? People did not agree about this question"*. With regard to mechanized production the *EDF* had a negative experience with the introduction of mechanized agriculture in the middle valley, mainly because of maintenance problems. For this reason they wanted to introduce animal traction. The farmers did not agree, but could not change the donors' mind. Besides, emotional discussions took place, because farmers wanted the contractor to hire workers from their villages only, but they had to give in. The involvement of farmers during the process is presented in box 10.1.

An important part of the meetings was dedicated to the organizational structure of the irrigation scheme. *SAED* extension officers spent a lot of time to mobilize the farmers, who had been told from the beginning they would have to work together with other villages. The organizational structure of the irrigation system is presented in box 10.2. Apart from this, the farmers were informed they had to pay for all costs of operation and maintenance once the system would be operational. It is remarkable that this was not an important negotiation issue. However, the question arises wether the farmers' representatives understood that the fixed costs would be an important part of the expense. It may very well be that the *SAED/EDF* have not presented this clearly, whereas, on the other hand, emphasis was put on the smooth operation and maintenance of the irrigation scheme. On one occasion, an official promised the farmers that the irrigation would pass of so smoothly, that they would be able to irrigate in their best clothes. Besides, communication about technical aspects was limited to informing the farmers about the 'independence' of tertiary units.

10.3 The technical design of Diomandou

The designers of *AGRER/SCETAGRI* wanted to reduce the costs of operation, assuring a higher level of so-called 'technical security' for the operation of the irrigation infrastructure (AGRER et al, 1987). By automatizing part of the daily operation it is tried to facilitate things for farmers. By designing solid canals and structures, requiring high investments in the infrastructure, the maintenance should be reduced as well.



The UNION consists of a president, a secretary, a treasurer and four members. The UNION maintains contacts with the bank, input delivering and processing organizations, and makes the planning for the growing season. The UNION manages the irrigation system on primary and secondary level, and employs two pump attendants. They do not employ water inspectors, as the SAED/EFD had wished. The members of the UNION considered this too expensive and refused to do this. The UNION covers 5 GIEs and administrates what each GIE has to contribute to all costs. In many activities the UNION was assisted by the extension officers. The UNION is controlled by all participants of the Diomandou scheme.

In the Diomandou system each participating village has formed a GIE. The GIEs can be seen as an intermediate between the UNION and the farmers. The GIE covers several UAIs, tertiary units. The UAIs have one UAI-president, who is responsible for the operation and maintenance of his tertiary unit. He has to mobilize the farmers of his UAI to this aim.

Box 10.2 Organizational structure of the Diomandou scheme

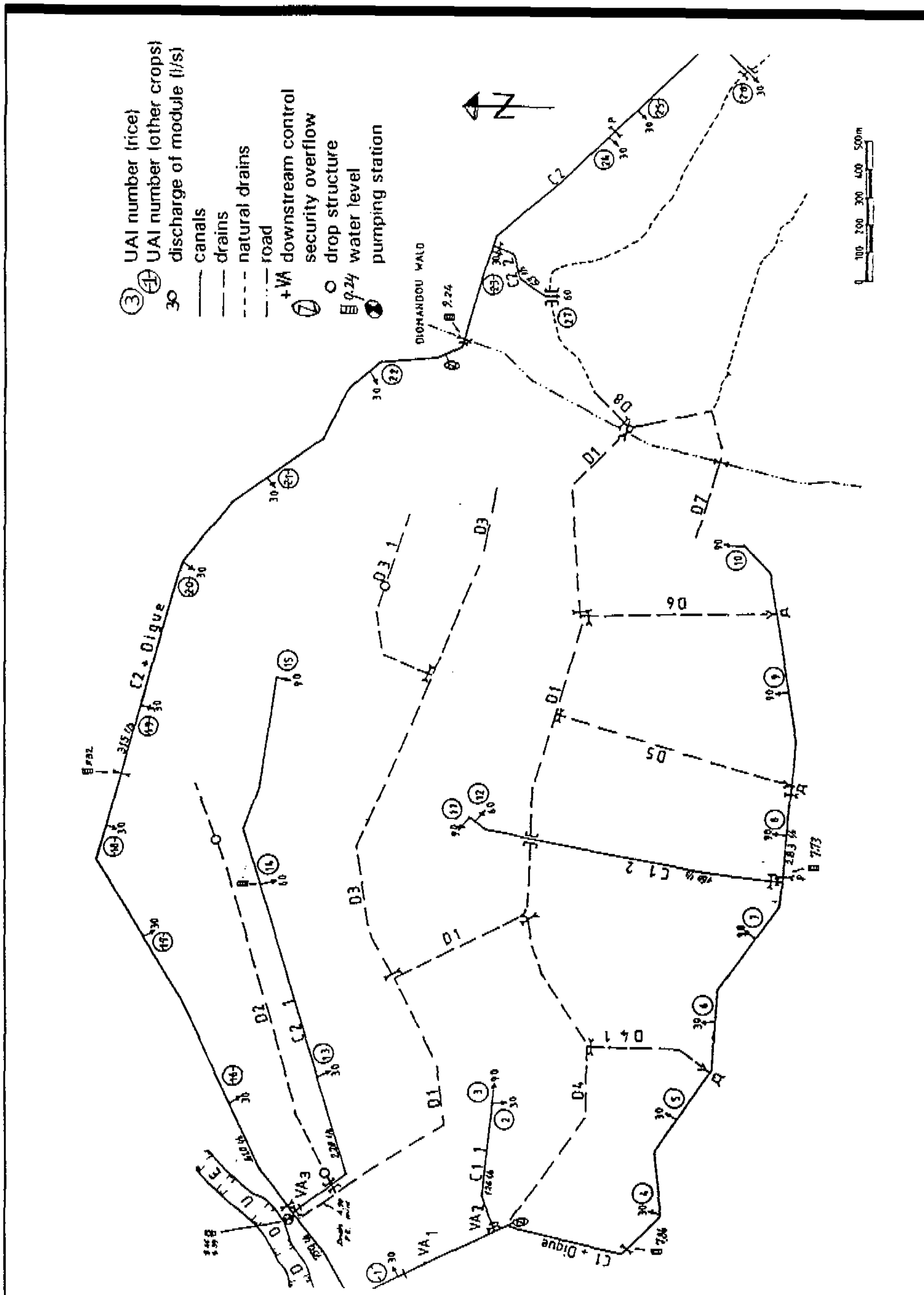
The lay out of the *Diomandou* scheme (468 ha) is given in box 10.3. In the lower parts of the environment that surrounds it, a high dike protects the floodplain. Near the river a pumping station is built with a capacity of 1530 l/sec. It is used for irrigation and drainage. When irrigation is necessary, drainage water may be re-used by pumping it into the irrigation canal. Whenever the water level in the irrigation canal is too low the pump turns on automatically and stops when a certain maximum water level is reached.

The floodplain of Diomandou is practically surrounded by a concrete primary irrigation canal and four secondary canals are required to transport the water to the area in the middle of the floodplain. The primary canal is equipped with two downstream control structures that automatically open and close when the downstream water level falls and rises. In the case of rainfall, automatic culverts start siphoning water from the main canal into the drains. Three aqueducts are provided where secondary canals cross drainage canals. *UAIs* take their water by means of *modules à masque*. In the tertiary canal check structures were placed, existing of 40 cm thresholds that were provided with a small orifice below (see box 10.4). Although the check structures in the prefeasibility study still were described as "simple structures of the type used in the PIVs of the *Ile à Morphil*", the design engineer, apparently, adapted this plan later on.

10.4 Different perspectives on canals

An interesting interface-situation occurred when water was applied for the first time to the *UAIs*, in the presence of supervising design engineers, seeing to the proper technical functioning of the irrigation infrastructure:

In July 1989 the very first water gift had to be applied with the newly constructed Diomandou scheme. In two days the 10 km concrete main channel that surrounded the Diomandou floodplain was carefully filled with water to avoid cracks in the concrete because of sudden water pressure changes. Then, the 'modules à masque' could be opened to provide each UAI with water. UAI 9 (30 ha), one of the eight UAIs of the village Diomandou, was one of those. A French design engineer of the supervising consultancy, extension agents and the local SAED director came together in order to explain the farmers how the water had to be distributed. The inlet could take a maximum of 90 l/s from the main canal, when all of the four slides that the 'module à masque' is composed of would be opened simultaneously. The engineer explained the farmers to only open the smallest slide of the inlet (10 l/s) to avoid breaches in the still dry soil of the canal. Despite this precaution, plot owners had to be present to check the bunds in front of their plots, in order to cope with possible canal leaks and breaches. The water was to pass several check structures (box 10.4). When the water would slowly reach a maximum level, the irrigation could start with full water volume, beginning with the most downstream plots.



Box 10.3 Lay out of the *AI* Diomandou (source SAED/BEC 1988)

But it all worked out differently. Realising the irrigation would proceed so slowly, several farmers were discouraged. They left their plots and went home. Finally, some farmers protested. The president of the GIE of Diomandou told me: "...During the first water gift, the supervising engineer (....) wanted us to irrigate little by little, but we wanted to take the whole volume at once, as we are experienced in irrigation. The engineer may have much knowledge, but his way was not our way of working. So we told him: 'When you do not accept our methods, we will leave the irrigation.' The engineer replied: 'When there will be some damage caused by this, you will have to repair it yourselves'. After this, we irrigated the way we wanted", the president said. "There were some leaks and breaches, but we stopped it. (...) Some canals broke near the field inlets, but we repaired them. Even in the PIVs this used to be our work."

The farmers' perspective

Before the construction the irrigation scheme is almost entirely left to the farmers' imagination. They were never invited to present their ideas about the scheme. On the other hand, it is not surprising that the farmers did not ask questions nor made firm demands, since they did not want to lose the entire project.

Later, while the irrigation system was being constructed, the farmer representatives tried to negotiate about the demands of the *EDF/SAED* but did not succeed and had to accept them. The only thing they got were promises about the smooth operation and maintenance of the scheme. Needless to say, they were keen on their fulfilment (Nieuwenhuis 1990). The farmers had some 'passive resistance' after the construction of the scheme: they were not as enthusiastic as the donor and the *SAED* had hoped for. When the pumping started no farmer was present to prepare his field. *"We were glad when we saw the first farmer"*, a Belgian mechanic said. By sowing the already irrigated fields himself, the *SAED* director of the Aere Lao region had to give the example. Only then, farmers started to sow their fields as well.

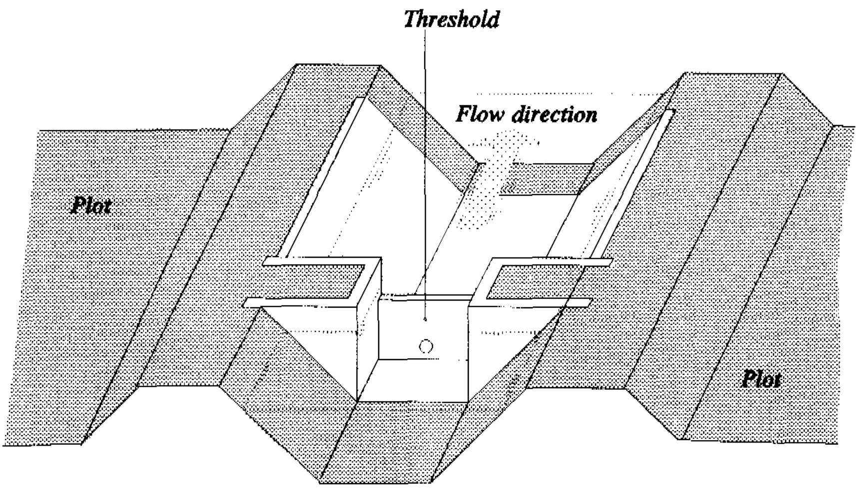
The first water gift may be regarded as an important moment, not only because a large number of different actors were gathered, but also because at this moment the scheme is turned over to the farmers. The farmers again had to take new demands for granted: demands from the design engineer. They could only open the smallest slide of the *module à masque* and had to be present on their plots while the water slowly continued for several hours. After a while, some farmers started leaving their plots, because it took too long. At this moment, the president of the *GIE* of Diomandou confronted the design engineer directly, saying the farmers refused to irrigate in this way. He may have tried to win back respect: in general, as a reaction to the frustrating negotiation process, and specifically as a reaction to the implicit judgement by the engineer, that their way of irrigating in the *PIVs* was not the right way. Being constructed in 1974, the *PIV* of Diomandou may be even the oldest *PIV* of the Podor region and the farmers were proud of this. Besides, having internalised the daily irrigation practices, the president of Diomandou was convinced about what he said.

The technical image of the farmers of Diomandou is related to their experience in *PIVs*, where every morning the *GMP* is started and the canal is filled with water. The 80 l/s water outflow may cause the water to advance at a rate of 10 meters each minute. The time farmers have to wait before they can irrigate varies roughly between 0,5 and 1,5 hours. The proposal of the engineers to start irrigating with 10 l/s does not fit with the 15 years' day-to-day habit of farmers to make use of the *GMPs*' full capacity (80 l/s). When it appears that the water advances much slower than they are used to the farmers object and protest. In the second part of this example we will see that the check structure with its threshold and small orifice is regarded to slow down the advance rate of the water even more.

The perspective of the design engineers

The design engineers who were involved remained at a distance from the farmers. The design engineer (or the design team) who made the design in Brussels probably did not talk at all to the farmers for whom he made the design. During the construction two engineers controlled the contractor: a Senegalese engineer of the BEC and an engineer of a French consultancy. Given the rhythm of the construction work they had a busy job, so there was practically no time to talk with farmers. This may well have been the reason why the farmers considered the French engineer to be 'not communicative'. The French engineer was present at the moment of the first water gift. When farmers considered his way of irrigation to be too slow the engineer was not able to stop them from irrigating with full water supply. Apparently, he did not manage to convince the farmers about his 'logic', and in this stage, he had no power over them: farmers had already received their plots. Later on, after the system had been turned over to the farmers, a third engineer came on the scene. He left the contacts with farmers to the extension officers, for one reason because his *TOR* did not permit him. He will receive attention later on.

In the design it is tried to make things easy for the farmers. By simply opening and closing their field inlets irrigation would be possible. By the end of each day, the plot inlets and the '*modules à masque*' were to be closed, and water was to remain in between the check structures during the night. In this way the water quickly reaches the plots again when the *module à masque* is opened the next day. An even more important advantage of the remaining water is its positive influence on the stability of the canal: the canal bunds were to be protected against the destabilizing daily pressure variations. Thinking *for* the farmers in this way made several functionaries promise the farmers that the irrigation would be very easy.



The water flow in the UAIs is regulated by concrete check structures. These small weirs have thresholds that make the water rise directly upstream, allowing the water level to rise high enough to irrigate the plots upstream. When the plot inlets are closed the water rises until the threshold overflows, allowing its users to start with the irrigation of the downstream plots. Under the threshold is a small orifice, which is provided to drain the canal for maintenance.

Theoretically, the only thing users have to do for irrigation is to open the inlet of their UAI, open their plot inlet and wait for the water to come: the water level will high enough to facilitate irrigation.

Box 10.4 The check structure of *Diomandou*

10.5 Different perspectives on structures

The first irrigation season in Diomandou the check structures posed problems. The type of the check structure with a threshold was new to the farmers. During and after the first water gift the engineer, and later on extension officers, explained the farmers how to use the structure. Probably, the farmers already expressed their doubts during the first irrigation. "When we saw it for the first time, we were afraid" a farmer said to me, and although at first he was relieved to see that "..if you want to irrigate the plots further away, the water first flows through the hole, and then over the threshold", later on his doubts came true: "In some cases we broke it. The hole is too small. One has to wait all day long and eventually only a small amount of water comes through. Moreover, the *water overflows the bunds upstream of the structure, since there is too much water in front of the structure and too little water behind it. So we judged the structure is not well made, even if it functions well in some cases" (farmer representatives of Diouwa). For similar reasons, farmer representatives of all five villages concerned with the Diomandou scheme considered the structure as a major irrigation problem.*

But supported by extension officers, the design engineer who was concerned with the operation and maintenance of the scheme, continued his efforts to explain how the structure should be used properly.

The farmers' technical knowledge

In the first generation *PIVs* farmers regulated the flow themselves by putting sacks or other obstacles in the canal, directly downstream of their plot inlet (cf box 5.6). When irrigating further downstream these obstacles were removed. In the second generation *PIVs* the concrete check structures were provided with a slide. For irrigation of upstream plots the slide was put into the frame, which made the water level rise. If one wanted to irrigate the downstream plots, the slide was taken away. The threshold of the check structure in Diomandou, however, cannot be taken away. The only thing to manipulate is the orifice, but although it is meant to be opened only once or twice a year, farmers open it whenever the downstream plots are irrigated. They open and close the orifice at moments they would have opened and closed slides. In their comments about the structure they frequently say "the hole is too small" and this indicates that, in their view, the orifice should replace the slide.

In the eyes of the farmers, the check structure is a major problem in the scheme, receiving their priority directly after plot levelling and overflowing (see box 10.5). According to them, it not only increases the time lag at the beginning of the day, but it even keeps blocking the water once the canal is filled. In their view, bund overflowing and canal-breaching directly upstream, are some of the effects. The farmers also state that the structure enlarges the time lag and/or the rotation period. For these reasons, in some cases, but at least in four out of five GIEs, they cut in the thresholds, despite the presence of five extension officers who forbid them to do so. Ironically, we saw that the check structure is designed to *increase* the advance rate of the water every morning when irrigation of the *UAI* starts. But for this aim, the water has to remain in the canal during the night. Farmers are not used to this and the concept is strange to them: in the *PIVs*, when the *GMP* is stopped at the end of the day the farmers continue irrigating, emptying the canal. It is a useful practice to farmers who wish to give their plot a small additional water gift in the end of the day. Besides, in their *PIVs* it would be useless to leave the water in the canal anyway, because it would flow to the lowest parts, and might even cause canal breaches there. Consequently in the *AI* the farmers prefer to open their plot inlet and the orifices upstream when the day is done, thus emptying the canal.

When one compares the ranking of irrigation problems by farmers of the Diomandou scheme to the ranking by other farmers in the middle valley, the check structure has a remarkably negative score:

	Farmers' representatives of the Diomandou scheme	*Average priorities of farmers in other schemes in middle valley*
1.	*Plot levelling*	*Plot levelling*
2.	*Canal breaching*	*Canal breaching*
3.	***Check structure***	*GMP defects*
4.	*Plot height*	*Plot size*
5.	*Plot size*	*Plot height*
6.	*Need for bunds in canal*	*Rotation period*
7.	*Drainage problems*	*Need for bunds in canal*
8.	*Rotation period*	***Quality of structures***

Examples of comments by farmers of the Diomandou scheme:

(Farmer representatives of the GIE of Thialaga)
"..Overflowing of bunds occurs, because the water is stopped before the structure"
"... the long rotation period is caused by the structure".

(Farmer representatives of the GIE of Diamy Baila)
"...because of the small hole the force of the water is small. It takes 4 days to irrigate a plot. So we broke it".

(Farmer representatives of the *GIE* of Diomandou)
"..the farmers saw it did not work out well because it stopped the water, and that is why we took it [the threshold, S] *away again."*

(Farmer representatives of the *GIE* of Diouwa)
"...In some cases we broke it. The hole is too small. One has to wait all day long....."

Box 10.5 Comparison between farmers' irrigation problem priorities of farmers in the *Diomandou* scheme and farmers' priorities elsewhere in the valley

The design engineers' technical knowledge

Another irrigation engineer 'inherited' the irrigation scheme and its history after it had been turned over to the farmers. He worked for a Belgian consultancy. It was one of his tasks to support the extension officers and the farmers with the operation and maintenance of the scheme as well as with the field irrigation method during the first years after the construction. About his work in Diomandou he says: *"It includes especially the taking care of the first water gift in the first year of irrigation, the solution of all kinds of problems (....), and the monitoring of the water distribution during the first year. So in fact my work started after the implementation of the scheme in the floodplain. During the first year, there are bound to be canal breaches, canals that overflow or leak. One has to control whether the water level is correct everywhere, whether the 'modules' are verified, and whether the plot inlets and distribution structures are well placed".*

The engineer is a busy man, writing reports, supervising contractors, doing administrative work like the writing of tender documents for small contract work, preparing and following the construction of two other intermediate schemes. He tries to schedule at least one day in the week for the Diomandou scheme: One day in the week for five villages, five extension officers, many small adaptations to control and many farmers' complaints to check. The engineer has the same idea about the use of the check structures as the design engineers who worked in previous phases of the process. He is concerned about the sustainability of the irrigation infrastructure and personally considers the maintenance of the scheme as an important bottleneck. Maintenance should be preventive and has to be done thoroughly. The profiles of the canals have to be protected by maintaining a wet surface. He insists on not emptying the canals to make a quick and sustainable irrigation possible: *"..In order to avoid* ..[that the canal has to be carefully refilled every morning, S]..., *it is **highly recommended to close all the plot inlets** by the end of the irrigation day (..............) and put or leave the plugs in the orifices of the check structure. In this way the tertiary canal will remain filled during the irrigation stops; this **protects** it and it enables one to restart the irrigation with the maximal water volume without losing time. The stocked volume in a tertiary canal only represents, at most, 0,40 m3 for each meter of tertiary canal; this is almost negligible compared to the volume that is needed for a rice field, while it represents several hours of filling with a <u>reduced</u> volume"* (*SAED/BEC* 1990a, with original underlinings and other accents, own translation).

10.6 Image about one another

A comparison between the two types of technical knowledge is made in box 10.6. For farmers, the step from an 'ill designed' check structure to the engineer who designed it, is quickly made: when preparing an excursion of Aere Lao farmers to Diomandou, I first met farmer representatives of the GIE and the UAIs of Diomandou. One of them, the ancient president of the Diomandou PIV, now the 'chef' of the UAI 10, did not agree about the check structure. When I showed him a drawing of the structure, he said to me: *"The engineers invent something. The drawings of the structures are also made by them. But whatever an engineer may do. The water has a power that can destroy his idea. **'There is another power called water'**, the Thiouballo (fisher caste) use to say."* Another farmer, the chef of *UAI 6* (Diomandou) prefers the old system, and the old design

Design engineers	Farmers
	About the check structure
The check structure is easy for farmers	The check structure is a large problem
The structures have fixed thresholds, reducing operation efforts.	The structures block the water, which leads to canal breaches. The orifice is too small.
The structure creates the conditions that are necessary to start irrigating as quickly as possible.	Because of the structure, the rotation period has increased. One has to wait all day long.
The orifice of the check structure should usually be closed. It should only be opened when maintenance is necessary.	The orifice is opened and closed frequently, just like the slides of the familiar check structures and division boxes.
	About the canal
All plot inlets should be closed in the end of the day	Farmers who want may leave their inlets open
In order to keep the canals stable, one should always fill them with a reduced volume.	In order to irrigate quickly the whole volume should be used as once. Canal breaches are normal.
	About each other
Farmers 'just wait for the next project to come'. The mentality of farmers has to change.	Whatever a design engineer may do, the water has a power that may destruct his idea.
Farmers have done a lot of stupid things.	In this case, the design engineer was not right. We prefer the other one.
The design should not be adapted.	Our practices are correct.

Box 10.6 Technical- and other arguments compared.

engineer. When I ask who cut in the thresholds, people just laugh. Nobody reacts, until a farmer comments: *"The reason is, that we did not have these structures in the beginning. Later, the engineers have put down these thresholds. But the farmers saw it did not work out well, as it stopped the water, and that is why they took them away again"*. He concludes the first design engineer must have been right. The farmers' distrust in the structure becomes a self-fulfilling prophecy: since they do not use it for what it was designed for, the situation changes in a way that is unfavourable for the functioning of the structure. Their perception that these structures 'block' the water comes true.

With regard to the design engineer it should be noted that his terms of reference did not leave much space for an open dialogue. He had an overloaded working programme with many other activities. This could only lead to superficial contacts with farmers with practically no time for reflection. Besides, he has inherited an almost impossible task: *"We gave them too much to start with, so what can be done? How can the message be transferred that they have to maintain the system themselves?"* As to the first period, the engineer says: *"Especially the first year, the farmers do not know what they have to do. They have done a lot of stupid things"*. It is true that especially during the first period of irrigation the farmers may make mistakes. Their alertness and motivation are very important during this stage. Diomandou was no exception: the limited number of skilled leaders had to be divided over many *UAIs*, which implied that new leaders had to be formed. Also new irrigation groups and practices had to be developed in water distribution, as well as new responsibilities with regard to maintenance. Later on, the results of the canal breaches came forward as *hardened history* in the scheme. The design engineer has become somewhat cynical about the farmers' motivation to maintain the scheme saying: *"They just wait for the next project to come"*. It is part of his job to assist in an extension programme about the operation and maintenance of the scheme. He wants to solve the problem by explaining it to the farmers: *"I have to write a document about this: "**This** you have to do, and **that** will happen if you do not do it. I want to make drawings. I want to tell them what they have to do.......sometimes there is a small leak and the water flows slowly through, ... if you do not 'move' today...."*. Despite his efforts to change the farmers' behaviour by explaining the rules, through the intermediary of extension officers, the profiles are not kept wet, and the farmers maintain only curatively, like they did in their PIVs. Although he agrees that in some cases the canal bunds are constructed with a freeboard that is too low, he is not inclined to adapt his perception about how one should irrigate, probably because most of his observations of canal breaches and unnecessary time lags may prove to him that he is right. He blames the deterioration of the tertiary canals on the farmers. He is convinced that their way of irrigating is wrong. About the check structure, he says: *It is not necessary to change it, it is the mentality of the farmers that has to change.* He decides to equip two new intermediate schemes with the same regulation structure. The story may repeat itself and the fears of the design engineer may become a self-fulfilling prophecy.

10.7 The effect of the actual communication

It should be noted that, despite its top-down design process, most farmers of the Diomandou scheme, one year after the construction, would recommend other farmers to say "yes" to an intermediate scheme like theirs. One example: *"I would say: "Take it!" Not because the scheme is so good, but because the times are changing. (.....) I think in the future the farmers can make a living with the scheme" (Nieuwenhuis, p50).* This does not alter the fact that the aim of the designers to assure a higher level of 'technical security' will not be reached. Canal breaches are frequent, and even piping of the structures occurs because of the daily pressure variations in the canal profile. Steadily, the number of weak spots in the canal bunds increases, and it will not be long before the stability of these canals is comparable with those of the old PIVs. The originally favourable high water levels in the canals will have an adverse effect. Farmers will have to break even more of the check structures, to prevent too much overtopping. This will lead to irrigation problems and water shortage for the relatively high or downstream plots. This may cause the farmers to think that the thresholds of even the '*modules à masque*' should be adjusted, which has been frequently the case in the delta (see box 10.7).

Apart from the physical infrastructure, other factors were probably more important for the sustainability. The costs for the farmers will be at least twice as high as they used to be, which means that they have to farm the scheme commercially in order to pay for it. But the conclusions about the farmers' future production orientation in the feasibility studies is highly questionable. It can be summarized as follows: Firstly, the importance of rainfed and waalo agriculture has diminished because of climatic degradation, which is illustrated by the fact the population has accepted the small scale irrigated culture. Then it is stated, that the small scale irrigation does not completely satisfy the farmers and numerous cases of indebtedness and stopped exploitations are noted. As a conclusion:"*The farmers feel that this exploitation structure severely punishes the farmers of good will*" (AGRER et al 1987). One might ask: who are these farmers of good will? Are those the ones who think in terms of a surplus in rice production? If that is the case, they are probably still 'punished' in the Diomandou scheme: illustrative is the decision of all villages in the Diomandou scheme (in 1991), to cultivate corn or sorghum without fertilizer input, despite important efforts of the extension officer to make them change their minds.

The turnover of the irrigation infrastructure to Diomandou also calls for an independent farmers' organization in five villages, but as shown in chapter 4, Haalpulaar villages do not easily accept authority of other villages. By 1991 the farmers' organization could not prove itself because the *UNION* was still dependent on the assistance of extension officers. With the unfavourable market situation in mind there is a considerable chance that farmers of one or more villages will leave the 'commercial' production. Consequently the high (fixed) costs of the scheme will be difficult to pay. Villages may fall apart in

A design engineer who worked for *BEC* told me that farmers in two *GAs*, both of which were to be rehabilitated, refused to accept the *modules à masque* once again. They said these structures had not functioned satisfactorily. For this reason the *modules à masque* were replaced by simple slides in one scheme. But in the other scheme the design engineer managed to convince the farmers that it was not the structure that had caused their problems, but a shortage of water. He promised them that no water shortage would occur once their scheme was rehabilitated. So, farmers accepted the *modules à masque*. However, when there will be water shortage for some reason or other, farmers are likely to feel justified to break the thresholds of the structures once again.

In the *Ile à Morphil* project, the structures used to have small, 10 cm thresholds in their upstream entrance. These were also often broken by farmers.

In the Italian scheme near Podor (cf paragraph 7.4), design engineers had implemented a scheme where no distribution and regulation structures were required. The earth canal served as a reservoir that *was not to be emptied* during the night. However, after the supervision of the Italian projects ended, several years later, farmers of *Diattar* decided, after long discussions, to change the water distribution. From then on, canals were drained in the night and in between the irrigation seasons. Just like in their *PIVs* they turned on the *GMP* every morning. To avoid that *all* canals would have to be filled every day - which took a long time - they decided to construct division boxes (box 5.3). But, since the canals had no longitudinal slope, it still took a long time before the water reached the end. According to the farmers this problem had one fundamental cause: the design engineer had not foreseen the change the farmers had considered to be necessary.

Box 10.7 Other examples of taking away thresholds or emptying the canals

their production strategies, which is difficult, since the UAIs are not independent. It remains to be seen whether the *UNION* can solve these problems.

Within this problematic situation the daily confrontation of each farmer with the, unacceptable check structures and the deteriorating tertiary canals have their own role to play, but can have far-reaching effects on the sustainability of the *Diomandou* scheme as a whole. Farmers will blame it on the engineer. They may feel themselves justified to consider their technical knowledge superior to the knowledge of the engineer. Other technical 'disputes' in the scheme, such as about the quality of plot levelling, also proved that they were 'right' (see section 11.2). The engineer, of course, blames the farmer.

Chapter 11

TOPOGRAPHICAL ADJUSTMENT

11.1 Introduction

The following example is not structured around a single case, but around a theme that often returns in communication between farmers and design engineers: the 'topographical adjustment' of the environment. To implement an irrigation design, earth works are needed to modify the existing environment, plots have to be levelled and canals need to be constructed. Farmers' and design engineers' knowledge about the topography is different and it will be shown that this leads to misunderstandings during and after the design process. I will start this section by giving an example of topographical adjustment on the plot level and continue with the topographical situation beyond the plot.

11.2 Plot level

Design engineers conducted a precise plot levelling in Diomandou. The greatest possible difference in level within one plot was supposed to be 6 cm. The contractor used laser driven machines and was controlled by the BEC. However, the farmers of Diomandou had no confidence in the work. They said: "Already before the first irrigation we saw that the plots were not well levelled. We were told that we were wrong. But during the irrigation it became clear that parts of the plot could not be drained. So we went to the engineers and they came here."

The design engineers later on said to me: "Although the land survey was well controlled, some plots appeared to be problematic after the first water gift". The plots had probably suffered from an irregular setting of the soil.

The farmers, to whom it was promised that they could irrigate wearing their best clothes, apparently did not believe the design engineers did a satisfying plot levelling from the start. They said: "We have no instruments to look at it, yet we saw it better." They were particularly dissatisfied with the fact that the promise was not kept.

Promises, tactics and misunderstandings about levelling

Before the implementation starts, misunderstandings often occur about the degree of levelling of the plots. Not only in Diomandou, but also in other projects such as *Ndoulo-madji* and *Salde Wala*, the farmers complained that a more precise levelling had been promised to them. In some cases, like *Diomandou*, these promises indeed have been

"May the mature man not break his promise" (wata mokubaa bonnu ahdi) is a saying in 'the *Fuuta Tooro*', the province of the Haalpulaar (Gaden, 1969). It illustrates how sensitive the Haalpulaar farmers are about breaking promises.

Misunderstandings about promises made frequently occur. It may be explained by the different strategies of farmers and design engineers during the design process.

In chapter 4 it became clear that farmers have a 'dependency disposition' and often put the design engineer on the pedestal of the benefactor. Any of his promises may be over-valued, without seeing the exact message. It might be that they do not *want* to recognize the exact message: it may be part of their tactics (cf their 'blackmail strategy'). An extension officer declared: *"This is a farmer's tactics: Never say 'no' when something is concluded. And later, once the system is constructed, they try to back out saying things like: "......I did not know we had agreed on that" and "......but this is not what we had expected".*

In addition, the design engineer may abstain from slowing down the farmers' enthusiasm and may not object explicitly to the role of benefactor that is bestowed on him. Maybe the design engineer does not (want to) see the ambiguity of the farmers that put so much trust in him. But in some cases, one may even suspect a conscious strategy to use promises, in order to convince farmers to cooperate with the design process.

It is tempting to take up the role of a benefactor. From my own experience I know how quickly I sometimes took up the role farmers gave me. For instance, in one village were I stayed for several months, people seemed to test from time to time whether I would not help them, using my relations with other 'white' people. I felt I had to do something in return for their hospitability. In some cases I could and did help them. So, slowly I more or less accepted the role they seemed to give me. In this way, I may have created too high expectations which probably led to the accusation of a woman farmer I knew well. She was angry and told me I had not helped them to find "means" to work with. *"You promised"*, she said. I felt guilty, although I could not remember I ever promised this.

Box 11.1 Promises

made, although not always by the design engineers themselves. In most cases, at least, design engineers promised a scheme of 'good quality'. In box 11.1 some examples of these promises are presented. Misunderstandings about these promises may have different causes, reinforcing each other. A first cause is that their strategies differ (cf box 11.1). But a difference in technical images, also distorts the communication. For instance, the terms *préplanage* and *planage* (pre-levelling and levelling, see box 11.2), which are often used during the design process, seem to stimulate this. At least two design engineers, While conducting the *préplanage* only the most important irregularities are flattened, leaving a clear slope within the plot. Only some plots, having a slope which is considered too large, may be further improved (for instance plots that have more than 0,20 m height difference). *Préplanage* often implies that the driver of the grader or bulldozer works 'on the eye' without topographical control. Other improvements have to be made by the farmers.

Only by conducting *planage* levelling is done in precision and the slopes within the plot are corrected within a desired interval of precision, e.g. between +3 and -3 cm of the average plot level. For this a grader is needed. More and more, laser techniques are used, replacing the skill of the engine driver.

Planage by hand requires hard work and perseverance and is in fact never finished. (Anyone who has tried to adapt the topography his or her garden may know this). Suppose one has to level a small plot of 20x20m with +10/-10cm differences in height. In this case, one has to transport 20m³ of soil over a mean 14 meters. To improve 0,4 ha in this way would require many working days. In practice, farmers often prefer to make small compartments of bunds, separating the lower parts from the higher parts. They even may prefer to hire a grader.

Box 11.2 *Préplanage* and *planage*

discovered - independent of each other - that farmers often think these terms mean the same, and therefore made an effort to explain the difference to them.

Directly after the construction farmers sometimes refuse to accept the irrigation infrastructure because of a lack of levelling. They put the subject back on the agenda (compare the example of *Hamady Ounare* and *Orkadière*, box 8.2), refusing to work in the scheme, negotiating and using their political contacts. Also in *Ndoulomadji*, farmers succeeded in receiving mechanical assistance by using the argument that they needed to be compensated for the poor quality of the soils. In general, the first year after construction, the quality of the scheme is still warranted and design engineers are more or less open to complaints. But also a long time after the construction, farmers try to arrange mechanical assistance whenever they can and sometimes succeed. Their wish may be granted as a part of the occasional 'improvement' programmes in the valley, but occasionally help may be given as well when a grader is near the village. In return for the work farmers may pay the fuel costs to the *SAED* or the project. Sometimes they are prepared to pay even more (up to 100$ an hour), for instance when a grader is hired from a contractor.

The perspective of design engineers

Although levelled plots lead to a higher water efficiency and the resulting equal layer for all rice plants within the plot leads to a high and regular yield, design engineers often leave a large part of the work to farmers, not only because mechanical plot levelling is costly (about 1000-2000 USD/ha), but also because of the ideology that farmers who participate in construction works will feel more responsible for their scheme. The degree of plot-levelling can be relatively easy altered during and after the design and the construction process, because there is no need to change other design elements radically. Upgrading the levelling of plots is always favourable to improve irrigation on plot level. For this reason plot levelling remains a dynamic issue which is relatively open to negotiation with design engineers, even after the construction of a scheme.

In some cases design engineers who lack time to do a land survey, have to estimate whether a plot is well levelled or not and this is difficult since deceptively flat looking plots may in fact have a slope and the reverse may be true as well. Our perception of horizontality depends on the surroundings of the observed area, on the possibility of seeing a clear horizon, as well as on experience. Individual differences in judgment appear to occur: once they are in the field design engineers sometimes disagree among themselves about the topography.

The farmers' perspective

Farmers perceive the topographical situation of their plot as their major problem (box 5.1). They are conscious of the advantages of plot-levelling, but in practice they reluctantly adapt their plot and seldom as thoroughly as design engineers would wish. They prefer to leave the tiresome work to machines, reasoning "....*what a grader can accomplish in one hour, we cannot even accomplish with ten farmers during a whole day!*" In a new situation farmers may have difficulties to assess the topographical situation of their plot. But after having irrigated their plot for the first time, they see the specific irregularities of the water level. They remember where the water first dries up and where the water is deepest. One extension officer declared respectfully: *"Farmers are topographers"*, when he assisted to additional levelling in an *UAI*. Normally, surveying plots is too time consuming for design engineers and therefore farmers know their plot better than visiting engineers who have, at best, a topographical plan that is too rough for the plot level. In the case of the example it might be doubted whether the farmers indeed saw beforehand that a precise levelling had not been reached because they probably cannot judge whether or not a plot is levelled before irrigation (cf box 11.3).

Image about each other

Being forced to return to Diomandou, the design engineers had lost credibility to the farmers. They had to admit that some plots indeed had problems. Moreover the design

In Matam, it was decided not to inform farmers beforehand when the grader would come to improve the *PIV* mechanically, to avoid emotional and time-consuming discussions with farmers. The extension officer and the design engineer simply took some farmers' representatives with them, to indicate which plots should be levelled. However, the priorities of these representatives were probably biased. In this way, farmers of the village as a whole were not given a chance to come to an agreement among themselves.

In other places, for instance in *Ndoulomadji* after the first season, another strategy was followed. Here, the farmers were told they were allowed to use the grader for two days per *UAI*. An extension officer attended to this activity and declared: *"We do not need a topographer because the farmers already irrigated"*. Indeed, once water has been applied to the plots farmers can estimate whether it is levelled or not, by judging the equality of the depth of the water layer on the plot.

Leaving the control to farmers and extension officers may result in decisions that are opposed to the ideas of design engineers. In Cascas, for instance, a village was given time to decide which 10 plots should be levelled, but once the farmers were more or less free to decide on the use of the grader they preferred to redesign their *PIV* by constructing new plots. If he had known this beforehand, the design engineer would not have agreed. The extension officer and the engine driver did not tell the design engineer about the decision of the farmers.

Box 11.3 Using the farmers' knowledge while levelling plots

engineers were probably not convincing while choosing the plots that required assistance, admitting they had experienced difficulties in drawing a line between plots that should receive assistance and plots that should not. Therefore, to the farmers the confrontation with the technical knowledge of design engineers easily ends up in a confirmation of the validity of their own knowledge.

To many design engineers farmers are not always easy to work with in the field. One design engineer said about the farmers in Diomandou: "*.....as soon as they perceive the grader they want to profit by its assistance. And none of them wants less than his neighbour. But we had to draw the line somewhere...*" It is not easy to draw a line, without knowing the plots as well as the farmers do. Therefore, some design engineers simply accept the superiority of farmers with regard to the levelling of existing plots. But since most farmers tend to be oriented towards their own plot, one cannot be sure which farmer needs priority. From box 11.3 it appears, that a proper use of the farmers' knowledge may have to be supervised one way or the other.

11.3 Land levelling beyond the plot

The example

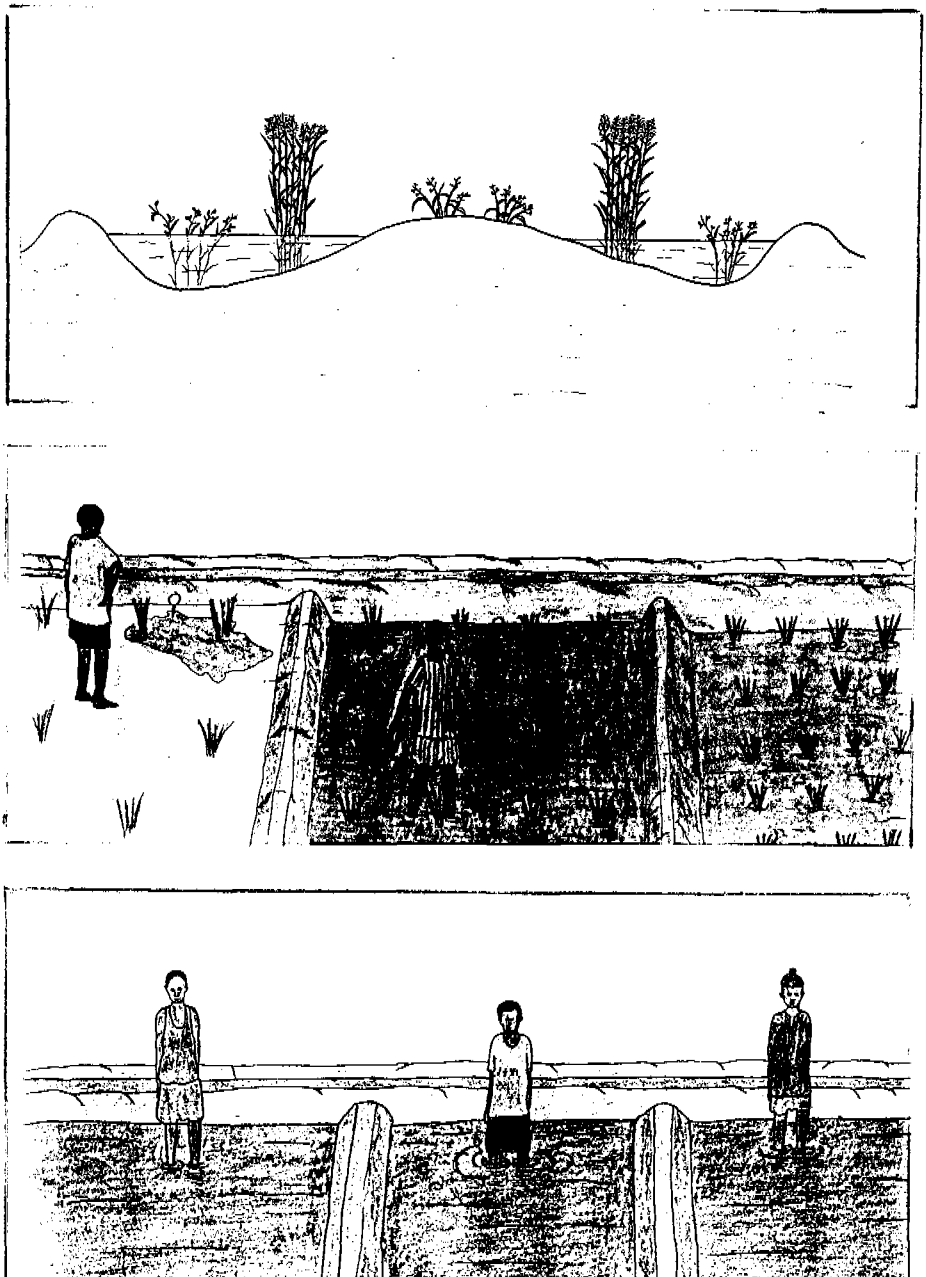
A peculiar example of communication about *planage* at the interface between design engineers and farmers leads to the insight that levelling can be interpreted totally different by farmers:

In 1990, resulting from the EFD rehabilitation project in the department of Podor, the farmers of Guede Ouro received a PIV (Guede Ouro II) of 41 ha and two GMPs. During the first season the water distribution was problematical and 8 ha were not irrigated. Farmers blamed ir t on the quality of the scheme. The design engineer who had supervised the works told me: "We were asked to do the levelling anew [+3/-3cm]. We controlled it, but everything appeared to be within the tolerance. The farmers were wrong".

The farmers' technical knowledge

In general, I used drawings while discussing with a group of farmers about their problem priorities. I discovered that three drawings (see box 11.4) were often put together and were all considered as *"planage"*-problems. Nevertheless, they recognized the difference: the first drawing concerned irregularities on the plot itself, the second drawing concerned a plot that was relatively high and could not easily be irrigated and the third drawing concerned a plot that was relatively low and could not easily be drained. When seeing the drawings, the farmers used the word "*Ngesa potani*". *Ngesa* means fields. *Potani* is the negative of the word "*Foti*" indicating that something is "of the same value". The word may be applied to the width of a surface, but also to a volume or height. *Ngesa potani* is - easy enough - often translated as "*parcelles malplanées*" (badly levelled plots) because this is its current meaning. However, it is important to note that the notion of *"ngesa potani"* is broader than the notion of "not levelled plots". Whether the plots are too high, too low or irregular or whether one has to do with an unfavourable topographical situation, it was all related to *"ngesa potani"*. Therefore, the notion should be related to a broader topographical adjustment and not only to plot levelling. In Guede Ouro the water head between the canal and the plot was so small that only part of the plots could be irrigated, despite the fact they were levelled in precision. Due to this limited hydraulic gradient even centimetres turned out to be barriers.

The notion '*ngesa potani*' even goes beyond topographical adjustment and may have to do with the ('unequal') quality of the soil. This is illustrated by a farmer of the village Diamel who complained about *ngesa potani*. It was translated by my interpreter as a 'lack of levelling. However, on the spot the plot appeared to be flatter than many other plots. His real problem were the high percolation losses on his plot, but the effect was partly the



Box 11.4 Three examples of *ngesa potani*

same: in this case the water level relatively quickly drew back, following the contour lines.

The design engineers' technical knowledge

We return to the example of Guede Ouro, where twenty percent of non-cultivated land in the new *scheme* was said to be caused by a lack of levelling. Therefore the complaint had to be taken seriously by the consultant who had supervised the contractor. But after controlling, the design engineer saw proof that he was not to blame: the farmers were wrong! But in the communication process a misunderstanding was hidden from the beginning. As a result, the thoughts of the design engineer were led away from the real problem in Guede Ouro, which was not a lack of plot-levelling (This example will be elaborated in chapter 13).

Image of each other

When farmers proved to be wrong after measuring the degree of levelling the design engineer brought this forward as an example of the mentality of farmers to blame the others. He was convinced that the problem in Guede Ouro was to be found in the farmers' organization. An important argument that he used was the fact that *other* villages cultivated the whole surface of their scheme. He used the example to indicate that farmers' knowledge should not be taken too seriously.

Farmers were not satisfied with the design engineer and complained to me about the situation. Possibly, they felt that the design engineer had not taken their problem seriously enough, or they thought that the topographical control had not been right. Their problem remained unsolved.

Two design engineers with relatively close contacts with farmers experienced that farmers refer to something broader than only "*planage*" when they bring up these problems. A design engineer in Matam said with a smile: *".....for farmers, everything is a "problème de planage"*. And the design engineer of the *Ile a Morphil* project confirmed that farmers once complained about *planage* problems, but when he controlled the plot levels, these were all within +2,5/-2,5 of the average plot level. However, both design engineers did not know in what sense the farmers' notion was different.

11.4 Reference points and contour-lines

A design engineer reasoned that the conveyance canal of the improved second generation PIV Mboyo I and II should remain in its original state, for instance, to prevent canal breaches in the upstream part. Therefore farmers of Mboyo were asked to dig the first *part of the conveyance canal. The farmers refused, and argued: "The water returns, so it is no use to dig the canal".*

In many cases the overall effect of the top down design processes results in a final implementation of a faulty design. In other words, throughout the design process reification occurs: an idea or plan is mistaken for reality. More specific examples of reification follow below.

(1) During construction, many executors experience problems that are related to reification, but are not hired to solve them. Contractors often give a disappointing message, when farmers propose changes: *"This is what we have to do according to the plan...."*

(2) It took a long time until design engineers in the *Ile à Morphil* decided to take the farmers complaint about a bad canal in a *PIV* of Wallalde seriously. The plan looked alright. They thought the design engineer who made it, could never have made mistakes. But later on, when the canal was finally surveyed again, it appeared that an obvious mistake had been made by him.

(3) A plan of an improved second generation *PIV* with a complete drainage lay-out looked perfect on paper. However, the surroundings of the *PIV* were not visible and only in the field it appeared that these are too elevated for the drains to function.

(4) A topographer who had to implement a design thought he saw an elevation in the field, but he could not trace it back in the plan. He asked me what I thought about it and I had the same impression. We asked the opinion of the topographer who had done the survey. He looked on the map and then to the area and said: *"There is no elevation"* - *"But look!"*, we said, *"it is so clearly visible, and we both see it"* - *"No"*, he said, pointing at the plan, *"I measured it, there is no elevation"*. He refused to look at the real world... (but he may have been right! (cf box 2.2))

(5) Not only design engineers or land surveyors make reification errors. One extension officer for instance checked a farmer's complaint about the slope of the canal, by looking at the plan of the canal lay out. He concluded: *"No construction errors have been made"*. What he saw on the map, however, were only figures.

Box 11.5 Some examples of reification

The design engineers' technical knowledge

It has been indicated that assessing topography is not easy and highly subjective. For this reason maps are extremely important instruments for design engineers. Especially the contour lines, indicating the elevation of a certain area by relating it to one single reference level, are a useful tool. Therefore, design engineers quickly find their bearings in an irrigation scheme. When farmers mention problems a design engineer will consult his map and compare it to reality. An agronomist who worked together with a design engineer even said about his colleague: "*He is absolutely lost when he has no plan with him*". However, the same limitations of human perception that make a design engineer use the map, raise the danger of *reification*, the result of a process in the mind, leading to the confusion of an idea with reality (see box 11.5). The problem is, that a map may incorporate mistakes. In the case of Mboyo I and II, the design engineer in fact *supposes* that the canal is well designed and constructed and therefore concludes that maintenance is necessary. In this case he was probably right, since the topographical team was well supervised, but one may never be sure.....

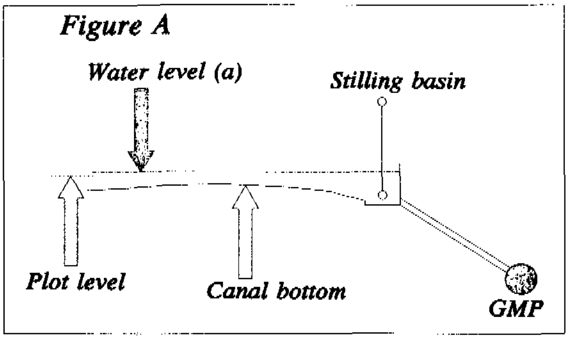
The farmers' technical knowledge

With regard to their judgement of the elevation farmers do not have a fixed reference level. Depending on their point of view, they put the same problem in different words. Suppose water cannot reach a plot easily . According to farmers, two explanations may be possible: (1) the plot is too high; (2) the canal is too low. In the first case (this may be for the pump attendant), the plot seems to be the problem, in the second case (e.g. for the owner of the plot), the canal seems to be the problem. In box 11.6 it is explained how the farmers of Mboyo I and II may have reasoned to come to their conclusion to not maintain the canal. In box 11.7 another example is given.

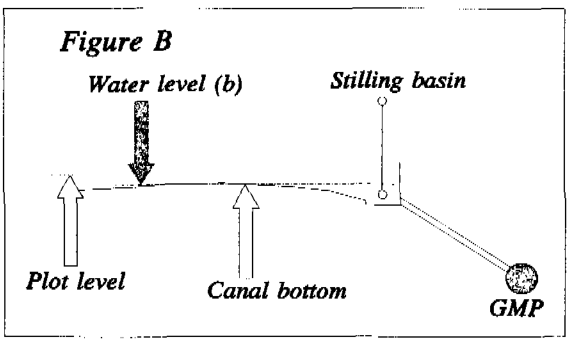
11.5 To what extent can the topography can be adapted?

During the first week of irrigation of a new PIV in Cascas canal breaches occurred, especially in one area with a difficult topographical situation. The area, inevitably, had been included in the design. As a member of the project, a farmer held me responsible for it and claimed mechanical assistance for the problematical part, saying: "In the other part it is better. You have to improve it here". I was irritated because I considered the scheme to be well constructed, despite the difficult topographical situation.

A design engineer reasoned that the canal of the PIV of Mboyo I and II should be maintained and he asked farmers of Mboyo to dig out the sand on the bottom of the canal. The farmers refused and argued: "The water returns, so it is no use to excavate the canal". What would they have meant? See the figures below.



a) Situation during irrigation: the GMP is turned on and the water flows to the plot.



b) Situation some time after the GMP has been turned off: The water seems to have 'returned' from the plot to the lowest parts of the canal and the stilling basin.

The figures are not to scale. The distance to the plot may be about 500 meters. The water level (a) above the threshold of the stilling basin may be 120 cm.

Farmers of the example observed the water should have an elevated level to reach the plots, since the plots in these PIVs are considered to be 'high'. The problem 'plots too high' was ranked second in priority. It seems useless for them to lower a canal bottom, when it is (already) low compared to the plots.
In this case farmers seem to relate the canal bottom to the plot height. The design engineer relates the plot height, the canal bottom, as well as the bottom of the stilling basin to one reference height. Therefore he has a better overview. The example also indicates implicit assumptions about water flow. These will be treated in chapter 12.

Box 11.6 A misunderstanding due to using reference heights differently

The design engineers' technical knowledge

In practice, due to the topography of a site, the irrigation system will have some areas that are easy to irrigate and maintain, whereas other areas are problematic. A design engineer will try to exclude problematical areas and, for this reason, large parts of the area within the protection dike may not be included. In some cases, these areas have to be included, not seldom for political reasons.

The farmers' perspective

Farmers tend to compare problematic parts with good parts and, in some cases, the good and easy parts seem to 'prove' to them that the problematic parts suffer from a construction error. For instance, when three out of four field canals remain stable and one single canal deteriorates relatively quickly, it may easily be seen as a 'construction error'. Often, farmers seem to think that it is easy to implement all parts of one area. Once the protection dike of intermediate schemes is constructed, e.g. in *Ndoulomadji, Diomandou* and *Salde Wala*, farmers are inclined to think that all the land within the dike will be implemented, which is most often not the case. This can be a source of misunderstandings: during my research farmers often asked me why the land within the dikes was not constructed. In some cases they may recall promises that the whole area was to be implemented. And especially in cases where farmers have a bad relation with the project, stories may arise about the project's bad intentions: *"We think the project consumed the money that had to be used for the scheme"*, and *"Our plots are too small. It is all due to politics (.....) because we own a lot of land here [*within the protection dike*]"*. When *PIVs* are implemented farmers often seem to cling to the tangible survey markers (cf section 9.3).

One clever farmer put the farmers' notion of topographical adjustment well into words, after I had explained why part of the area within the protection dike was not implemented: *"Indeed, it is this that the farmers think the construction of a scheme means: to take the soil from the high parts down to the low parts. But this is not always true, for some places the natural state is such, that it is not possible"*. This farmer also seems to have the idea, that other farmers think too easy about the construction of a scheme. It corresponds to the experience of many design engineers that farmers seem to have high expectations as to what extent the topography may be adapted. Although this may have to do with the fact that construction costs are not paid by the farmers, whereas, at the same time, they have land rights and village politics in their minds when choosing a site, their ideas of an easily adaptable topography play an important role.

Farmers often use distribution structures as a reference point, which can be useful for water distribution. One example of a farmers' representative in Thioubalel: "*.........the canal on the right is lower. The canal that continues straight on is higher and the canal to the left is higher too. If we close the right hand canal to irrigate the two others .....this canal* [he indicates at the *arriving* conveyance canal] *will breach and we'll have to stop the GMP. This is why we irrigate with three canals at the same time. But we should open the right hand canal just a little.....*".
In this example farmers prefer to solve their problem by adapting their water distribution to it. But what is the cause of the problem? In this case it might be that

(1) the bunds of the conveyance canal lack height - the canal is "too low", according to the farmers.

(2) the two 'higher' canals may suffer from a lack of maintenance (causing siltation) or from a construction mistake. In both cases these are "too high" for the farmers.

Even when he or she would survey the situation very carefully, it would be difficult for a design engineer to start a discussion with them. Discussions about high and low can be very confusing in the field, since reference levels may vary. So, how to 'prove' a lack of maintenance?

Box 11.7 Discussions about '*high*' and '*low*'

Chapter 12

WATER FLOW

12.1 Introduction

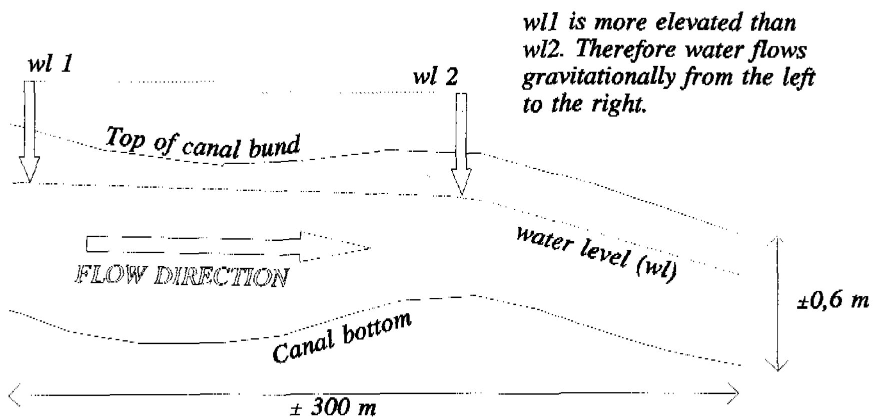
Just like the previous chapter, this chapter is centred around a theme rather than around a case. This time, the subject is water flow. The implicit assumptions of design engineers and farmers about water flow are perhaps the major source of misunderstandings about technical issues on the *interfaces* between design engineers and farmers,since water flow is such a central element to both actors. Every technical design, as well as the practices of farmers is centred around this notion. Water flow between water source and plot is regarded as a given. Confronted with a request to give an explanation about water flow, design engineers would probably answer in scientific terms, referring to the laws of gravity, whereas farmers are likely to put the question in a religious perspective, which would come down to the advice to just accept that it flows. This does not alter the fact that farmers actively control the water flow by changing its conditions and must have a *practical logic* about its causes. Although their knowledge cannot be translated in well elaborated concepts, their various solutions for all kinds of practical problems can be used to approach their technical images - as adequately as possible.

12.2 the design engineers' technical knowledge about water flow

Between the water source and the plot the topographical conditions for gravitational water flow limit the degrees of freedom of a design in a much more tangible way than socio-economic and cultural conditions. To limit costs of earth works, gravitational water flow is best possible by laying out the canals on a surface which already tends to slope down. Besides, to cover a significant area the irrigation canals have to connect the highest parts of the locality, whereas the drainage canals have to connect the lowest parts. Crossings of irrigation and drainage canals should be avoided, since these are expensive and vulnerable. These basic rules for designing make many design engineers shrug when representatives of 'softer' disciplines try to set conditions: *"There is not so much to talk. In a certain topographical situation there is a certain logical design"*, one design engineer said. *Water flows from high to low* is probably the most basic rule of thumb of design engineers.

Taking a closer look at water flow, one discovers that it is best to relate water flow to energy gradients and not always to a land surface. The energy gradient that is needed to pump up the water on the river bank is created by the *GMP*, whereas it is gravity that provides the energy gradient once the water has flown out of the tube in the stilling basin.

Longitudinal section of a field canal (not to scale)



Box 12.1 The design engineers' perception of water flow in an open canal

This concept also deals with situations like the one presented in box 12.1: in some situations water does not flow in the direction of the down-slope. The Manning formula (box 12.2) is widely and successfully used for the computation of all kinds of canals within the normal ranges of slope, cross section and roughness (Meijer 1992). Unlike the design of plot levelling, the design of water levels in canals is clearly related to practically all the other design elements. Knowledge how to project the most favourable canal lay out on a topographical plan, as well as subsequent calculation of the required water levels in the canals are a core part of the design engineers' technical knowledge. Once the required water levels are designed with the help of the Manning formula - and additional formulas that deal with situations in which no 'normal flow' occurs - it is presupposed that these may only fluctuate within limits. If not, the water distribution structures will not function as expected. To guarantee limited fluctuations, maintenance is absolutely necessary.

12.3 The farmers' technical knowledge

The pushing force explanation

The *GMP* has an important role in the farmers' perception because its operation is fundamental for water flow. Farmers often slow down the *GMP* when canal breaches have to be avoided and speed it up when they want to irrigate more quickly. Their practical logic may be expressed as follows: when a canal breaches they say that *the GMP is too strong for the canal*, when the water reaches the plot with difficulty they say that *the GMP is too weak* and in the case of a long rotation period they say that *the pump is tired* or *we need a stronger GMP*. In all these cases, they talk about a certain force of the *GMP*. In the eyes of farmers, its task is not restricted to 'passively' delivering the water into the stilling basin after which the water flow is left to gravity. By contrast, it *actively pushes the water through the canals*. On its way the water needs the force to reach the plots and to overcome obstacles if necessary. An expression like : *"First the water flows forward, but if we stop the GMP it returns"* already seems to indicate a dynamic 'battle of forces', but practices make this even more clear. In Ndoulomadji, for instance, the one-way valves through which the water enters the stilling basin were kept open by branches, or

The Manning formula for normal* flow reads:

$$v = k_M \; S^{1/2} \; R^{2/3}$$

v	= flow velocity [m/sec]
k_M	= flow factor related to the canal roughness [$m^{3/2}/s$].
R	= hydraulic Radius [m], R = [Water area]/[wetted perimeter]
s	= hydraulic gradient or energy gradient [m/m]

* Normal flow conditions are reached in a canal with infinite length and equal water depth (in this case the bed slope equals the slope in the water level).

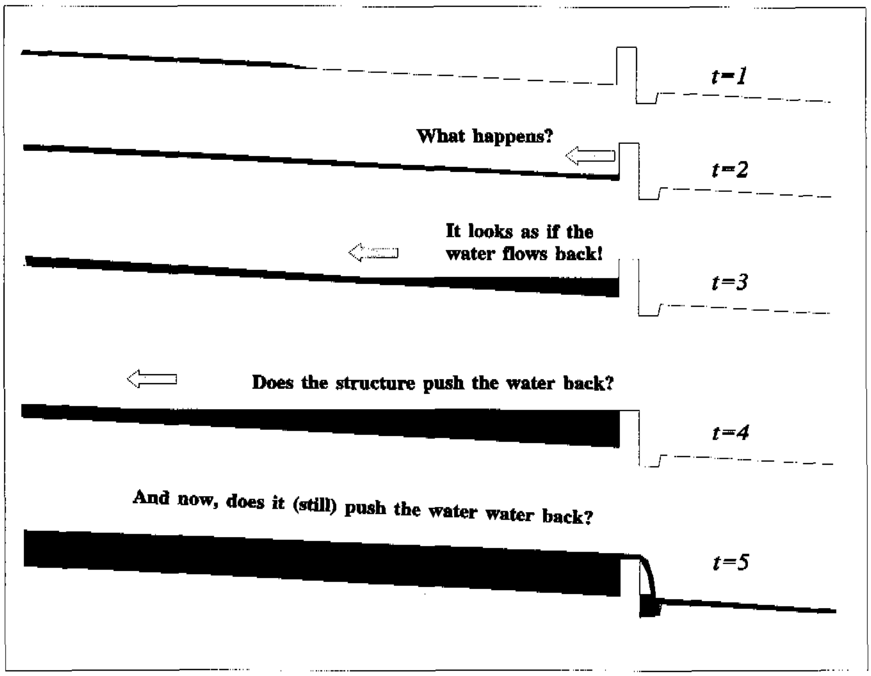
Turbulent water flow is unpredictable and it cannot be satisfactorily approached with a fundamental physical law. The user of the Manning formula should be careful, since the exponent of the hydraulic radius varies and is in fact a function of the hydraulic radius itself (Meijer 1992). To make the formula fit reality, a roughness factor is introduced. Lists of applicable roughness factors in varying situations are available in order to implement the formula.

According to Meijer the roughness factors that are applied to small tertiary canals are often too optimistic, in the sense that they limit the costs of construction. The reason for this is that the exponent should not be treated as a constant. So, when farmers complain about such canals, an engineer may make the mistake to blame the farmers for not cleaning the canal, whereas, in fact, the designer is to blame.

Box 12.2 The Manning Formula

In this box attention is paid to what may be seen when looking carefully at water flow. ***Is the water pushed*?**

Once the pump attendant has started the *GMP*, the water is pushed through the polyester tubes. After a few seconds it flows into the stilling basin. The water whirls, which farmers as well as engineers may see as ***a pure manifestation of the force of the GMP.***
While the water slowly finds its way into the canal, it becomes less turbulent. ***Is the energy destroyed by the stilling basin, or has the water 'chosen its destiny' does it concentrate its forces?***
Meter by meter, almost carefully the water 'feels' its way down the canal bed. Upon reaching higher parts the water stops and seems to 'hesitate. ***Is the water level not yet high enough to overflow it oris it gathering its forces to overcome the irregularity?***
The water is held back by a low threshold of a drop structure. It slowly rises, but at the same time, the water surface in front ofseems to move iin the reverse direction (see figure). What happein the minutes before the water sarts to overflow the structure? ***Does the threshold push the water back? Or does the threshold cause a more or less horizontal water surface which extends in the reverse direction, as long as the energy gradient is not sufficient to flow over the structure?***



Later on, the water falls into an inverted siphon. When it reaches the other part of the road, the water rises in its downstream end. **Does the water flow upward?**

Box 12.3 What meets the eye when observing water flow?

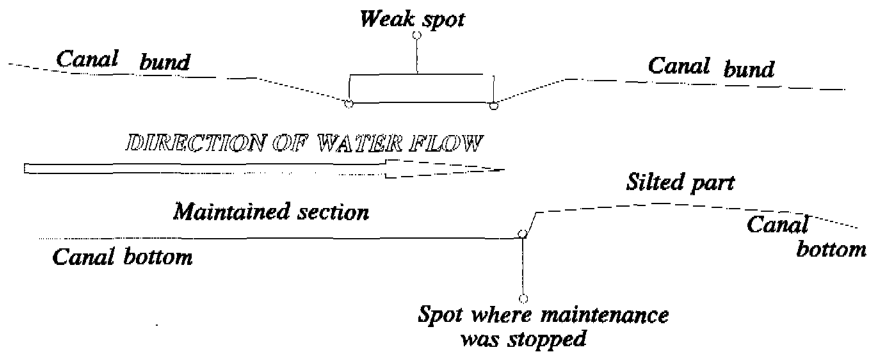
simply taken away. In other cases, farmers refused to accept propositions to place vertical walls in the stilling basin - to avoid erosion of the top end of the canal. In yet another case farmers put the tube ends of the *GMP* on top of the stilling basin, to prevent the water from *"flowing back"*. Structures with thresholds, such as the structures in Diomandou (chapter 10), are probably disliked for the same reason: they seemed to block the water. In fact, this is compatible to what meets the eye (box 12.3). Equally, higher parts of an irrigated area are often seen as obstacles that have to be overcome by the force of the *GMP*. The example in the previous chapter about the water returning to the lower parts, after the *GMP* had been turned off, illustrates this (box 11.6). Farmers often do not realise that the irrigation of the higher parts requires the downstream water level to rise (box 12.4).

The fact that the irrigators actually hear the noise of the *GMP* during irrigation, may reinforce the idea that the *GMP* pushes the water through the canals. But farmers do not necessarily relate the force to the *GMP*. In Diomandou, for instance, some farmers mentioned the *force of the canal*, or the force of the tertiary inlet, probably because the primary canal in Diomandou had a reservoir function, remaining full even when the pump was stopped for some time. But to most farmers, this is an unknown situation. Farmers who visited Diomandou for the first time were even surprised, to see so much water remaining in the canal while the pumping station was turned off.

It often seems that the farmers' concept of a 'force in the water' implies that water can flow uphill over a limited distance (box 12.5). Whenever design engineers capture the slightest suggestion of water flowing to higher parts, they may mention it to others, in order to prove that farmers' technical knowledge should not be taken too seriously. One design engineer, for instance, had no confidence in farmers technical knowledge, arguing: *"They asked me to irrigate the plots 'up high'"*. When another design engineer in a comparable situation replied the farmers that the site was too high to irrigate, farmers said: *"Then we need a stronger GMP"*, which made him shake his head once more. However, unlike design engineers, farmers are not trained to separate characteristics of water flow from the topography, because in practice they always deal with both elements at the same time. As a consequence, the notion of a topography which is easy to adapt cannot be separated from the concept that water can flow uphill.

High and low parts as causes of water flow

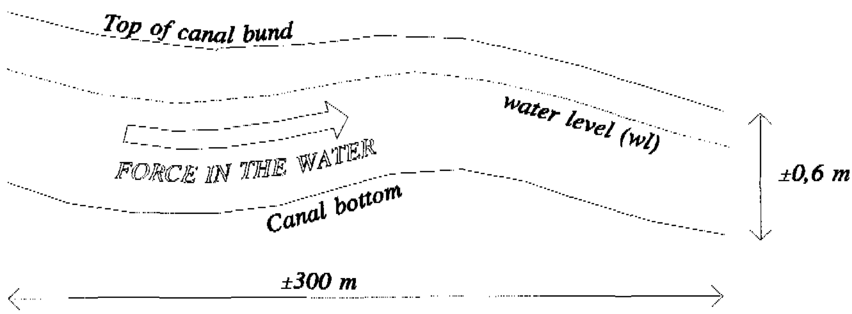
Farmers' practical logic about water flow is ambiguous and cannot always be related to the *pushing force* explanation. Sometimes explanations for upstream problems are sought in the height of the downstream canals or plots, being more congruent to the explanation of engineers. It may be that, once differences in height are evident, for instance by using distribution structures as reference points (box 11.7), farmers will not refer to the force explanation. Woman farmers of Dodel for instance shared one distribution structure with the men. Their plots could only be reached when the men's canal was closed. The women



For the first time in the history of their PIV, farmers of Ndormboss were prepared to maintain their canal thoroughly and removed the sand on the bottom of their canal. At one point, the vice president concluded: "Downstream from this spot we never had problems, so we will stop here". A design engineer would have reasoned in the exact opposite sense.

Box 12.4 Downstream from this point we never had problems...

The farmers' practical logic often suggests that water can flow uphill over a limited distance



Longitudinal section of a field canal (not to scale)

Box 12.5 A perspective regarding the farmers' practical logic about water flow said: *"If the men open the distribution structure the water cannot reach us because of the slope"*. Another example is found in Sadel where a farmer gave the following explanation for frequent canal breaches: *"Over there is a high part. It makes the water rise and overflow over here"*. He explains the process, using words that a design engineer might use, probably because the farmer joined an alternative maintenance programme that was organized by a French NGO. As a part of it, a joint problem assessment had been made.

Preference for the shortest water track

In a *PIV*, after turning on the *GMP*, it usually takes between half an hour and one and a half hour before the first plot can be irrigated. The plots that are furthest, take the longest time to be reached and require 'more force'. A pump attendant said for instance: *"....when we irrigate the first* [most distant] *sector, I speed up the GMP most"*. This practice is not unusual, and, partly for this reason, canal breaches especially occur when distant plots are irrigated. Farmers do not like winding canals and prefer a direct route between the *GMP* and their plot. However, design engineers sometimes design a 'winding' canal, connecting the high parts of the environment and avoiding to cross drains. A winding canal causes that the time lag between turning on the *GMP* and irrigating the plots becomes longer. In many cases the farmers complain about this. In Sadel for instance, such a winding canal was designed and constructed. The farmers told me: *"In the beginning there was only one single canal around the PIV. But it did not work. Even in three hours the water did not arrive. So we constructed a new canal."* They ignored that the *SAED* and the design engineer did not agree with them and constructed a new canal that passed through a depression, using sacks to stabilise it. According to the farmers, it functioned well. They even adapted their water distribution to the new situation and divided the total water volume in two. One part flowed in the old surrounding canal and another part in the new canal that passed through the basin.

Another example of short-cutting the water route is the use of drains for irrigation. In one case, a design engineer could not be convinced that this would be possible and would only believe this when he saw it (personal communication Frans Huibers). The farmers' wish to take the shortest route frequently arises at the interface between farmers and design engineers. It is probably based on their observation about the rate of water advancement in the canal each morning. A design engineer who automatically avoids lower areas by constructing longer canals may sometimes be too careful and too rigid in this decision. On the other hand, he has to choose between 'the devil and the deep' because when he would design a straight stretch of canal, it would be not as stable as in other parts in the scheme, since it would have to pass a depression. The farmers might well blame him for this, since they do not distinguish between difficult and easy parts of the topography, when judging the design engineer's work (see paragraph 11.5).

Chapter 13

CANAL MAINTENANCE AND WATER FLOW IN THE PIV OF GUEDE OURO

13.1 Introduction

Discussions about canal maintenance or the technical quality of the scheme frequently occur and centre unconsciously around the notion of water flow (Scheer, 1992). The stakes are high: farmers have an interest in blaming the construction while design engineers often are keen on proving a lack of maintenance. In this setting of contradictory interests, the underlying views of water flow hamper explicit negotiation about the real issue: who is responsible for what? To illustrate how important their different underlying views on water flow may be I will reconsider the situation in the *PIV* Guede Ouro II, the *PIV* where farmers and design engineers clashed because of a *"planage"*- problem (section 11.3). It will become clear that misunderstandings about *planage* are not the only problem. Guede Ouro II is a part of the *EDF* rehabilitation project of *PIVs* in the department of Podor. The *PIV* was constructed in 1990.

13.2 The engineer's design and the practices of farmers

The design engineer's perspective

The *TOR* of the design engineer was restrained (box 13.1). *"We had to construct many PIVs within a short period. So, what can one do? One uses existing ideas, looks around in the field. One cannot come up with new things"*, he comments. However, the *PIVs* in the rehabilitation project have some new features. Their scale is larger and many *PIVs* require more than one *GMP*. The engineer had observed that the existing canals in PIVs were much lower compared to their theoretical dimensions, and therefore he designed large primary and secondary canals, *"to compensate for soil-setting"* (see box 13.2). The canals were not compacted. With regard to the sustainability of the project, his main worry is maintenance.

The design engineer does not think that farmers can be helpful in designing because they lack the proper knowledge:..... *"Will they be able to judge objectively?..(....)...Farmers have ideas, that is right, but these are often false. Too bad! They do not have the basis for a good judgement. (.....) Sometimes, I know, he* [the farmer, S] *would like to be more involved in the design, participating in certain choices, because he thinks he knows things very well. Don't get me wrong, I do not imply that he is ignorant....., but they forget - they do not even forget but they do not* **know** *about certain technical conditions. They insist on constructing their plots "uphill", even when these never can be reached"*. He is

From the start, the design engineer who was responsible for the concept of the 'improved' *PIV* generation in Podor would have preferred to look deeper into the failure of the other *PIVs* that had to be rehabilitated so soon after their construction. He wanted to do applied research, comparing investment costs, durability and maintenance requirements of different types of canals. He brought this up to the *EDF*, but they were already six months behind schedule and did not agree to his proposition. In a few months (in February 1989), he was supposed to be ready with the tender documents, enabling contractors to construct 642 ha in a first phase. In June 1989, another document had to be ready in order to construct more *PIVs*. Indeed, new *PIVs* were rehabilitated and extended at a high speed, although not as quickly as expected. Between May 1989 and June 1990, 1046 hectares had been implemented (Greppi 1990). Another 1000 hectares were in the pipeline for a next phase; the construction rate would have to be speeded up to provide *PIVs* for refugees from Mauritania. The design engineer's work consisted mainly of preparing the tender documents, controlling the works, supervising *SAED* topographers and designers. He said he had no contacts with farmers. According to him they were not interested and never present during the execution of the works. But he daily meets extension officers, who play an intermediate role between the farmers and the *SAED* or donor. His most important worry is the maintenance. The *EDF* starts a maintenance programme his colleague will have to implement: *"I am not optimistic. Even the extension officers have not yet been educated. They have to occupy themselves with the farmers"*.

Box 13.1 The design engineer's position

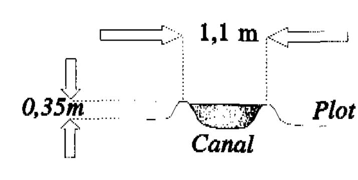
not sure about some farmers' sincerity either, giving the example of a two hours' discussion about maintenance where the farmers accused the contractor of having put a heap of sand in the canal. He dug out some soil of the canal to check their complaint and this proved to him the farmers were wrong. *"Of course, not all farmers are like that"* he adds.

The farmers' perspective

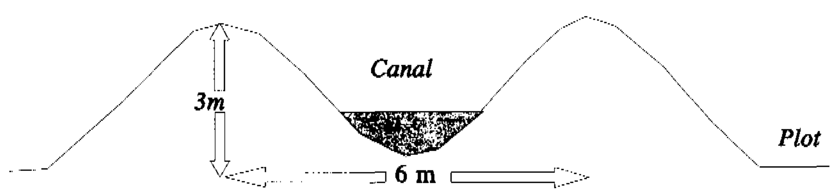
The experiences farmers acquired in their old *PIV* (*Guede Ouro I*) have become part of their *technical image*. The old *PIV* (11,5 ha) is one of the few first generation *PIVs* in the area that is not rehabilitated and still functions. The irrigation canals are hand dug. Several field canals are used at the same time to avoid canal breaches. The water distribution is problematic due to the low capacity of the canal. To irrigate the plots farmers have to check the water with earthen bunds in the canal and the scarce soil they need for this is taken from the canal bottom (cf box 5.6). In this way maintenance is done automatically. In this *PIV* 88 households have a small plot of 0,11 ha and it takes 9 days to irrigate all plots. As is the case with most of the *PIVs*, plot levelling is considered to be the major problem. The most obvious differences between the new and the old *PIV* are their canal dimensions (see box 13.2) and the scale.

The main canal in the old PIV (on the right) has a low capacity. Siltation does not occur because any silt in the canal will be gratefully used to reinforce the canal and plot bunds. In the new canal (below) the soil is not scarce at all. By contrast, siltation occurs in large parts of the canal. The canal bottom will not automatically be dug.
Compared to the old main canal, the amount of water transported by the new canal (max. 160 l/s) is about two to three times as much.

Cross section main canal old PIV



Cross section main canal new PIV



Box 13.2 Comparison of canal dimensions of the old and the new PIV

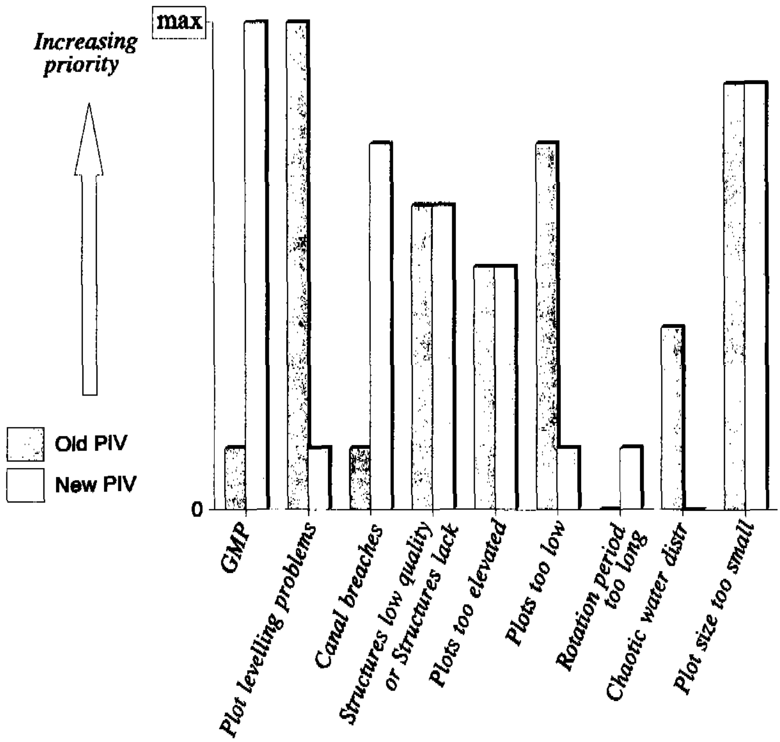
The new *PIV* is almost 4 times as large, (41,3 ha), whereas the number of participants is almost three times as high (260 ha). Soil for repairing canals is no longer scarce in the new *PIV*, and the canal bottom is not automatically dug out: after the first season large amounts of sand have raised the canal bottom 40 to 50 centimetres. In this *PIV*, the farmers started irrigating the way they were used to, but problems arose when some families could not transplant their rice in time: the rice that was transplanted earlier already needed new water and in the village meeting it was decided that the transplanted rice got priority. As a consequence, in the first year 8 hectares were not irrigated, corresponding to 52 families.

In box 13.3 farmers' problems priorities in both *PIVs* are compared. Not unexpectedly, the farmers confirmed that the *long rotation period* was an important problem in the new *PIV*, but they did not give it priority, since *"According to us, this problem is caused by the new GMPs.. "*. Consequently, the *GMPs* of the new *PIV* are seen to be the major problem, contrary to the old *PIV*: *"the old ones* [GMPs] *are better than the new ones"*. Later in the field, they confirmed: *"The water does not flow like it should"* and *"When 50* *litres flow out of the GMP, only 30 litres flow into the canal and 20 litres return"*. These arguments relate to the *pushing force* explanation. The quality of the canal is linked to the *GMP* as well: *"Although we have two GMPs, the canal is big and the water has to travel a long way"*. Apart from the *pushing force* explanation, they give explanations to their problem in terms of *high and low*, assessing the topography and apparently using the water level in the canal as a reference: while classifying the *plot height* as the fifth problem, they say: *"In the new PIV almost 8 hectares are too high"*. They tried hard to irrigate these plots, but *"[even] when we irrigate with only one canal at the time, it would take one day to irrigate three plots"*. The structures are considered to be too *low*, and also here they use the water level as a reference: *"When we want to irrigate the distant parts of the PIV the structures overflow"*. Finally, despite its dimension, the farmers say that the canal is suffering from breaches: *"The canals* [in the new PIV] *are not well compacted. The soil falls down into the canal, because the water eats the soil* [undermining the bund, S]. *In some parts the clayey soil causes leaks. In the old PIV we have less problems. The canals are small but solid."* The canal breaches were probably aggravated because farmers were used to irrigate with the complete water volume at the time of the first water gift (cf chapter 10).

The farmers internalised the practices of their old *PIV*, unconsciously assuming that the new *PIV* should function according to the same principles as their old *PIV*. But this leads to problems. Putting their practices beyond suspicion, they jump to the conclusion that the new infrastructure cannot be sound. In the eyes of the farmers, the design engineer probably lost credibility after deciding to heighten some distribution structures that had been overflowing from the beginning. For the 8 hectares that cannot be irrigated, the farmers are also likely to blame the design engineer, although he says the plots are '*within the norm*'.

13.3 Opposite arguments compared

In box 13.4 I placed the different ideas and arguments that are part of the design engineer's and farmers' practical logic next to each other. The design engineer may interpret the suggestion of farmers that 'the new type of *GMP* is too weak' and 'the canals are to wide' as just another proof that they lack technical knowledge. He also may have heard arguments that plots are too high and the structures too low, with which the farmers come to an opposite conclusion. Listening carefully, the engineer might find the farmers ambiguous, illogic and intangible. Out of all farmers' arguments he unconsciously selects the complaint that plots are poorly levelled. He decides to control it. It is probably not coincidental that plot levelling is relatively independent from other design elements: adaptation would be simple. When, for instance, the canal profiles and the lay out would be faulty, it would be difficult and costly to change it.



Box 13.3 A comparison of the old and the new PIV of Guede Ouro, with regard to farmers' irrigation problem priorities

On the other hand, if farmers would listen carefully, they would find the design engineer just as intangible and difficult to convince. The arguments they hear always point to similar conclusions: 'maintenance is necessary' or 'an improvement of the organization of water distribution is required'. Probably they are not impressed by these familiar arguments: they already heard the story time and again from extension officers. They are convinced that the design engineer does not want to listen to them and refuses to accept full responsibility.

After having controlled the plot levelling, the design engineer made a *'fiche technique'* in which he indicated what parts in the Guede Ouro scheme had to be cured by the farmers.

Thirty percent (1500m) of the canals were silted up and had to be dug out. He had also made a precise schedule for the water distribution. In the peak period the schedule was tight. The rotation would last seven days, coming down to four rotations a month. The farmers would have to irrigate 13 hours a day. The sequence of plots was fixed and the irrigation duration of each plot was accurately determined to the minute. The *'fiche technique'* was handed over to the extension officer, who was to persuade the farmers. In chapter 5 it can be learned that such a schedule is worlds apart from the farmers' reality of flexible irrigating groups.

After the additional land survey the farmers lost the argument in the eyes of the design engineer, but when I visited them they still clung to their own reasoning and were apparently not convinced at all. It is doubtful whether the design engineer's advice will be taken seriously. The design engineer concluded that the farmers' organization is to blame. Given the large number of farmers that have to work together in Guede Ouro, organizational problems are likely. Farmers' representatives even admitted organizational problems. But this does not alter the fact that the technical concept should be questioned. On the contrary, it should receive even more attention.

13.4 Conclusion about the concept

It is important to note that farmers are at least partly right, when blaming the quality of the new *PIV*. The new concept probably leads to water losses that are higher than expected. The silted canals cause the 'wetted perimeter' to increase. This increases the percolation losses. Besides, since the siltation is irregular, the water volume in the canal between *GMP* and plot may also increase. For distant plots, e.g. 1000-1500m away from the *GMP*, the required filling time of the canal may easily be doubled. This explains their statement: *"Even when we irrigate with one canal at the time, it would take one day to irrigate one plot"*. It might even be, that the problem of 'high plots', which was frequently mentioned by farmers in this project (e.g. in Mboyo 1 and 2, box 11.7), is, in fact, a percolation problem.

Being familiar with farmers' problems regarding canal breaches, aggravated by the lack of soil, I was enthusiastic when I first heard of the large profiles. Also the farmers were probably enthusiastic beforehand. The design engineer's concept of large canals was a serious effort to make things more easy for farmers. The choice not to compact the canals was risky, assuming an alert supervision by farmers during the first season. On the other hand, compacted canals would be very expensive. As an inexpensive experiment (e.g. covering 20 ha), the concept of the large canals seemed to be worth trying, but now, after having constructed 2000 hectares, it seems to be a loss of money: due to canal breaches some *PIVs* deteriorated quickly.

Starting images of both actors

Farmers' representatives	*Design engineer:*
Eight hectares cannot be irrigated, although we really tried. The concept must be wrong and design engineers apparently make mistakes.	Farmers do not maintain properly. They lack the knowledge for objective judgement. Apparent siltation in the *PIV* of Guede Ouro (1500 m).

Opposite ideas

- The new type of *GMP* is too weak	- The *GMPs* are not weak at all; they function well in the other *PIVs*
- The canals are too wide, the water has to travel a long way.	- The canal profiles are all well calculated during design. The scheme can be irrigated in seven days.
- The canals are not well compacted and the soil falls into them from above.	- Sand that falls into the canal must be dug out
- The distribution structures overflow, and are constructed too low.	- The structures overflow because the canal bottom is too high. It should be dug out.
- Eight hectares of the area consist of 'not levelled fields' (*ngesa potani*).	- Interprets that the plots are not well levelled and decides to control it.

After surveying, it appears that all plots are perfectly levelled. The design engineer feels justified because the farmers' arguments proved to be wrong. Consequently, the problem must be a lack of maintenance, like he already thought in the first place. The discussion is closed.

- Farmers will not see that something is wrong with their "*curative maintenance*" practice.	- Farmers should excavate 1500 metres of canal, to achieve a better water flow.
- Farmers will not question their distribution method [based on flexibility and irrigating groups]	- Farmers have to distribute water according to the schedule I made.

Image about one another confirmed

Farmers	*Design engineer*
- The design engineer does not want to listen and does not understand water flow in practice.	- The farmers use false arguments, are not always to be taken seriously, do not want to maintain. Their organization is to blame.

Box 13.4 Technical arguments compared

It is the uncertainty about maintenance for which the design engineer had wanted to do some experiments in the first place, but the *SAED* and the *EDF* had not allowed him to. Ironically, it appears to be this maintenance that gives rise to important problems and misunderstandings.

PART IV

EXPERIMENTS AND EMERGING PERSPECTIVES

Chapter 14

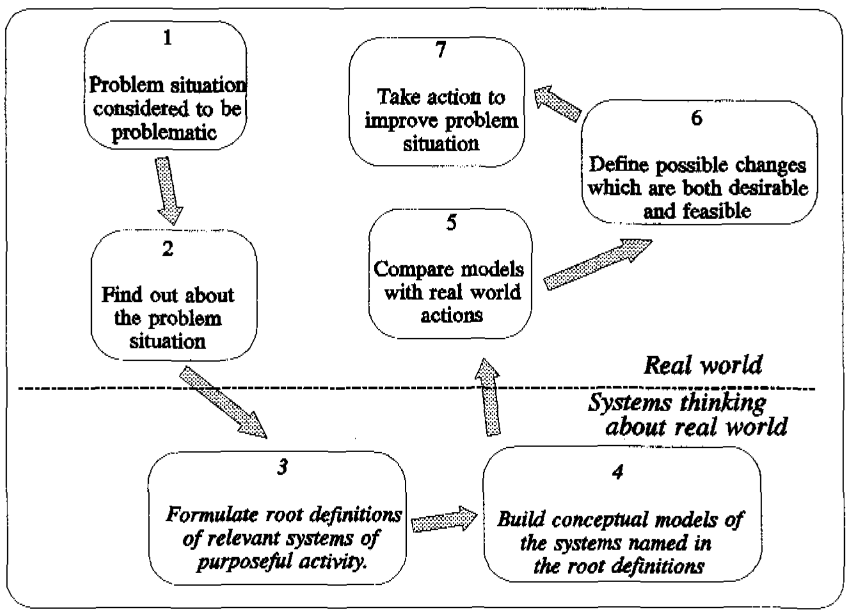
A SSM PERSPECTIVE ON IRRIGATION DESIGN IN THE MIDDLE VALLEY

14.1 Introduction

From the previous chapters, it may be concluded that the exchange of knowledge between design engineers and farmers is too superficial with regard to relevant subjects. One may question whether design engineers can be held responsible for failing to see how different farmers' objectives are from the objectives of government and donors (cf box 14.1), but the lack of insight in the differences between the farmers' technical knowledge and their own technical knowledge is a problem that directly touches the design engineers' professional domain. These technical differences are summarized in the annex. Both actors do not learn from the other and seem to be entangled in 'unconscious confirmation cycles' rather than in learning cycles. In this chapter I will look for ways to reduce the sharp edges of the process, and focus on the question how to reveal aspects of the two types of knowledge in the design process.

> To a large extent, design engineers are the natural allies of the government or donor, who seek to maximise the irrigated production in the middle valley by constructing irrigation schemes at a great pace: 3000 hectares a year. On the other hand the schemes will have to be operated and maintained by farmers. Therefore, he also designs for people who have different objectives: farmers tend to minimize risk and in their perspective irrigation is only one of the 'instruments' to secure their own food production.
>
> The *AI* concept is a design engineer's solution to bridge the gap between planners and farmers. It is supposed to combine the advantages of the *PIVs* - a concept that fits well into the farmers' perspective - and large scale systems that permit a surplus in rice production. However, it is doubtful whether a concept as such will be sufficient, because farmers still would have to adapt their practices considerably: *AIs* (large plots) call for commercial farmers who are full time involved in irrigated agriculture, whereas *PIVs* (small plots) allow for a combination with other activities. Moreover, *AIs* would require several villages to work together, whereas the farmers' attitude to suspect any authority of other villages is deeply rooted.
>
> Low quality socio-economic feasibility studies prefer not to question the underlying contradiction between government's and farmers' objectives.
>
> Box 14.1 Underlying contradictory objectives of farmers and planners

Soft Systems Methodology provides some answers. It consists of seven stages that are part of one learning cycle (Checkland 1989). The stages are represented in box 14.2. These stages are not meant to contribute to a linear process, and the *SSM* cycle should not be seen as a single seven-stage cycle. In practice, the process evolves along inner cycles, 'short-cut' cycles and re-cycles, passing from one stage to another. *SSM* is a collaborative approach, meant for people with different technical, social and cultural backgrounds and objectives, who have interest in the same complex problem situation. In the process they 'learn their way' to a collective solution. In this chapter the reader will get more insight in *SSM* and the material of the previous chapters (3-12) is used to illustrate the methodology.



Box 14.2 The seven stages of the SSM learning cycle (Checkland 1989)

14.2 Stage One and Two: assessing the problem and finding out

The *SSM* cycle starts with a situation in every-day life which at least one person regards as problematic. The second stage of *SSM* concerns the 'finding out' of the problem situation. According to Checkland "*It will not be possible for any problem solver, whether an outsider or part of the problem situation, to simply 'find out' about the situation in a neutral manner*". For this reason it is important in this stage to discern the different groups that are part of the problem situation, their roles, norms and values, as well as their political and social relations. The most important mistake in the middle valley is that the ones who did the 'finding out' (researchers, planners) generally did not seriously look into this. Whenever a group seemed to have objectives or world views that were contrary to the government objectives, it was usually assumed that these would change within several years. Because of a restricted *TOR* engineers often did not have the possibility to 'find out' about differences in technical knowledge, but even when they did, they were often not interested in communication with farmers during the design process.

In *SSM*, the 'finding out' should be done in a collaborative way, and others than the researchers should be involved in the study. But in the middle valley the future owners of the irrigation infrastructure did not participate in feasibility studies at all, except for providing data that were interpreted and processed beyond their control. Some rare 'consultative' sessions underline rather than contradict the general lack of participation.

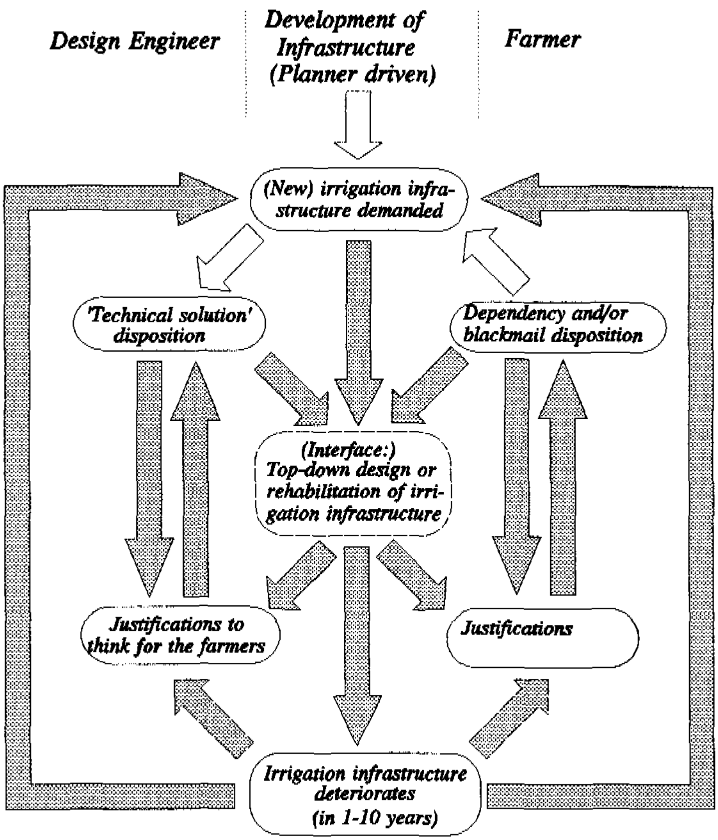
The research during the stages of 'finding out' is an important part of the so-called *cultural stream of analysis* of *SSM*. When following this stream, the '*myths and meanings*' people attribute to their relation with others are an important focus. *Rich pictures* may be used in this stage, illustrating the 'climate' of a problem situation by means of drawings, symbols or metaphors, pointing out what multiple perspectives exist. It is essential that people come to share these rich pictures in the course of the *SSM* process, recognizing other perspectives, regarding these as equally valid.

The major part of my research can be regarded as an extended stage of 'finding out'. Before entering the next stages of *SSM*, I will present what I found about the communication at the interface between design engineers and farmers. This will be done by means of diagrams.

Diagramming a long term communication pattern

When encountering design engineers, farmers in the *Senegal* middle valley often present themselves as being dependent on project support and they often try to please them in order to secure a project for their village. Farmers may also use political contacts to force the design engineer and the local *SAED* people to help them out in the case of problems. In this way farmers try to benefit from irrigation development. Design engineers also profit by the irrigation development. Knowing how to sell it to planners, they are paid to follow their orientation towards technical and ever more elaborated solutions: the hand-made simple *PIVs* were replaced by more and more expensive, solid and sophisticated *PIVs* and *AIs*. But they are structurally distant to farmers, and, at best, design engineers think *for* the farmers.

Originating from these farmers' and design engineers' dispositions, but also strongly stimulated by the impulses of planners and government to construct irrigation infrastructure, a communication pattern developed in the 15-20 years of irrigation development in the



Box 14.3 Diagram of a communication pattern repeating itself in the long term

Senegal middle valley. Not only in distinctly top-down design processes, but also in design processes where farmers' consultation takes place their practices may be brought down to this systematic behaviour. This long term pattern is illustrated by the diagram of box 14.3. It is an unconscious confirmation cycle with two hidden *habitus*, each of which *"..ensures its own constancy and its defence against change through the selection it makes within new information by rejecting information capable of calling into question its accumulated information, if exposed to it accidentally or by force and especially by avoiding exposure to such information"* (Bourdieu 1991). According to Bourdieu, the *habitus* may even be reinforced in the process.

The simplicity of the pattern may not always be evident in day-to-day situations, as improvisations evolve around it. However, these are not accidental improvisations, but regulated by the *habitus* of both actors. The personal improvisations may, for instance, be related to the different convictions that design engineers have about farmers and vice versa (see box 14.4). These convictions provide the justifications of both actors to maintain the pattern. The pattern reinforces - and may even lead to - the perpetuation of

DESIGN ENGINEERS	FARMERS
Farmers......	The design engineer ....
"..need a high quality irrigation infrastructure"	"..promised us high quality irrigation infrastructure"
"..need to be educated about irrigation by extension officers"	"..is our father and we are the children"
"..require me to behave like a school teacher"	"..must be pleased during the design process"
"..prefer to *talk* about irrigation problems rather than *solve* them"	"..has to decide, it is not our responsibility"
"..try to avoid work"	"..has to decide, what do we know about a technical design?"
"..are not interested in participatory design"	"..does as he pleases so we must only tell the design engineer what we want him to hear"
"..lack the knowledge to participate in the technical design"	"..has to be influenced by his superiors"
"..play smart political games, do not always trust them"	"..'eat' the money that was meant for us"
I, the design engineer....	We, the farmers...
"...I am not to blame, because a similar irrigation system worked out well in another village"	"...we are not to blame, but the project should do more for us just like the other project did for the farmers in ..."

Box 14.4 Convictions of design engineers and farmers about each other

the construction of a new and more sophisticated irrigation infrastructure that relatively quickly deteriorates.

Diagramming a pattern that evolves around technical images

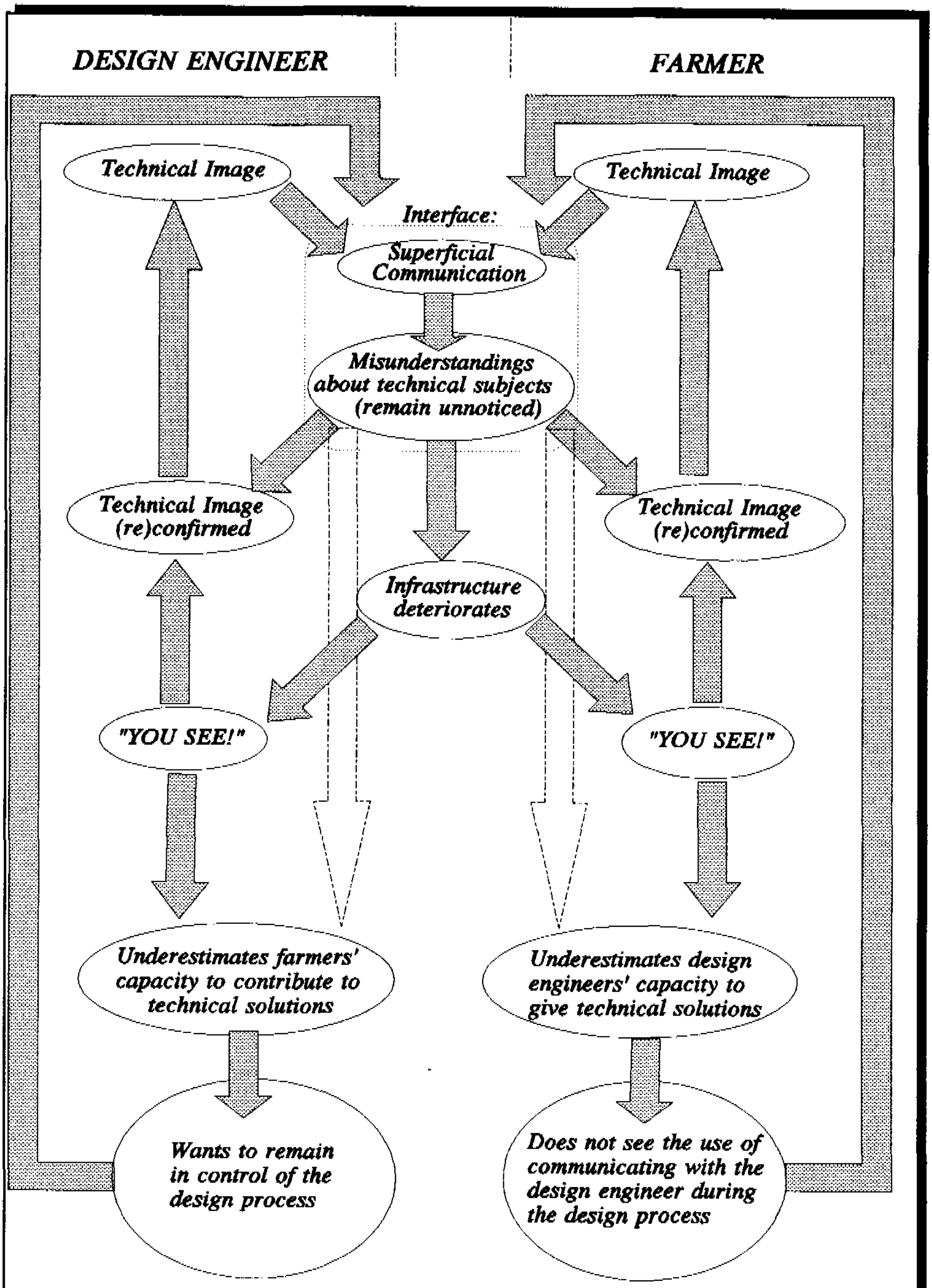
The communication pattern of box 14.3 is strongly stimulated by the planners' conditions. When planners expect a high construction rate, it is difficult and probably impossible for a design engineer to step out of this pattern. However, even without the direct influence of planners, design engineers and farmers are likely to develop a pattern that is unique for their relation. From part III it appears that communication between design engineers and farmers did not succeed in a knowledge-exchange. This was caused, on the one hand, by the superficial character of communication on the interfaces *before* the construction was finished. On the other hand, on interfaces *after* the construction underlying contradictory technical images led to a communication pattern, which again led to the confirmation of these images (see box 14.5). Even in cases with a relatively intensive farmer consultation, like the two design processes near the village of Cascas (see chapter 8 and 9), the technical images were not explicitly dealt with.

Diagramming the overall communication pattern

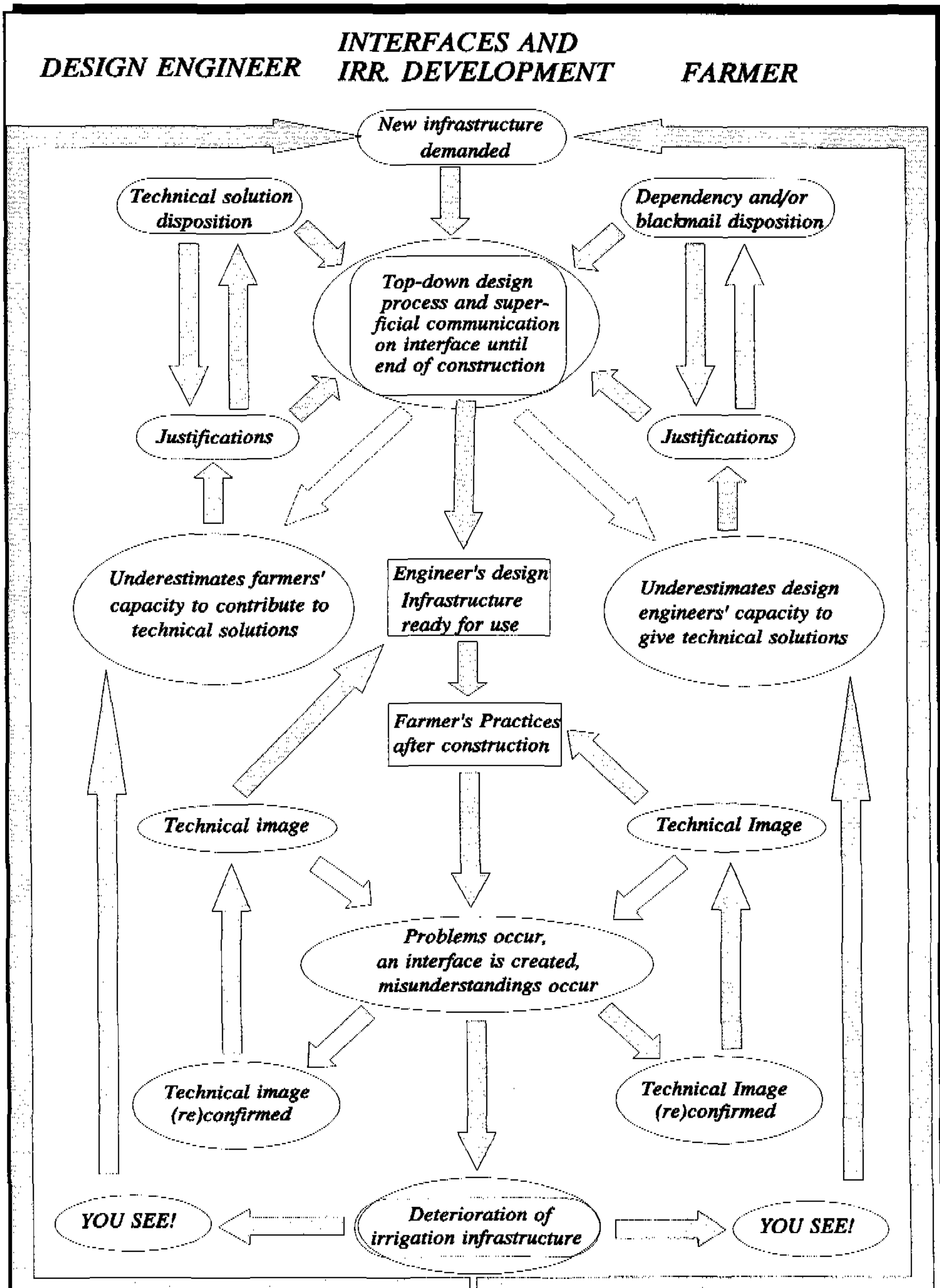
The processes represented in box 14.3 and 14.5 are in fact part of one complex process, illustrated in box 14.6. In short, the pattern that evolves from contradictory technical images provides the justifications for design engineers and farmers to continue with the long term pattern. And, the other way round, the long term process ends up with justifications to continue with superficial communication, or no communication at all, leading to misunderstandings about technical subjects. The communication patterns can be seen as a kind of *system* with its own emergent properties.

14.3 Stage 3: Selecting relevant systems and formulating root definitions

The use of systems is part of the *logic-based stream* of analysis of *SSM*. In this part of the analysis, systems serve as 'logical machines' to question reality. Based on the yield of the first explorative stages, *systems of purposeful activity*, relevant to the deeper exploration of the problem, are selected. The choice of systems is always subjective. Therefore, through debating with others about a range of different systems, the *SSM* user has to learn the way to truly relevant systems. Each system should be carefully described by *root definitions* and these can be constructed by consciously considering the elements of the mnemonic CATWOE, which is explained and illustrated in box 14.7. The examples concern systems that are relevant to the three diagrams of the previous paragraph. The diagrams have all the characteristics of a relevant system, except for the fact that the systems they represent are not composed of *purposeful* activities, but are



Box 14.5 Communication pattern evolving from contradictory technical images



Box 14.6 The overall communication pattern

THE PRINCIPLE (source: Checkland 1989)

Formulate root definitions by considering the elements CATWOE:

Element of Root definition	Description of element
C Customers	The beneficiaries or victims of the transformation process
A Actors	Those who do the transformation process; The users of SSM
T Transformation process	The conversion of some entity into another
W 'Weltanschauung'	The world view which makes this 'T' meaningful in context
O Owners	Those who can stop the process
E Environmental constraints	Elements outside the system which it takes as a given

TWO EXAMPLES

A system transforming top-down design processes of irrigation systems into a learning process , in order to stimulate rather than to discourage farmers' design and rehabilitation, and, at the same time, to discourage rather than to stimulate the design engineers' orientation to give but technical solutions.

1

- C Government, donor, farmers
- A Planners
- T Top-down process → Learning process
- W Both the state and the farmers need sustainable irrigation systems. A top-down process triggers unfavourrable practices of farmers and design engineers, causing irrigation schemes to deteriorate. This system is essential for the success of the second system (below)
- O Farmers, planners - among whom design engineers -, government, donor.
- E Limited capacity of the *SAED* and limited funds; many procedures may not be changed easily.

A system meant to transform communication patterns that hamper conscious learning about technical subjects into new forms of communication, leading to conscious learning about technical subjects, in order to design irrigation systems with 'learned relevance'.

2

- C State, donor, farmer, design engineers
- A Design engineers
- T Existing communication pattern without learning --> 'Open' communication and learning
- W Collaborative learning about technical knowledge leads to a better design and changes the images of farmers about design engineers and vice versa. This system contributes to the sustainability of irrigation development.
- O Farmer, design engineer
- E Existing planning environment

Box 14.7 Six elements defining the system.

regulated by the *habitus* of the two actors involved. Suspicious minds might consider the diagrams as 'systems to avoid the exchange of knowledge'.

In Senegal, planners and design engineers searched for the best means to achieve a granary in the Senegal middle valley. But according to Checkland this is not the best way to deal with a complex human situation. In fact, *SSM* emerged as a reaction to the inadequacy of engineering and management methodologies that simply searched for the best means to achieve an end defined as desirable. In Checkland's words, Senegal planners thought of systems as 'hard systems'. However, in *SSM* (*Soft Systems Methodology)* the questions '*what are the objectives*' and *'what are the relevant viewpoints*' are part of the problem.

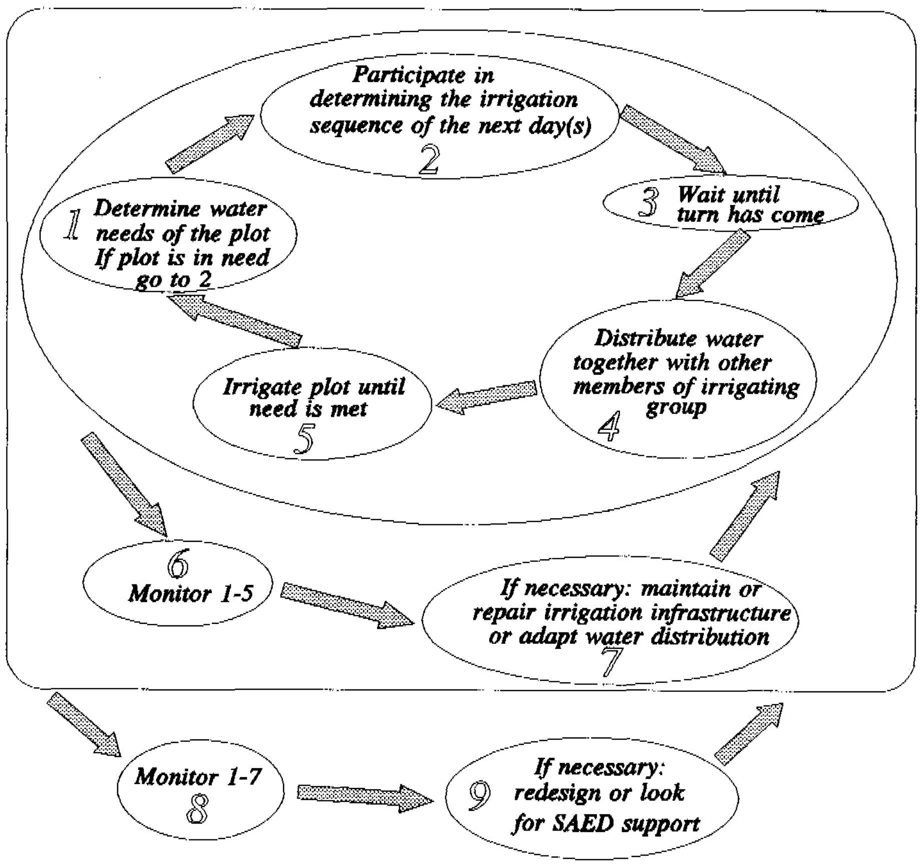
14.4 Stage 4 and 5: Building conceptual models and comparing them to perceived reality

After selecting and defining the system, the process of modelling starts, assembling and structuring the minimum necessary activities to carry out the transformation process. The structuring is based on 'logical contingency' (see box 14.8 for an example). The modelling language is based upon verbs, allowing precision. Later on in the process, the model will usually change: one model may break down into several models - for instance by expanding one activity into several activities - or an entirely different new model may be made. However, according to Checkland and Scholes (1990), models should not be made too complex, because then it would be easy to slip away into thinking about models as parts *of* the real world. It should be kept in mind that models are meant to *debate about relevant changes* in the real world. In *SSM*, monitoring is considered to be an indispensable part of the transformation process. In this way, human activities can be adjusted, whenever changes in the environment call for it.

After modelling it, the system has to be compared to perceived reality. This can be done in different ways, but in *SSM* it is usually done by using the model as a source to ask questions about reality. The models are meant to come to a well-structured and coherent debate about a problematic situation, in order to decide how to improve it. The debate may be conducted in any way which seems appropriate to a particular situation. Often new information is obtained and this may lead the *SSM* user back to stage 1 and 2.

14.5 Stage 6 and 7: Defining changes and taking action

Once a certain accommodation of objectives is reached between the different groups in the process, the models may be regarded to represent 'ideal situations' and as such they can be compared to a present situation. Consequently, differences between the ideal and the present situation will become clear and relevant changes to the perceived real world can



A farmer owned and farmer managed irrigation system, meant to transform barren plots into fertile plots, by taking water from the river and distribute it to the plots, by means of irrigation infrastructure.

C Farmers, government, people in the cities
A Farmers
T Barren plots → irrigated plots
W Irrigation is a relevant way to spread risk, is supported by farmers and may even lead to a surplus production.
Irrigation has to be 'farmer managed'.
O Farmers
E Farmers' habitus, favourable market prices, presence of traders, factories, etc.

Box 14.8 Modelling an irrigation system

be defined. According to Checkland, care must be taken that the changes are not only desirable from a systemic point of view (for instance, making sure that a system is effective, resources are appropriate, etc.) but also feasible from a cultural point of view. According to Checkland, scientists and engineers sometimes tend to overemphasize the importance of 'logic' and fail to notice cultural aspects which in fact determine whether or not change will occur.

When some changes are accepted as 'desirable and feasible', the cycle of *SSM* is completed by implementing these changes. The readiness to make the changes, again changes perceptions of the initial problematic situation itself. In Senegal, for instance, the farmers' perspective appeared to change once they were sure about construction! In terms of *SSM*, the redefinition (redesign) of the *PIV* systems during the construction period in Cascas, may well serve to illustrate the flexibility that is sought by *SSM*.

14.6 Using *SSM* to solve the *how*-question of this thesis

Using the *SSM* method *ex-post* I could not follow all of its constitutive rules. It may be clear that the stage of 'finding out' received major attention during my field work period. The thesis now proceeds with other stages. In a practical situation the principles of *SSM* would be more respected if more 'cycles' of stages would be made.

The second system in box 14.7, which aims at transforming confirmation cycles into learning cycles, is the system that may solve the problem situation identified in part III. It is a learning system, following *SSM* principles, meant to result in the implementation of irrigation systems that have learned relevance and therefore may well be sustainable. It should be noted that the irrigation system, which is defined in box 14.8, is the subject of this learning system.

In the following sections I will mainly pay attention to two stages of the learning system: the stage of modelling irrigation systems (cf stage 4 of *SSM*) and the stage of discussion (or debate) that is based on the models (cf stage 5 of *SSM*). The irrigation system was modelled in several ways, sometimes only parts of it were modelled. The models were not based on written language, but were physical models, drawings, adapted physical maps or even relevant 'real world' irrigation schemes. The demand of 'logical contingency' was not followed strictly. During my field research, it was more important to present the models in a readily understandable visual form. I considered an elaboration of the 'definition of changes' of the irrigation system (cf stage 6 of *SSM*) and 'taking action' (implementing the system) (cf stage 7) beyond the scope of my thesis, but it may be clear that many designs that have been described in part III require changes.

Chapter 15

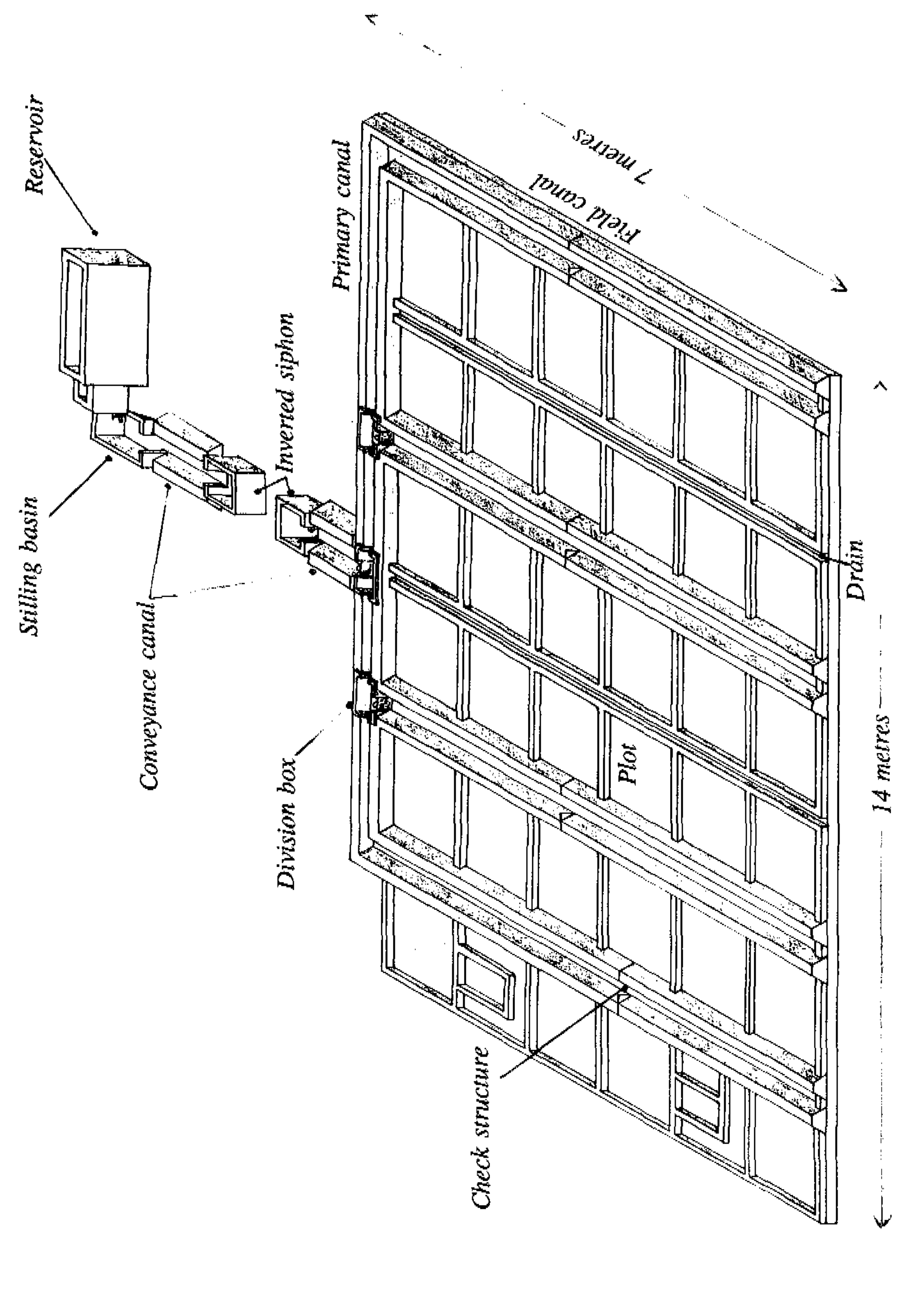
THE SCALE MODEL[1]

15.1 Introduction

Part of my field research was dedicated to the development of a canal maintenance extension programme for the *'Ile à Morphil'* small scale irrigation project. The project assumed that part of the irrigation problems - especially the deterioration of the irrigation infrastructure - could be solved by changing the maintenance practices of the farmers. Not surprisingly, the farmers had a different point of view: during field research it became clear that they perceived construction errors and a lack of project support as the main causes of these irrigation problems. After some research it appeared that farmers easily reproduced the conventional extension message about "how to maintain canals", but preferred to maintain in their own curative way. Several reasons for this could be mentioned: (1) the scarcity of labour for irrigation, as well as other production activities, (2) organizational problems in the *PIV*, (3) the farmers' (strategic) dependent attitude towards the project and (4) the lack of insight in the advantages of a 'preventive' maintenance. The latter explanation led to the idea to construct a scale model, with which the use of such an anticipatory maintenance could be shown. A visit by a group of farmers to the scale model was to be only one of the elements of the canal maintenance programme on the *Ile à Morphil* (cf Scheer, Burger, Ndongo, 1994).

In terms of *SSM* I had been asked to look for a relevant system to solve a project problem, but in order to be successful, it should not only be relevant for the project, but for the farmers as well. I had to make sure that canal breaches, unlevelled plots (*'ngesa potani'*), a 'weak *GMP*', as well as other problems that required priority in the farmers' eyes, received attention. The scale model can be seen as a result of the modelling of the system. The model itself was purely physical. But it also serves as a base for a human activity system because it allows for the imitation of irrigation practices. It measured 125 m^2 and was equipped with irrigation and drainage canals (scale 1:10), distribution, check structures and an inverted siphon (scale 1:10), as well as 36 plots (scale 1:50). A reservoir of 2 m^3 allowed for the irrigation of all plots. With its constant discharge (0.4 l/s), it took about 3 minutes to irrigate three plots. People could walk over the concrete scale model and irrigate the plots themselves. The scale model is represented in box 15.1.

[1] The idea of a hydraulic scale model originally comes from Mali, where it was part of a rehabilitation programme of the *Office de Niger*. The success of this Malian model convinced the *Ile à Morphil* project in Senegal that it would be useful to construct a scale model.



Box 15.1 The scale model (not to scale). Drawing by René Verhage.

As a part of the maintenance programme, ten farmers of one village visited the scale model at one time and, later on, they informed their fellow villagers about it. Seeing it and working with it, they readily recognized it as a model of their *PIV*. Only a small throbbing GMP lacked and was replaced by a storage reservoir. In the scale model, subsequently, four field canals would receive water to irrigate the plots. Each canal had a characteristic surrounding topography. A clearly visible clock was to indicate the time passing by: each minute representing an hour. It started ticking as soon as the '*GMP*' (i.e. the reservoir) was turned on. In this way, one irrigation day started around '7 a.m.' and ended around '6 p.m.', lasting about 10 to 12 'hours'. In actual fact, one 'day' came down to 10-12 minutes.

Each of these 'days' was followed by reflection. What happened today? Do you recognise the situation in your own *PIV*? Why did you decide to do that? Did any problem occur? How could it have been solved? What do you plan to do tomorrow? The cycle of creative action followed by reflection was repeated at least four times. Ideas were put forward and were discussed. The effect of their implementation could be observed in the scale model. In comparison to a field visit to an existing irrigation scheme, this direct implementation and check of ideas is one of the advantages of a scale model. Within ten minutes, a bird's-eye view may be obtained of the water distribution pattern along one field canal. In a 'real world' *PIV*, a similar water distribution would take at least one or two days and it would be difficult to obtain an overview because of its large surface. Moreover, in the real world *PIV* experiments would be more risky for the farmers. In general, farmers highly appreciated the excursion to the scale model and found it instructive.

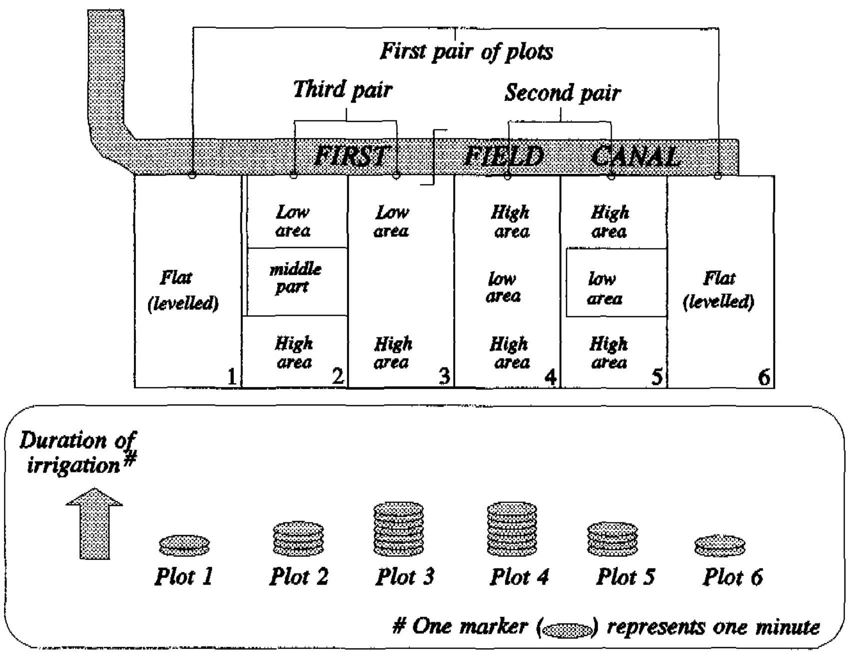
From the project's point of view, the scale model had to motivate farmers to change their maintenance practices. With the project's goal in mind, I tried to reach an agreement about certain actions in the 'real *PIV*' of the visiting farmers. But at the same time I used the model to find out about their technical knowledge. To this end, I observed their practices, asked questions about these and took time to discuss what happened. In this chapter, I will especially focus on the role of the scale model in finding out about the technical images. Equally, I will pay attention to its role in finding out about the *myths and meanings* in the farmers' irrigation organization.

15.2 Finding out about technical knowledge: plot level

> *The field canal that receives water the first 'day' is well maintained. It provides six plots with water, three plots at the time, each plot receiving the same discharge. Two by two the plots have a similar topography. A first pair of plots is flat, a second pair of contains a basin in the middle and a third pair has a particularly elevated area. Each of the second and third pair of plots contain one plot with compartments and another plot without (box 15.2). As a result, the required*

irrigation time varies per plot. The two flat plots are completed in no less than two minutes. The two plots with compartments require three to four minutes and the two others require 7 minutes. The irrigation time is recorded and markers next to each plot indicate the number of minutes.

The first 'day' of irrigation with the scale model



Plots with compartments require a shorter irrigation period than plots with a similar topography without these compartments. But flat plots are preferred.

Box 15.2 The required irrigation time for different plots

The discussion that followed after this 'first day' was always lively. Frequently, comparisons were made with plots in the real *PIV* and experiences were exchanged. Some remarks were for instance: *"This is exactly my plot, it tires me to irrigate it"*, or: *"For this reason, some days we can irrigate five plots only, but other days as much as ten"*. The first conclusion farmers drew after this experiment was that flat plots were to be preferred to sloping plots and many of them took the opportunity to declare that the project should help them to improve the bad plots in their *PIV*. This may not only be explained by their dependency disposition, but also by their technical image (cf 11.5). In response to their questions, the design engineer of the *Ile à Morphil* project explained that a certain natural topography can only be changed at high costs. For this reason the natural surroundings will only be slightly adapted. Important moderations, like a precise levelling are simply too expensive. Therefore the design engineer had considered no more than a rough levelling (*preplanage*). Consequently, difficult plots cannot simply be regarded as mistakes.

A second remark of the farmers was that the irrigation time, and consequently, the consumption of fuel for plots with an irregular topography was more elevated, but could be reduced by creating compartments. In practice, farmers have different experiences with the use of compartments: the efforts of some of them have more effect than those of others. Again, discussions were lively and experiences were exchanged. Some farmers were to change their 'real world' plot design afterwards. The amount of money required to level plots mechanically was compared to the efforts of creating compartments.

Farmers eagerness to talk about these irrigation problems on plot level illustrate once again that plot levelling problems should receive high priority in their eyes. When designing, the engineers' perspective on the degree of plot levelling is often only a stroke of the pen compared to his or her calculations, design drawings, lay out and profiles of canals, dimensions and threshold-levels of structures, etc. Design engineers may learn how important plot levelling is to the users of the schemes they design, and how frustrated they may be about an irregular plot. While discussing and negotiating about it during a design process - with the help of a scale model - it may even appear that farmers are prepared to invest in plot levelling. It may also be that they prefer fewer or simpler structures or less solid canals, if only their plots would be better levelled.

15.3 Finding out about technical knowledge: Maintenance, water distribution and topography

The second 'day' of the visit, the water was led into the second field canal, which was full of sand, had an irregular shape and had insufficient capacity to transport the total water volume. Consequently, canal breaches occurred. To avoid these as much as possible, the water distribution had to be adapted. While irrigating farmers found out by trial and error that it was no longer possible to irrigate three plots at the same time, situated close together. Instead, as many as five to six plots scattered all over the field canal had to be irrigated at the same time, just to avoid canal breaches. In this way, the higher plots along the canal even took more than one 'day' to be irrigated.

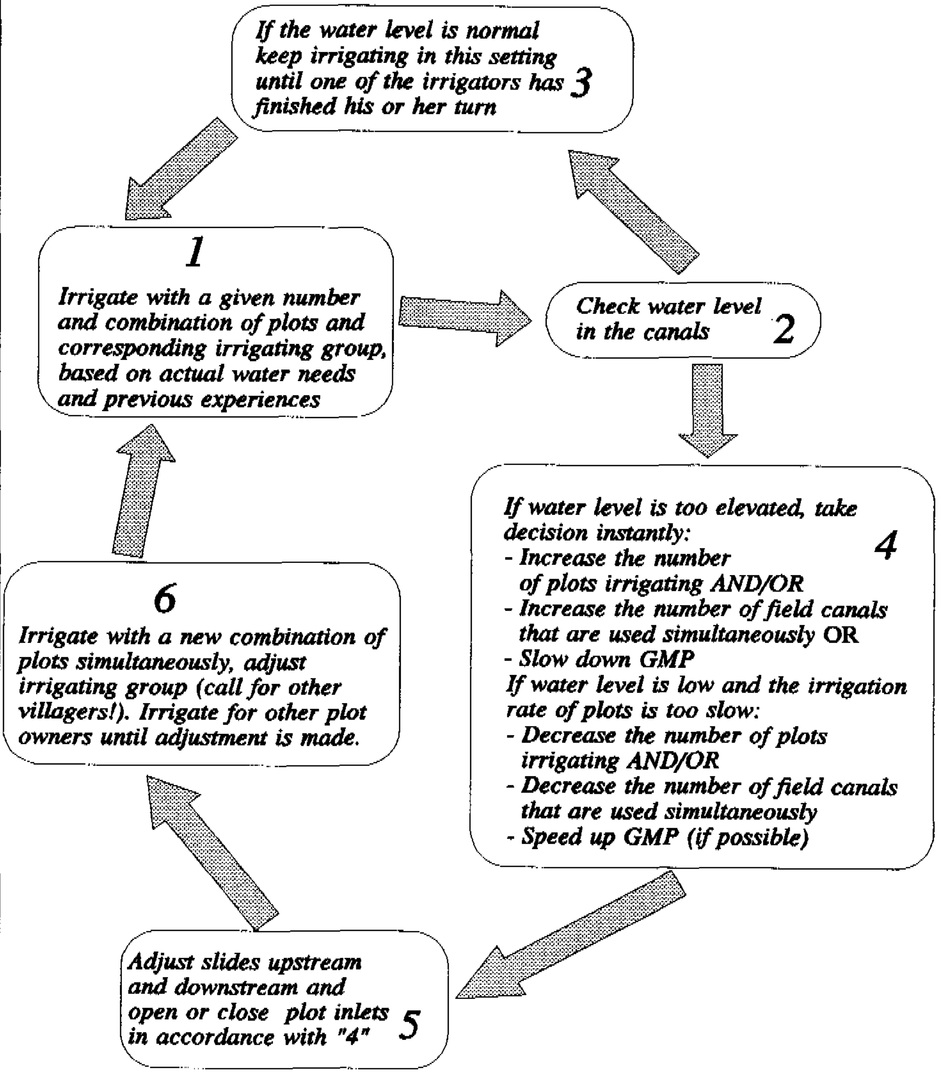
inlet". Although farmers were not used to the particular topographical situation of the scale model, most of them quickly learned how to adapt the water distribution while irrigating. In other words, a certain water distribution learning system can be discovered when observing the farmers' practices with the scale model (see box 15.4). This water distribution learning system is more effective than a system based on schedules because these hardly ever fit reality. However, it should be kept in mind that the organizational dispositions of the Haalpulaar allow for such a water distribution learning system.

The project's maintenance ideal to keep canals in their original shape is difficult to sell by referring to the more simple water distribution. The only other argument that might be demonstrated by the scale model is that the owners of the higher plots in their *PIV* endured obvious problems because of a decrease of the water level in the canals. During demonstrations I would raise this question, but it appeared that the discussion about collective action to be taken for individuals with higher plots was a delicate one. It was often considered just to be bad luck for the owners of high plots: *"You know, each of us obtained his plot by chance. So sometimes you're lucky and sometimes you're not."* However, in practice they may adapt their water distribution, by starting to irrigate the higher plots early in the morning.

Topography

Although the utility of the scale model may be restricted with regard to farmers adapting their maintenance practices, the model makes them conscious about the effects of low canal capacities, such as a slow irrigation of the higher plots along the canal. In spite of the fact that the problems of the higher plots seem to be caused by levelling problems *within* the plot, it becomes clear that they are caused by something else: inequality because of height differences *between* plots. Although these height differences can theoretically be alleviated during the construction, the costs would be even higher than in the case of alleviating levelling problems *within* the plots. Besides, such a complete levelling may lead to a loss of fertile top-soil.

In the case of levelling problems *within* the plot, which was demonstrated while irrigating with the first field canal (15.2), it was observed that the canal was quickly filled, delivering water at the same rate to each plot. Since the 'slow' plots are not further away than the 'quick' plots and soil differences cannot have caused the 'inequality' between plots either, the irregularities *within* each plot are the only clear variable in this experiment. Therefore the situation can be used to distinguish one type of '*ngesa potani*', (the lack of levelling *within* each plot) from the other type (the lack of 'equality' *between* the elevation of one plot and another).



Box 15.4 A model of the water distribution-learning system of the Haalpulaar (This system can be regarded as a sub-system of the irrigation system, represented in box 14.8. It is an elaboration of activity 4 of that box)

15.4 Finding out about technical knowledge: increasing complexity

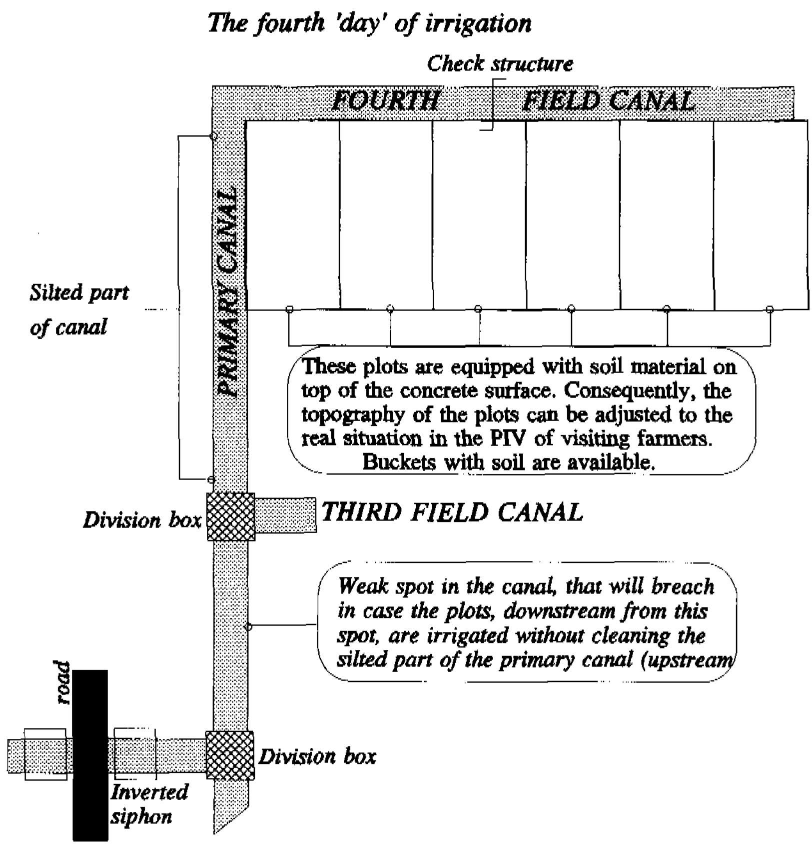
The next irrigation 'day', the farmers received a plot along the fourth field canal. After having elected a supervising president, farmers were asked to prepare themselves for tackling any problem that might occur. The built-in problems that were to be encountered in the fourth field canal were a combination of the problems of the first, second and third field canal (box 15.5). Plots, field canal and primary canal had to be observed simultaneously, which rendered the situation less surveyable than before. Farmers irrigated by trial and error. I only asked them for explanations afterwards.

Orientation towards the plot

While preparing themselves, farmers occupied themselves exclusively with the creation of compartments in their own plots, even after the president had ordered to turn on the '*GMP*'. As a result, they were hardly conscious about the problems that might occur in the primary canal, which looked solid, but was in fact silted up, having a bottom slope in the reverse direction of the water flow. If they would do nothing, the silt would cause canal breaches in the upstream part of the primary canal. In one case one of the visiting farmers detected the problem beforehand. He proposed to clean the canal to avoid canal breaches. In another case farmers started to realize that it took a long time before the water reached the field canal, but once the first amount of water seeped over the highest point and its velocity increased, they were reassured and waited for it to arrive. The canal would breach two minutes later. In another case, the farmers were hardly conscious about the breaches in the canal. Once they had discovered it, they simply repaired it by raising the sides of the canal in the upstream part. Equally, after the problem in the primary canal had been solved, the plot level clearly remained the most interesting level. In several cases farmers forgot to cope with a breach in the field canal, which led to a chaotic situation.

Maintenance and water flow

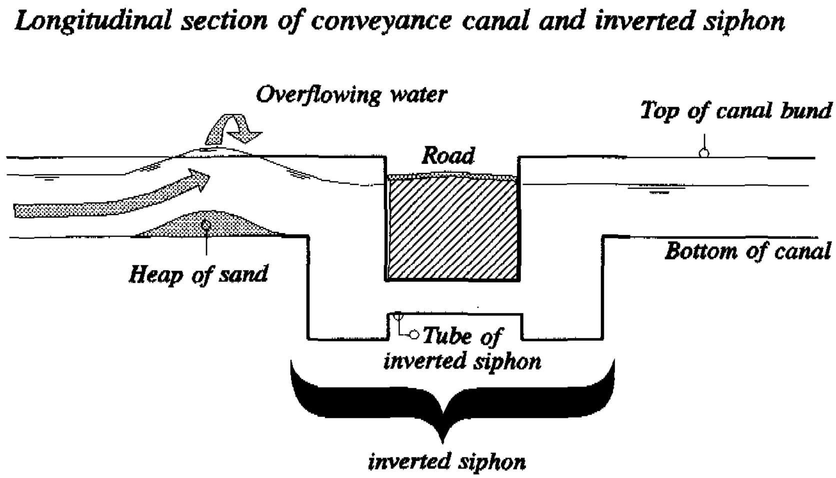
The built-in message of the silted primary canal was: *If a canal breaches it is often caused by silt deposition downstream*. The message had been told several times before as a part of the maintenance programme, for instance with the help of a simple levelling-instrument (see chapter 16). But now, it could be checked by cleaning the canal downstream and by comparing the water level upstream. Later on, I asked the farmers to explain where they would put a heap of sand if they wanted to create a canal breach directly upstream of the inverted siphon. Some farmers placed the heap of sand upstream of the 'would be' canal breach (see box 15.6). They indicated that the speed of the water would work like a kind of 'redoubt'. Others placed it directly downstream of the siphon, reasoning "*If there is a canal breach, it is often caused by too much silt in the*



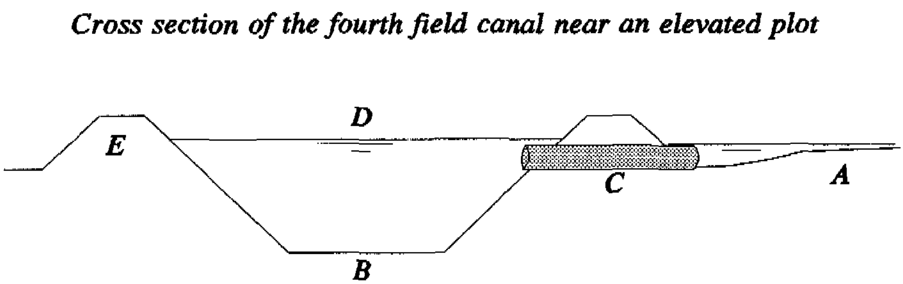
Box 15.5 Irrigating the plots alongside the fourth field canal

downstream part of the canal". Some farmers proposed another scenario: simply put a plug in the tube....!

Most farmers accepted the project message on the causes of canal breaches and could explain what it meant for their particular situation when I visited their *PIV* - some of them applied it in their *PIV*. During the visits to the scale model I was satisfied when farmers saw the effect of downstream siltation on canal breaches. This was sufficient from the project's perspective. Later on, I realized that this did not imply that farmers would drop the notion of a pushing force and would accept an exclusive notion based on hydraulic gradients and gravity. From a learning perspective, the principle of a downstream situation influencing an upstream situation should perhaps have been used to explain



Box 15.6 A heap of sand serving as a kind of redoubt (writer's representation of a farmer's perception)



Quotes of farmers about the causes of the problematic irrigation of the plot

A "The plot is too high"
B "The canal is constructed too low"
C "The field inlet is too low"
D "The water should rise......; the GMP lacks force"
E "The canal is too powerful for the plot"

Box 15.7 Farmers' explanations of a problematic situation farmers about 'universal' characteristics of water flow. However, would they have accepted a 'universal law' on the basis of one or two examples?

Complex situations

Farmers' explanations for difficulties strongly resembled their explanations in the field. Consider for instance the explanations they gave for the difficulties as to the irrigation of the highest plot (see box 15.7). Such varying explanations probably lacked in the other field canals because these concerned situations that were more transparent. The fact that farmers were mainly geared towards their own plots probably reinforced their lack of overview.

'Traditional checks'

It is remarkable that farmers hardly referred to a lack of maintenance, despite the fact that raising the bunds in the downstream part could have solved the problem - had not they agreed with the advantage of the solid third field canal? This also indicates, as was stated before, that they agreed with the project's message too eagerly. All visiting groups considered it a better idea to create an earthen 'traditional check' directly downstream of the higher plot, irrigating it as soon as downstream plots would have received water. The word 'traditional check' was introduced by my interpreter, Abdullahi Lom, who used it to indicate that farmers used these checks right from the beginning of irrigation development.

In fact, while trying to explain to farmers that properly maintained canals are the best way to facilitate the irrigation of higher plots, I discovered that my own thinking followed general rules too easily. I observed that farmers frequently irrigated the high plots by closing the canal, using an extra check. I firstly overlooked the idea of introducing such a 'traditional' check structure because I thought it would be too difficult to implement in reality. But later on, I became convinced that using extra traditional checks is often more easy than just using the 'scarce' concrete checks: the latter solution would require a joint maintenance of the canal bunds downstream. One farmer explained to me: "*For the farmer with the high plot it is preferable to make the 'traditional check'. If he would have to convince the others to raise the canal sides along the whole canal, it simply would be too tiring for him*". Besides, especially silted canals may be favourable to the use of traditional checks (cf box 15.8). Therefore, even the owner of a higher plot may sometimes object to maintenance actions.

As a conclusion, my 'general rule' that maintenance is especially important for the irrigation of higher plots only holds when the weak spots of the canal bunds are to be found *upstream* from the high plot.

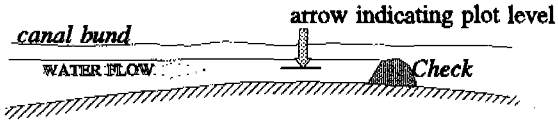


Figure 1: silted canal

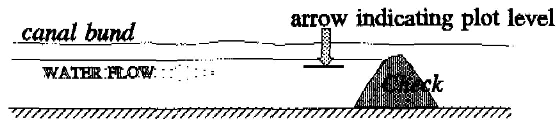


Figure 2: maintained canal

The irrigation of a high plot alomgside a silted canal (figure 1), only requires a small check.

If the canal would be dug out (figure 2) the check would have to be higher and more solid, demanding a lot of attention from its owner.

For this reason, silted canals may be preferred to maintained canals in case 'traditional' (earthen) checks are used.

It may well be, that a farmer in the situation of figure 2 would state that the canal is too low, or that the canal is too 'powerful' : his check may easily breach when he irrigates his plot (cf box 15.7, quotes B and E).

Box 15.8 Another reason for not maintaining a canal

Maintenance and water distribution

I also had to conclude that farmers try to find the ideal balance between water distribution and maintenance, which results in many specific practical solutions. But design engineers presuppose that farmers give priority to maintenance. Consequently, the design is not adapted to the farmers' practices. With the help of the scale model, it is possible to discern the different approaches regarding water distribution and maintenance. With this in mind, a design engineer could decide to adapt the design to the farmers' maintenance- and water distribution practices, instead of putting more efforts in over-dimensioned canal profiles, maintenance programmes that are meant to change farmers' *practices*, and so on.

Costs and 'construction errors'

Box 15.7 shows that the construction may be blamed as well (cf "*The canal is constructed too low*"). To some extent, this is a reasonable explanation: if it were not too expensive to construct a concrete check structure for only one plot, a design engineer would probably have agreed to design one in this part of the canal. Once again the delicate balance between costs and smooth irrigation is at the basis of this particular design problem. Working with the scale model, I assumed that its design and construction were correct: '*One check for three plots should be the maximum*', I reasoned in accordance with design engineers' norms, automatically presupposing that the construction costs in irrigation schemes have to be limited in this particular way. Only after having received several groups of farmers it became clear to me that my assumptions, hidden in the design of the scale model, were questionable.

15.5 Finding out about the farmers' organization

From the interpretation of roles in the scale model (like the role of the president in water distribution) one can learn about the characteristics of the village organisation in the real world *PIV*. One president, for instance, had often complained to me that his villagers always had to be told what to do and that they were difficult to handle. The visit of this president and nine of his villagers to the scale model gave me insight in the 'myths and meanings' people attributed to their relation with others in the village. While working in the scale model, the users of this village reacted passively and distantly when an unexpected problem would occur. When they were asked why the canal breaches occurred, they would not bother to give any explanation except for: "*It is the fault of the president. He should have told us what to do*". On the other hand, it appeared that the president clearly lacked the persuasive power. The village organization was more or less paralysed. The case made me curious and I asked a Senegalese topographer, who knew the area very well, about it. He explained that the village was divided in two groups and stated that the president was not elected because of his authority, but because of his 'insignificance'. All authorities of the village belonged to one of the two groups and were not acceptable to the other. This also explains the passive behaviour of the villagers: each group waited for the other to take action.

Another example was the woman president of Cascas, who was known for her strong leadership capacities. She proved her qualities while visiting the scale model. It was always very clear who would have the next turn and who was responsible for solving certain problems.

A final example was provided by the former president of Fonde Elymane, who had been accused by his villagers of implementing project directives instead of listening to his villagers. After the accusation he decided proudly to leave the presidency, against the will of his villagers. A new president was elected, but in the scale model it became clear that he did not know how to cope with irrigation problems. Consequently, everyone proposed something else and a chaotic situation resulted. However, during the reflections, the former president impressed me, and others, by his remarkable insight in the situation. Slowly but inevitably he started to take the lead in irrigating with the scale model. I do not know what happened afterwards in the village of Fonde Elymane, but it must have been clear to everyone that the former president could be valuable for the village.

Role plays

These examples indicate that the scale model can also be used in the cultural stream of analysis of *SSM*. Situations like these might have been used to discuss issues like the village organization, but this is delicate because the scale model is so realistic. It might be better to organize 'irrigation' role plays, using the scale model. In general, the scale model encouraged its users to play theatre. The fact that every farmer got a plot and a president was elected, automatically resulted in a kind of role play. Farmers who would receive a 'bad plot' might easily start playing the role of the 'poor victim' or the 'rebellish dissatisfied water user'. Farmers who would play the role of president gave strict orders or would complain about the bad behaviour of their users. I have seen a president stealing water with pleasure, now that someone else had been elected 'president' of the scale model. It may well be that role plays can be designed to treat delicate subjects like 'factions in the village', water stealing, etc, without people loosing their face. It enables them to experiment without risk.

Role plays about design engineers who visit a *PIV* and request farmers to 'maintain properly', whereas farmers complain about the bad quality of the *PIV* would have provided fascinating material to explore their relationship. Role plays would generally provide a solid basis for discussion about the human activities in an irrigation system.

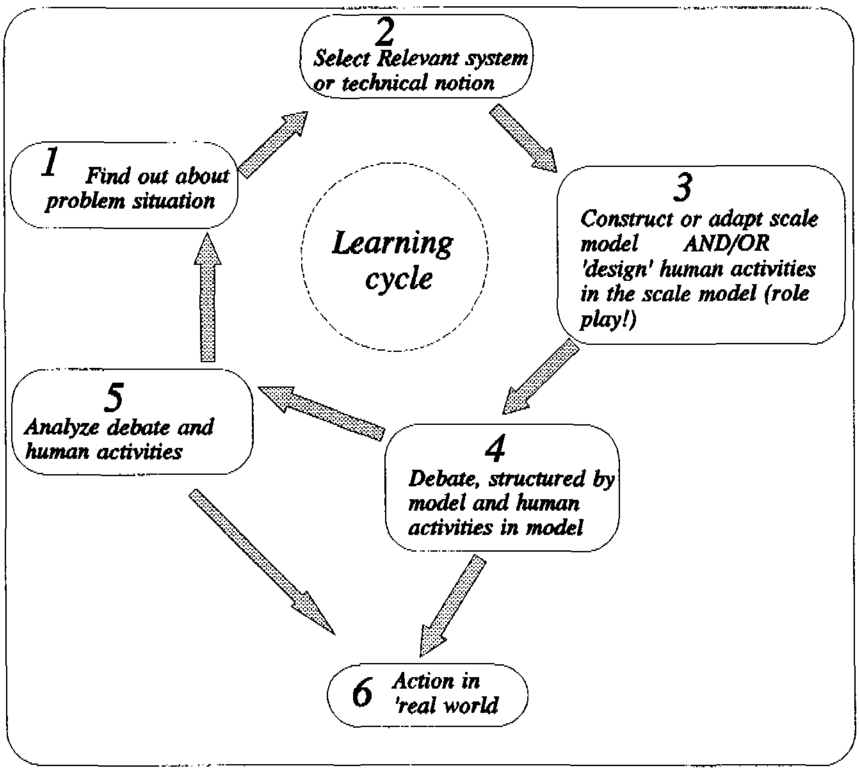
15.6 Role of the model in a learning system

Learning about technical knowledge

The scale model can be a useful part of a learning cycle (see box 15.9). It can for instance be used by design engineers to explore the farmers' notion of maintenance and water distribution, to gain insight in the farmers' ideas about causes of water flow, to detect the danger of applying 'universal' rules in a local situation, to explore the farmers' notion of '*ngesa potani*', etc. Equally, farmers may learn when working with the scale model, which was in fact its original aim. The example of the scale model indicates that one should be careful with general built-in project messages and that one should allow for variation. Ideally, the communication pattern that evolved from the contradictory technical images of design engineers and farmers (box 14.5) loses its paralysing effect, once farmers and design engineers stop to underestimate each other's knowledge about irrigation.

Learning about the irrigation organization of a village

The scale model may also be used to understand the farmers' irrigation organization, which may differ from one village to another. Role plays may be designed to set up a debate about delicate issues, such as the existence of two factions in a village. A design



After having progressed in the learning cycle, the experience may eventually lead to actions like maintenance, construction and changing management in the 'real world'.

Box 15.9 Role of the scale model in a learning system

engineer may use this kind of information, for instance by creating irrigation units for each faction. Meijers (1990) indicates that outsiders may fulfil an important role, by formulating solutions that are acceptable to everyone. The extent to which a village may change its organization through scale models and role plays is not clear, but it may be worth trying, especially in a case like Fonde Elymane (see section 15.5). Role plays, serving to discuss certain organizational *practices* with regard to water distribution and maintenance are a promising aspect of the scale model.

Learning about plot level or scheme level

It has been indicated that most farmers are geared towards their plot and only a few (e.g. the president or the pump attendant) may keep track of the entire scheme. The scale model could be useful when other farmers also require a broader perspective, for instance when farmers who used to work together are 'split up' in five or six *UAIs*. Design engineers, in turn, may learn about the plot perspective, e.g. when playing the role of a farmer who wants to irrigate his irregular plot as efficient as possible, facing the fact that others also demand water, leaving the difficult decisions to someone else.

Learning towards a new irrigation system

When progress has been made in the learning cycle, reaching a certain accommodation between goals and notions of design engineers and farmers, a scale model may be designed (or adapted) to represent the 'ideal' situation. Based on experiences with this model, lessons can be learned about the 'would be' irrigation infrastructure. By designing a scale model, as well as by suggesting a certain use, design engineers propose an irrigation system. By working with it, farmers *show* whether this system is relevant for them, rather than that they *discuss* a logic, abstract model. For instance, the problematic check-structures of Diomandou, that were entirely new to the farmers, could have been tested in a scale model. Their advantages and disadvantages would have become clear, before the high investments were made. The same is true for the two pumping levels in intermediary schemes like Ndoulomadji and Hamady Ounare: since farmers only saw the disadvantage of the high costs of pumping, design engineers might have pointed out the organizational advantages, using a scale model. Further more, certain lay out questions, such as the position of the conveyance canal, winding irrigation canals, the number of check structures, etc, can be made explicit and tried out, without risk, before implementing them.

Being conscious about each other's technical knowledge, farmers and design engineers could discuss their priorities for the design, especially in the case of limited means. Since the number of misunderstandings about technical subjects is diminished, they may succeed in discussing responsibilities more openly now, without jumping to the conclusion that "*the other does not really know what irrigation is about*".

Changing the dependency pattern?

When breaking through the circle of 14.5, the pattern represented in box 14.3 may become more explicit: Design engineers may question why they keep thinking *for* the farmers. Farmers may question why they maintain their *wish to please* mentality. The 'game situation' may serve to experiment with different kinds of behaviour.

15.7 Other examples of scale models

In box 15.10 examples of other scale models are given. These physical models may be used to approach many problems that have not been mentioned in this chapter. Drainage problems, siltation of canals, irrigation problems in mountainous areas, erosion problems, etc, can be thought of.

The project *Sensibilisation et Formation des Paysans autour des Barrages* in Burkina Faso, was often approached by farmers and extension officers with a request to adapt the existing infrastructure in order to improve their water distribution methods. The design engineer experienced how important it was to explain the effect of a certain water distribution method that was proposed by farmers and extension officers. He designed a scale model, provided with perspex canals and distribution structures. The water was pumped round by a pump made out of the spare parts of a washing machine. The scale model was small and could be transported. The height of the thresholds of structures could be altered by inserting different pieces of perspex. In this way the design engineer could show what influence the new distribution method would have on the water quantities and water levels in different parts of the scheme. He could explain that if one wishes to change the water distribution, the structures in many cases also have to be adapted - if not, water excess in the one part of the system and water shortage in the other part are very likely to occur. The design engineer, who, previously, had failed to convince farmers and extension officers verbally, now succeeded in convincing them (personal communication Joost de Jong, 1994).

Another scale model was used as a part of a rehabilitation programme in the *Office du Niger* in Mali. With the scale model the consequences of the rehabilitation for the management on tertiary level were shown, for instance the tuning of the management of tertiary inlet with the water use on tertiary level. Equally, the difficulties of irrigating with a badly maintained canal were shown. The use of creating plot compartments and small canals on plot level was demonstrated and farmers learned how to make their own design for their plot. Especially the last element of the demonstration was successful and many farmers implemented new plot designs in the field. The success of this Malian scale model convinced the *Ile à Morphil* project in Senegal that it would be useful to construct a scale model (Office de Niger, 1990).

Another example is not linked to irrigation, but shows how important a scale model may be when farmers are expected to construct the infrastructure themselves. An NGO in Nepal constructed bridges in remote areas. After construction problems in the field, it was decided to experiment with scale models. These realistic models were constructed near the spot of the future bridge. Also the environment of the bridge was copied realistically, because the features of a bridge, especially its way of anchorage, highly depend on it. It took a week to construct these models, but the efforts paid themselves back: the construction was completed several months quicker, materials were used more efficiently and supervision took much less time (personal communication René Verhage, 1994).

A physical model, simulating rainfall and run-off, proved to be very useful and effective as an on-farm learning tool for soil and water conservation (Hamilton 1995, pp78-88). The rainfall simulator is a transportable machine, producing 'rainfall', with drop-size and energy similar to natural rain, which is applied to two adjacent 'plots', allowing to treatments to be applied and compared by the farmers themselves.

Box 15.10 Examples of other scale models

Chapter 16

DIAGRAMS, MAPS, DRAWINGS AND FIELD VISITS

16.1 Introduction

Apart from the systems' models used in *SSM* and physical models such as the scale model, a range of other kind of models can be distinguished: drawings, maps and diagrams. These present information in a readily understandable visual form and can also be applied by users of a learning system. These models will be paid attention to in this chapter. Field visits to existing irrigation schemes are useful as well. In this case, relevant 'real world' irrigation schemes take the role of a systems 'model', although these lack the simplicity that make many models so useful as such. In *Rapid Rural Analysis* or *Participatory Rural Analysis* models serve to 'tap' or 'mobilize' local knowledge. Models may also be used by a design engineer to explain what he or she means. One example of such a model is a water level composed of a garden hosepipe and two pickets. It can be used to explain the principle of communicating vessels and gives insight in principles of water flow. Of course, farmers' responses to the demonstration of such principles may again be part of the exchange and the design engineer may learn from the farmers.

In this chapter I will start to present some general aspects of *Rapid Rural Analysis (RRA)*, *Participatory Rural Analysis (PRA)* and *Participatory Technology Development (PTD)*. Then, I will give my own examples of the use of drawings, maps, field visits and the 'water level' and finally I will indicate how these models can be used in a learning system.

16.2 *PRA, RRA* and *PTD*

In literature, reference is made to the use of diagrams, maps and other schematic devices, which are often used in the field of *Rapid Rural Analysis (RRA)* or *Participatory Rural Analysis (PRA)*. Both *RRA* and *PRA* part from the importance of local peoples' knowledge and use a menu of methods to 'tap' or 'mobilise' it. In box 16.1 a number of these methods is represented. *RRA* and *PRA* are not easy to separate, but in general in *RRA* the outsiders' role is the one of investigator, extracting information from the farmers, while in *PRA* the outsider is a facilitator and the information is owned and interpreted by farmers (Chambers 1992). In *Participatory Technology Development (PTD)*, the role of researchers, extensionists and field workers is to contribute to and to improve local capacities to adjust to changing conditions through experimentation and adaptation of technologies. It is concerned with the construction of a locally adapted technology from complementary contributions of farmers and technicians (Haverkort et al 1991).

Maps and aerial photographs

- participatory analysis of aerial photographs (often best at 1:5000)
- resource maps of catchments, villages, forests, etc
- social maps of residential areas of a village
- soil maps
- irrigated field maps

Diagrams

- seasonal diagramming - by major season or by month to show days and distribution of rain, amount of rain or soil moisture, water availability, crops, agricultural labour, fuel, income, etc.
- Venn diagrams: the use of circles to represent people, groups or institutions and their relations
- Participatory diagramming of flows and causality (cf systems' models in *SSM*)
- Participatory diagramming of quantities, trends, rankings, scorings by means of bar diagrams, pie charts, etc.
- time lines: chronologies of events, listing major remembered events in a village with approximate dates

Interviews

- key informants
- group interviews
- short, simple questionnaires (if at all) late in the process
- key probes: questions which can lead to direct key issues like: "What would you suggest other villages to do in the design process?"

Other methods

- secondary sources
- 'They do it' (research by villagers and village residents)
- do it yourself: asking to be taught to perform village tasks
- role plays
- transect walks
- field visits to other areas, for instance to show the impact of erosion processes
- well being or wealth ranking
- analysis of difference (gender/social group, etc.), including contrast comparisons by villagers - asking one group why another is (or acts) different, and vice versa
- presentations of discoveries by villagers

Box 16.1 The menu of methods of *RRA* and *PRA*. (The list is not exhaustive. See for instance Chambers 1992, Mascarenhas 1991)

Participatory technology development also seeks to strengthen the existing experimental capacity of farmers and will sustain on-going local management in the process of innovation (Engel et al 1989). The process equally has many features in common with the principles of *PRA* and *RRA*, but more attention is given to on farm experimenting. All these participatory approaches and methods are now proving to be both popular and powerful, spreading rapidly, taking different forms in different places.

[Farmers may be asked:] "...... "do you know how to make a map of your village?" In addition, great play is made of the issue 'who holds the stick'. The person who holds the stick talks about what is most important to them. People use local materials, such as sticks, stones, grasses, wood, cigarette packets, tree leaves, coloured sand and soils, rangoli powders; but many also bring outside materials; such as coloured chalks, pens and paper. [.....] As maps and models take shape, more people become involved, and so want to contribute and make changes." (Mascarenhas et al, 1991, p12).

Box 16.2 Participatory mapping and modelling

Until recently, it has been widely assumed by professionals that rural people, especially when illiterate, would not be able to construct or understand diagrams, maps and other devices. However, recent experiences show that their capabilities practically always exceed the expectations of outsiders (Conway 1989, Chambers 1992). Compared to more conventional modes of investigation, the use of these devices appeared to have important advantages. Diagramming enables farmers to explicit their knowledge and the shared information of diagrams can be checked, discussed and amended. As a result, increasing awareness has often been reported by researchers and field workers. This results in a certain driving force for innovation: many examples exist of spontaneous actions of local people after discussions based on diagramming (Conway 1989). But the most remarkable aspect to researchers is probably the open and lively atmosphere. This is well described in box 16.2 and reminds of the atmosphere during the visits to the scale model. Participatory diagramming, mapping and drawing have certain unfreezing characteristics with regard to the relation between researchers or field workers and the local population. Both researchers and farmers take pleasure in diagramming and their rapport becomes more relaxed (Chambers, 1992). Another advantage of these methods is, that it does not have to take long before the researchers or field workers can go out and practise (Chambers 1992). This observation is in accordance with my own experience in a design engineers' training programme in Burkina Faso.

The above mentioned advantages are all excellent points of departure for learning, but the high expectations that result have a risk: once farmers' expectations are not satisfied within reasonable time, they may slide back into old practices. Being a novelty, the new method temporarily may have 'wet the appetite', but without follow-up and feedback towards results, nothing may happen. In some areas the method is so popular - especially its game-element - that farmers become tired of it and get the feeling they have not been taken seriously (personal communication M. Oomen 1995). Another danger is that donors or central government agencies are so eager to issue instructions for the adoption of the method, that it results in a speed of spread exceeding the capacity for individual institutions to conduct social and organizational experiments to discover what is most appropriate for them (Mascarenhas et al, 1991). In general, diagrams are useful and seem to be able to give impulses for shared learning and action, but only as a part of a learning system these actions may be sustained. In *SSM* methods of *PRA, RRA* and *PTD* may be used during the stages of *finding out, modelling* and *debate.*

16.3 Drawings

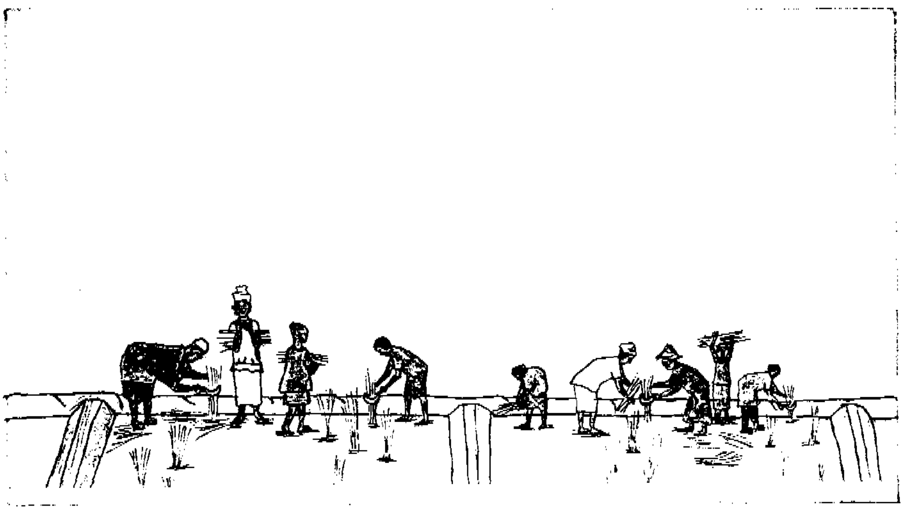
In this paragraph, I will elaborate on my own experience with drawings, maps and field visits as devices in a learning system. Drawings can be easily used as a base to discuss a problem or issue. The drawings I used were based on the perception of problems by farmers in two villages. Before making use of them in my interviews later on, these were tested in some other villages. Unfortunately, I did not invite farmers to draw themselves, but this worked out successfully in *PRA* methods elsewhere.

When designing drawings one should have some rules in mind to facilitate interpretation. Firstly, one should know what images and elements can be used to express a certain key-word or theme because these are largely culturally defined. Secondly, the contours of elements have to be clear and each element should have one uniform colour. Superfluous elements and refinements, as well as the use of perspectivity, should be avoided. Finally, experience learns that elements that are not completely visible may easily lead to misinterpretation. Drawings designed according to these rules look simple and seem easy to make, but as a design engineer I found it very hard to unlearn drawing in perspective. I was lucky to be able to make use of the services of an artist who worked for the Cascas project. He was also familiar with the cultural symbols of the region. Two of his drawings are presented in box 16.3.

Because of its simplicity some design engineers - but also extension officers - have the opinion that one cannot be serious using such an infantile method. Nevertheless, the use of these drawings proves that farmers do not find the drawings infantile at all. Other critics insisted that the drawings were not realistic, but when drawings are made 'realistically' in perspective, people may only recognize some separate elements in the drawing, but cannot make the connection. For this reason, drawings are preferred to photographs.

Drawings in the learning system

During the semi-structured interviews with farmers in 35 different villages and 8 different projects I used more than 30 drawings as a kind of questionnaire in order to learn



Box 16.3 Examples of drawings I used for joint analysis (drawings by Mamadou Ndongo, Cascas).

something about the design history and actual situation of *PIVs* and *AIs*. I also learnt about their technical knowledge, e.g. about the confusion that sometimes arises when showing '*ngesa potani*'. After asking them to react to each drawing, I requested people to classify the drawings according to the priority of the theme to the village. Especially when people were reluctant to answer questions, the drawings were useful to 'unfreeze' the situation. Some farmers were surprised that I 'knew' their situation so well. It is true that the drawings, much more than simple questions, reflect a condensed interpretation of life in the villages and irrigation schemes, while questions might give the idea that a visitor does not know anything, and just comes to extract information. I experienced that working with drawings leads to an exchange of information and a more open atmosphere.

I did not use drawings to elicit systems' models or rich pictures. In retrospect I would like to have experimented with it. When using drawings for this aim, one probably needs a set of drawings, each of them representing a certain activity. In an extension programme of the *Ile à Morphil* project, production processes were illustrated in this way and the drawings were placed in chronological order, like in a cartoon. This appeared to be easy to understand and was helpful to illustrate the processes. Irrigation systems' models like the one in box 14.8, 15.4 or 15.9 should be elicited by drawings to make them intelligible for farmers.

16.4 Maps

Design engineers know that a map can be very useful to discuss irrigation designs, because one has overview and it is not necessary to travel from one spot to the other. Many design engineers think that farmers are not able to read a map. According to Meijers (1991) they lack the visual perception of reading a map. Another design engineer in Senegal said: "*I sometimes explain things with the help of the plan, but people hardly respond, and no discussions follow.*" But in my own experience it simply depends on how one presents a map. Contour lines, for instance, cannot be seen in the field and therefore complicate the reading of the map. In general, maps that represent a desired *future* situation but lack clear marks of the *present* surroundings are too abstract. One also needs to make sure that the position of the map corresponds to the position of the real scheme. Often, if people do not understand the map, one simply has to reorient the map until its position is 'right'.

The use of maps in a learning system

In the case of Diomandou, I represented an existing scheme on a coloured map provided with drawings of the type described above. The drawings corresponded with the features and position of the trees, houses and land use in and around the system. It was easily understood by most men and women. After some orientation, but without help, most people could trace their *UAI* and find their own plot. The map was used during a field visit of Aere Lao farmers to the Diomandou scheme. Afterwards, when the visiting farmers had returned to their village and explained to their villagers what they had learned, they used the map again. Later on, I used the map as an icebreaker in an informal way, before starting the semi-structured interviews. Some people, men and women alike, could orient themselves quickly and apparently were familiar with maps. Others seemed to see it for the first time, but were very eager to learn to read it. They would ask very straight questions like: "*Where is the village? And the trees? Did you draw these infertile lands too?*" They helped each other finding out things. Apparent mistakes were for instance corrected by others: "*You did not draw the fields on the other side of the road ... O, now I see.....*". After 'having the picture', people started to indicate their plots. Border lines between different village territories, different soil types and the like were easily indicated by them. They even discovered mistakes in the map - e.g. some new rice fields that were not indicated.

A map may be very useful to relate different design elements (structures, canals, plots, etc) to each other. Therefore, maps could well serve as a basis for systems' models. For instance, farmers can easily indicate on the map how they distribute water in practice. During my research, I only made 'passive' use of the farmers' knowledge, by asking them to *read* the map. However, *PRA* and *RRA* experiences show that they can also draw a map.

Using maps in a participatory design

It appears from the above that maps can be used to discuss some existing situation. It is made clear that people can see differences between the map and reality, suggesting that the *plan should be better adapted to reality*. I did not experiment with maps on which future situations are indicated - in other words, in a situation where '*reality should be adapted to the plan*'. Damen (1990) recommends the use of adapted maps during the design process in order to "*rehearse the lay out of the scheme in detail, to test knowledge and understanding of the farmers about the proposed lay out and to make sure there are no remaining issues regarding the lay out, land use and desirability of the scheme*" (p 13). Therefore, design engineers should be careful to conclude 'from their own experience' that farmers cannot understand maps of future situations, without having experimented with the idea.

An interesting experiment I did not carry out would be to ask farmers to draw the lay out for a new irrigation scheme. Since a lay out depends so much on the topographical situation, such a map may be a useful entrance to discuss the consequences of a certain topography. Consequently a debate about water flow may emerge, requiring a new explicit model. From experiments like these, it would probably appear that a map can provide the basis for a useful systems' model when discussing designs or rehabilitations of future systems.

16.5 Field visits to relevant irrigation schemes

Although existing irrigation schemes have the advantage of being more 'real' than the scale model, their complexity is so high, that one may not see the wood for the tree. Therefore, one may experience difficulties when trying to use visits to existing schemes to *structure* a debate. However, through the questions of the visiting farmers and the selection of the objects of interest by the receiving farmers, their priorities may become clear. In a first phase of the learning process, this may be an advantage to the *SSM* user, but when in a later stage a debate is set up about a particular relevant technical aspect, it may be disappointing when farmers are much more interested in the size of the tomatoes, relations with the bank and finding jobs with the contractor.

It is not possible to find a 'real world' irrigation system that exactly looks like the 'would be' irrigation system that is looked for in a design process. This may result in conclusions that are not appropriate for the 'would be' irrigation system. Two examples are given in box 16.4. This makes clear that the irrigation scheme, serving as a model, has to be chosen carefully. The disadvantages of the abundance of information in a 'real world' irrigation system can also be alleviated by a sound preparation of design engineer and farmers. One example is the excursion of Aere Lao farmers to Diomandou farmers (see box 16.5).

When Soninké farmers of the Bakel region visited a *PIV* near Cascas, they were impressed by the ease of the irrigation. *"Even a child can irrigate here"*, they said and wished to copy the 'Cascas' design features in their *PIVs* near Bakel. However, one factor was overlooked: The topographical situation in the middle valley is simply more favourable than in the upper valley (Personal Communications of Nico Bakker (1989) and Huub Munstege (1991)). In other words: Also plots in *PIVs* with a 'Cascas' quality would be difficult to irrigate in the upper valley. The farmers' wrong conclusion is probably due to their notion about water flow and topography: Both are difficult to separate.

Another example concerns the Aere Lao farmers who visited the Diomandou scheme. They were much impressed by the huge pumping station and the lined primary canal. However, the scheme was only recently constructed and maintenance problems of these elements had not yet become manifest. In my view, this led to a perspective that was optimistic.

Box 16.4 Field visits to other schemes may lead to the wrong conclusions

The visit as a part of the learning system

According to Pradhan and Yoder (1989) field visits fit well in a training programme about irrigation management, are cheap, are effective and have a wide applicability. During the

The design engineer, the visiting farmers and the receiving farmers play a role in preparing the field visit. In this case I stimulated the farmers to prepare for the field visit, together with Trea Christoffers, a student of the *WAU*.

Visiting farmers were enthusiastic about the idea of the excursion. "*We sit in a dark room and do not know what we get until the lights are turned on*", they said (Christoffers 1991). We asked representatives of each village to prepare a meeting about what they wanted to learn from the Diomandou farmers. The visitors discussed among themselves about the questions and grouped these around five themes: (1) How were the contacts between the farmers and the *SAED* during the design process (2) Could they apply for jobs at the contracting company? (3) To whom the plots would be given after construction (4) How did they farm to reach a good production (5) How did the irrigation work and what were the differences between their *PIV* and the Diomandou system?

The receiving farmers also prepared for the excursion. It was discussed how the visitors were to be received, what route was to be followed when showing them around in the scheme, and who would tell them about the different levels of the scheme: primary, secondary and tertiary. I was happy with the fifth question of the visiting farmers and the systematic route the receiving farmers had planned. These guaranteed that technical aspects in the irrigation scheme were important to farmers and would receive some attention.

After the visit, the farmers' representatives informed their villagers about the things they had seen and about the answers to the questions they had posed. Their memory was remarkably good and precise.

Box 16.5 Participatory planning of the field visit.

field visits I took the role of a researcher and did not interfere during the excursion, only giving a short introduction. The atmosphere between visiting and receiving farmers was open and I could benefit from their enthusiasm. In the case of the field visit of Aere Lao farmers to Diomandou, the explanations that receiving farmers gave to their guests were often an eye-opener to me. Some information about the check structures and their attitude towards design engineers only reached me during the two excursions we organized, despite my search for it during semi-structured interviews. Not only did I learn from the questions and the reactions of the visiting farmers, but also from the answers of the receiving farmers. This implies that it may be useful to invite other farmers to some existing *PIV* needing research. The explanations of the receiving farmers are a source of information to the *SSM* user in the cultural stream of analysis. From part III of this thesis it can be concluded that the local knowledge of farmers is based on their experience in their existing *PIVs* or *AIs*. Consequently, in villages that opt for a new scheme, these are of special interest to the design engineer, who may learn from the farmers' explanation during a joint diagnostic analysis, getting insight in the local characteristics of their knowledge. Later in the design process he or she may be able to relate difficulties in the communication process to the farmers local knowledge and may avoid the pitfall of a dead-end communication pattern.

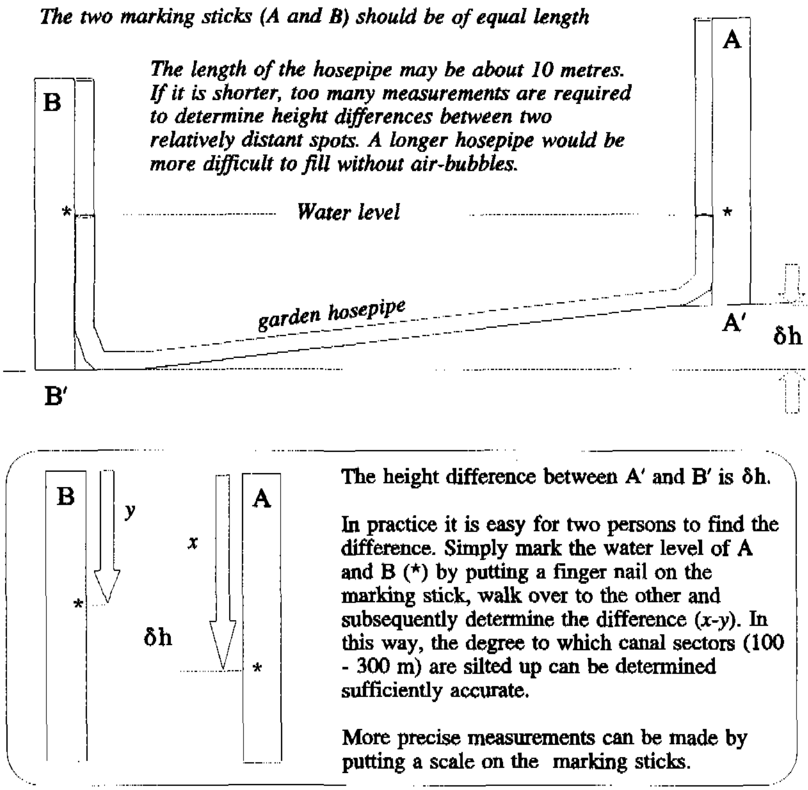
Using field visits in a participatory design

My position did not allow me to influence future designs. Especially in the case of Aere Lao (see box 16.5), the design already had been fixed and the contractor had started with the construction of the scheme. The information that came to me during the excursion indicated that the check structures gave rise to problems (see chapter 10). If a design engineer would take this information seriously, he or she would have to decide to construct other check structures, or at least would have to take time to clearly explain and demonstrate the advantages of the designed check structure. The example of the village Abdallah (chapter 9), where farmers - contrary to the design engineers advice - preferred to cultivate the lowest plots, shows that a discussion about the positive and the negative effects of the different options could have been useful. An excursion to a *PIV* with similar problems as the ones that were to be expected in Abdallah - low plots and drainage problems - would probably have been an appropriate 'model' of an irrigation system, serving to structure a debate about the issue.

16.6 The water level

The principle of the water level is illustrated in box 16.6. It was used in the canal maintenance programme, to indicate farmers to what level they would have to dig out the silted canal bottom. Together with my colleague and interpreter I would visit farmers during maintenance actions, demonstrating the water level. We showed farmers how the two water levels in both ends of the tube would always return to an equal level, by raising or lowering one end, and then see the water levels creeping to the same level again. We demonstrated that this principle did not change if one moved the two ends apart, even up to 10 meters. In other words, we explained them the principle of communicating vessels. We showed how this principle could be used to find spots with the same height, using two sorghum stems of the same length. Finally we indicated how one could determine the depth to which the soil had to be dug, whenever one discovered that a downstream part of the canal bottom was higher than the upstream part.

In all cases the farmers reacted with remarkable enthusiasm. Apparently, the principle of water creeping towards an equal level in both ends of the tube, regardless of distance and movements, was such an eye-opener to them, that they easily accepted the message that the canal had to be levelled in order to facilitate irrigation. They readily dug still deeper in the bottom than they had already done. Their reaction made me aware of the beauty of the principle, as if I saw it for the first time myself. The principle itself creates



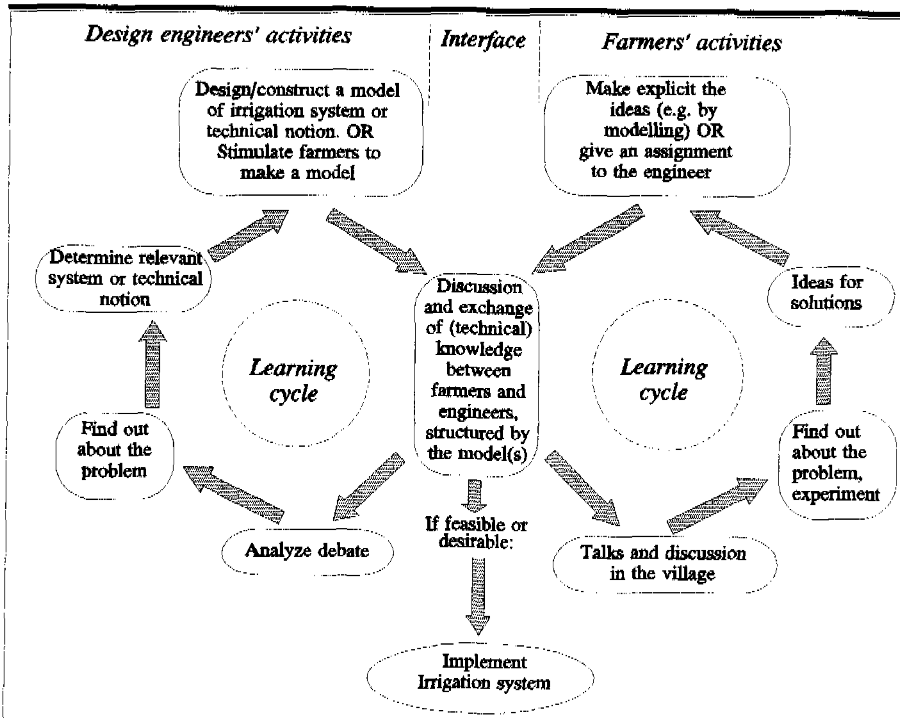
Box 15.6 The principle of the 'water level'

favourable conditions for learning, because it is intriguing and stimulating and it has an intrinsic value, explaining a principle of gravitational flow. I used the water level for the project's maintenance goals, but it would have been an ideal entrance to talk about water flow as well, and link the principle to the practical situation in their irrigation scheme.

16.7 *SSM* and *PRA, RRA* and *PTD*

In *SSM*, the user of *SSM* (in this case the design engineer) is supposed to set up a debate around relevant systems, but it is not explicitly mentioned that farmers may model themselves. However, from *RRA*, *PRA*, and *PTD* it can be learned that problem owners like the farmers should be considered as active creators of models as well. These may not be based on root definitions that follow the principles of scientific logic, but on a farmer's practical logic. The *SSM* user may therefore stimulate farmers to make their own models. The menu of methods that are presented in this chapter can be regarded as a 'box of ideas' that may serve well in the *SSM* learning process, but it should be kept in mind that creativity on the spot is more important. Even more important is that the 'box of ideas' must be subordinate to the *SSM* learning cycle and the learning principles: it must be problem-centred and experience-centred, the learner should participate in the research, there must be feedback towards progress, etc. As a part of their own 'finding out' stage, farmers experiment themselves or may be encouraged to do so.

In box 16.7 a model of a learning system is presented. It is relevant to participatory design of irrigation infrastructure. On the one hand, the system is meant to transform unconscious confirmation cycles into conscious learning cycles. On the other hand, the learning system focuses on the design of a 'would be' irrigation system which is relevant to, and desirable for, farmers and design engineers. Ideally, the system 'learns its way' to a sustainable irrigation scheme.



Box 16.7 Model of the learning system that may eventually lead to the implementation of an irrigation system that is feasible and desirable.

Chapter 17

CONCLUSION

17.1 A lack of exchange of knowledge during design processes in the *Senegal* middle valley

A fundamental problem of irrigation development in the Senegal valley, which restricts the exchange of technical knowledge between design engineers and farmers, is the difference between government and farmers' objectives. The government's objective to change the valley into the granary of Senegal, by means of a maximization of the irrigated area and production per hectare, is at odds with the practices of farmers, who seek to minimize risk. In their perspective, irrigation is only one of the 'instruments' to secure their own food production. Low quality socio-economic feasibility studies prefer not to question this contradiction between government's and farmers' objectives.

To a large extent, design engineers are the natural allies of the government or the donors. Design engineers are structurally distant to farmers and, at best, think *for* the farmers. The *AI* concept is illustrative. It is supposed to combine the advantages of small scale *PIVs*, being 'farmer friendly', with the large scale *GA*, permitting a surplus production of rice. However, in the *AI* concept farmers would still be expected to become full time commercial farmers in order to ensure the sustainability of the schemes, and, although the *AI* concept is better adapted to the organizational dispositions of farmers than the *GA* concept, it would still require different villages to work together. This implies that management conflicts may arise from farmers distrust of other villages. In this way the controversy between government and farmers' interests are incorporated into the design of the irrigation schemes, in spite of the engineers' efforts to think for the farmers.

The feasibility studies not only lacked quality in the socio-economic parts, but in the technical parts as well. These are often based on vague, faulty or incomplete data. With regard to actual design processes of *AIs* and the 'improved' generation of *PIVs* a tendency can be observed that technical data, especially about the soil quality, rely less on farmers' knowledge than before. Because future owners of a scheme hardly participate in decision making about their scheme and the design process usually has no built-in possibility to correct mistakes, faulty designs are easily implemented. To make things worse, as the construction rhythm increased over the years, planners and design engineers took more and more control of the design process at the cost of farmers' participation.

As communication between design engineers and farmers is limited, the physical infrastructure often turns out to be a one sided message of several design engineers, participating in one design process. The general absence of communication between farmers and design engineers during the design process is partly structural, because the employers of engineers seldom stimulate and most often discourage social interfaces between farmers and design engineers. In addition to this, most design processes are thwarted by discontinuities in place and time and consequently discourage even informal interfaces with farmers. In this environment, initiatives to communicate with farmers are difficult and, at least, require extra time and efforts from the design engineer. On the other hand, the lack of communication with farmers can be traced back to design engineers as individuals of whom the majority are not interested in communicating with the farmers during the design process. Others pay lip service to "farmer participation", in general referring to participation in construction or, in the case of *PIVs*, in information gathering for site selection, but only a few of them communicate directly with farmers beyond this level. With regard to these few, communication about technical issues receives little attention and the design engineer remains in control of the technical information.

17.2 Differences in technical knowledge of design engineers and farmers

Compared to the technical knowledge of design engineers, the technical knowledge of farmers is closer to the physical phenomena. It is highly adapted to a specific and local situation and developed by doing and learning. In a specific problem situation the best solution is found without elaborate beforehand planning, but by trial and error. The design engineers' knowledge, in turn, allows for reflection about the choice and design of many separate elements (structures, plots, canals, etc) and, subsequently, the combination of these elements in a model of an entirely new irrigation system. It is based on scientific education and relies on certain more or less universal rules about the design elements and their interrelations. Generally, design engineers work with ideas and are professionally predisposed towards interventions, but they are not involved in the daily use of an irrigation scheme. In box 17.1 some of the differences in technical knowledge of farmers and design engineers are presented.

The two types of technical knowledge may appear contrary, but can often be regarded as complementary. There are areas and skills which are covered by the technical knowledge of farmers but not by the technical knowledge of design engineers, such as the interplay of water distribution and maintenance. Despite the fact that design engineers are used to making a synthesis of the many elements in the technical design, they often attach too much value to the distinctive elements and characteristics when they assess a problem situation. On the other hand, there are also concepts which farmers cannot possibly have, not only because they depend on knowledge which is out of their reach, but because their experience, with regard to design and construction, is limited to small changes and extensions. For instance, some aspects that a design engineer considers separately, such as water flow and topography, are perceived as a whole by farmers, which need not be a

Design engineer	***Farmer***
With regard to *design*, design engineers have an overview on alternative concepts and design elements.	*Design* is done directly in the field, by trial and error. It often concerns minor adaptations. A broad experience lacks.
When *designing*, the model of reality is easily taken for reality itself (reification).	When considering a new *design*, the familiar practices are easily assumed to be valid in new situations.
The notion of *"planage"* (levelling) is most often limited to plot levelling. *Planage* and *preplanage* (rough levelling) are distinguished.	The notion of "*planage*" is translated in *"ngesa potani"* (unequal fields) and is often much broader than plot levelling. The distinction between *planage* and *preplanage* is not clear
Water flows because of an energy gradient. The gradient is provided by the *GMP* between the river and the stilling basin. From the stilling basin on, the water flows by gravity and the energy gradient is provided by a downslope in the water level.	In many cases, *water flows* because of a (*pushing* or *driving*) force in the water, which is often connected to the *GMP*, and it can flow uphill - at least over a limited distance - but in case of clear visible differences in height farmers may also use explanations that refer to the topography.
The irrigation system has to remain in its original state to guarantee the designed *water distribution*.	When the state of the canals changes, maintenance may be necessary, but also the *water distribution* can be adapted.
Maintenance is *preventive* and is a most important factor to the stability of the system.	*Maintenance* is *curative* and is related to short term production instead of long term stability.
The *drainage* system is separated from the *irrigation* system. Norms of water requirements are applied to the irrigation system and norms of water discharge to the drainage canals.	*Irrigation and drainage* are two sides of the same medal: A plot that suffers from excess of water will automatically have less water scarcity problems and vice versa.
Priority is given to canals and structures	*Priority* is given to the plot

Box 17.1 Some differences in technical knowledge between design engineers and farmers (a more extensive list is provided in the annex).

problem in a local situation, but may be limiting in new situations. In addition, design engineers and farmers may have different priorities. For instance, farmers are mainly concerned with the plot characteristics, while design engineers are oriented towards canals and structures.

Technical knowledge changing through an evolutionary process

The technical knowledge of design engineers and farmers is relatively independent of their face to face interaction, but modifies in a slow evolutionary process. Adaptations to the design practice by engineers seem rather to be based on observation of the physical reality and thinking *for* farmers than on learning *from* them. On the other hand, farmers' irrigation practices are influenced when they are confronted with new infrastructure, although in turn, their practices also change the new infrastructure. The change in farmers' practices may take some time and takes place through a learning process, based on interaction between the members of the constantly changing *irrigating group*. In village meetings important new practices may be condensed into rules. However, the evolutionary learning processes of design engineers and farmers are restricted by their habitus, or more specifically, by their technical image.

17.3 Circles of unconscious confirmation

It has been shown that the interface between design engineers and farmers in the Senegal valley can be characterized by circles of unconscious confirmation, leading to confirmation of the farmers' and design engineers' habitus. The communication pattern is determined by the top-down conditions in which the design process takes place. Design engineers are paid to follow their orientation towards ever more elaborate solutions and replace the cheap and hand made *PIVs* by ever more expensive, more solid and more sophisticated *PIVs* and *AIs*. In this way, looking for direct profit, farmers were stimulated to present themselves as being dependent on project support and they please the design engineer as much as possible, especially in the early project stages, to secure a scheme for their village. In this way, the top-down conditions result in superficial communication, and no learning can take place.

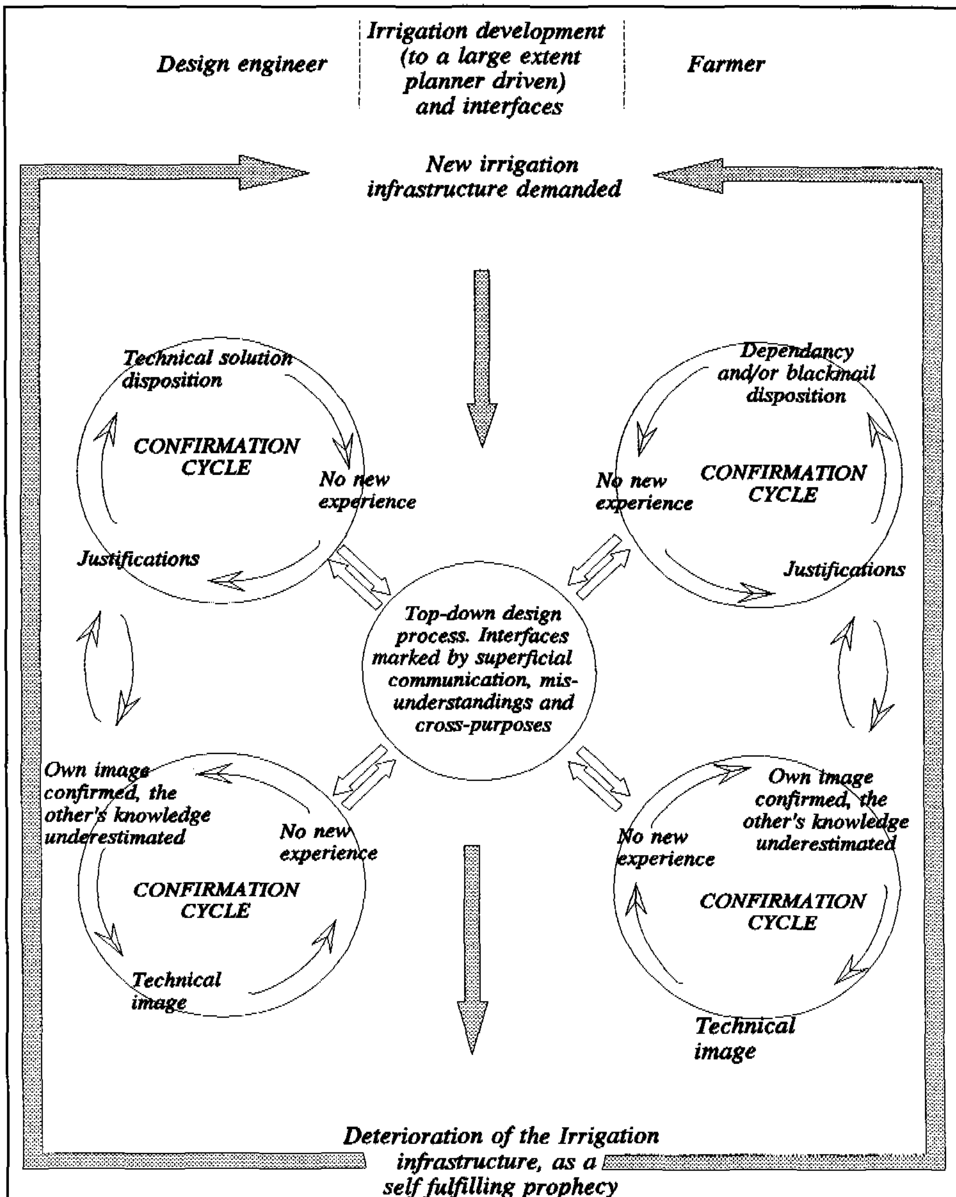
However, even without the direct influence of the planning environment, design engineers and farmers drift into a pattern of unconscious confirmation. This is due to their technical images, since these ensure their own continuity and their defence against change. The pitfalls of the technical communication pattern are not easily discovered, since during communication about technical issues, several elements are touched upon simultaneously, making it difficult to unravel what happens. One of the side-effects is that the design engineer will underestimate the farmers' capacity to contribute to technical solutions. Farmers, in turn, will underestimate the design engineers' capacity to give technical solutions. For instance, the practical logic farmers use to explain what happens (e.g. their water flow explanations) may contradict the Western and scientific logic. The design engineer, geared by his own logic, cannot but conclude that farmers do not really understand what they are talking about. On the other hand, design engineers' 'rules of thumb' based on universal laws (e.g. 'water cannot flow uphill') contradict direct observation of farmers (e.g. water flow in the downstream end of an inverted siphon) and they, oriented by their own logic, easily conclude that the design engineer 'does not really know about water flow in practice'. Both reject the good with the bad. In box 17.2 the pattern of unconscious confirmation cycles is visualized.

Design engineers and farmers are not aware of the fact that their deeds contain an 'objective intention', when they meet. This is the result of their habitus as a whole and their technical images in particular. The mechanisms of habitus and technical image bring systemic qualities to the communication processes of design engineers and farmers, whose interface becomes a system, in which the activities of the one trigger off the other. These systemic properties make it difficult for individuals to opt out. Not only insight in one's own habitus is required, the standard conduct of the other has to be overcome as well.

17.4 The influence of the unconscious confirmation cycles on the quality of the design and the sustainability of the system

Despite the fact that they deal with complex human activity systems, planners and design engineers regard the irrigation systems in the *Senegal* middle valley as *hard* systems, efficient means to reach a specified objective. According to Checkland, this leads to problems. Indeed, farmers will probably not make the profit they are expected to make, which leads to problems of maintaining and depreciating the expensive, sophisticated irrigation infrastructure of *AIs* and improved *PIVs*. In addition, the organization beyond village level can become problematic. Within the overall design process of an irrigation system, which includes these aspects of organization and production-orientation, the technical design process may be of crucial importance and when focusing exclusively on technical subjects, the cycles of unconscious confirmation appear to have their own negative influence on sustainability.

Generally, since the knowledge of both actors is complementary, the lack of knowledge exchange inevitably leads to a loss of production or a decrease in sustainability and has repercussions on the objectives that the donor, government, design engineers or farmers have in mind. More specifically, an engineer's design that results from his or her technical image is not adapted and often will not work in the 'real world': it has been shown that farmers often do not do what they were supposed to do, and examples in this thesis make it clear that this often has a negative influence on sustainability. One can conclude that design engineers' practices are inadequate. On the other hand, farmers' practices are often too rigid: having irrigated there for 15 years they are unwilling to



Box 17.2 The unconscious confirmation cycles of design engineers and farmers that characterize their interfaces

change their practices, even when a new design could be more profitable if only they changed their practices. Consequently, a new scheme that may be well adapted to their farming system and organizational capacities may not have time to 'prove itself'. The reason for this is that the physical features of the scheme may already change before new, 'appropriate' practices have the chance to evolve from the learning process of farmers in the new infrastructural environment. In this way, ideas about the one another's 'wrong concepts of technical issues' become a self-fulfilling prophecy and the infrastructure deteriorates due to a lack of adaptation between (technical) practices and technical design. Both actors see the other as the one who causes sustainability problems.

The illusion of the PIV as an 'irrigation school'

Fifteen years ago farmers were not familiar with irrigation and *PIVs* were seen as 'irrigation schools' for them. However, it has been shown that the practices they developed cannot be simply applied to a new irrigation infrastructure or to another topographical situation. The internalized practices may prove more difficult to *unlearn* compared to the *learning* of new practices in a field where the knowledge is still undeveloped. In other words, when farmers were not yet familiar with irrigation, the physical infrastructure of the first handdug *PIVs* largely determined their irrigation practices. Now, when farmers receive a new type of physical infrastructure, their acquired practices determine the prospects for the scheme, sometimes even to the extent that it starts to function and look like the original infrastructure. A self-fulfilling prophecy in optima forma! Therefore, one should be careful to conclude that the *PIVs* have been functional as a school for new, larger irrigation schemes.

17.5 Improving the situation: A system of participatory irrigation design

In this thesis, it has been shown that learning is *necessary*, even when it concerns 'technical' issues. In addition, it became clear from experiments, that learning is *possible* as well. In other words, the cycles of unconscious confirmation can be transformed into learning cycles. The planning environment should have a built-in space for learning processes in which engineers' and farmers' technical images are transformed. For such a learning process, *Soft System's Methodology (SSM)* is highly adequate, not only because it deals explicitly with many valid viewpoints, but also because it fits in with the design engineers the engineers' solution-oriented and model-minded dispositions. Yet, *SSM* can be applied whether or not, in the end, a solution is implemented.

In soft system's thinking, sustainability is a quality which evolves from a learning system. A participatory design, which is considered as a learning system, implies joint analysis, action plans and joint decision making. Ideally, farmers should take the initiative, but design engineers should also contribute to the process, as aspects of their knowledge are pattern result in a new pattern, a learning system, helping both sides to 'learn their way' to a feasible and desirable irrigation system. The shared experiences with models become reference points for both actors enabling them to develop new practices and a joint technology. The learning processes should continue during the construction phase, because, during this stage, farmers often start to consider many issues for the first time and, as we have seen, design engineers can make important mistakes in earlier phases of the process. Experiences in the *Senegal* middle valley, especially in the *Ile à Morphil* project, make clear that it is possible to maintain a certain flexibility throughout the construction process.

With regard to the design of larger and more complex irrigation systems, the intensive communication with farmers is probably not more expensive for planners than the common design processes in the *Senegal* middle valley. One argument to underpin this, is that the design process of the *AI* near Cascas, which was never implemented, required an investment comparable to the investments during the first stages of 'common' design processes in the valley. In the Cascas design process the emphasis still remained on 'the design engineer as the owner of information' and farmers were excluded from the major decision not to implement the scheme. But until then the process had been flexible and the design engineer could establish a relation based on trust, since it appeared to the farmers that he took their comments seriously. In addition, the project used an interdisciplinary approach and, compared to other projects in the valley, communication with farmers was considered important.

Another cost-argument that pleads for participatory design is, that conventional design processes in the valley usually turn out to be much more expensive than planned: these take longer than expected, requiring extra measures - or even extra projects - in order not to lose the investments that have already been made.

17.6 Recommendations

The initial theoretical and methodological perspectives of Checkland, Bourdieu and Long were generally useful to me. I grounded them to some extend by comparing them to my observations, but, as I used the perspectives retrospectively, their scientific value is modest. In box 17.4 some feedback to the initial perspectives of this thesis is given.

The most important recommendation is, to change top-down design procedures into designing in a participatory manner, along the lines of the model in box 17.3. This implies that the planning environment in which design engineers operate, has room for learning processes between farmers and design engineers. However, it are not only the planners who are at fault. Communication about technical issues and learning about their own blind spots are a design engineer's responsibility and, consequently, in cases when

Most of my observations were in agreement with Bourdieu's theory. Even interaction on the interface would generally confirm what both sides already knew. This does not alter the fact that the experiments showed that the social interface between engineers and farmers may also be the place for a learning process. The concepts of habitus, structural environments and practices have proved to be useful in a phase of 'finding out' (cf the cultural stream of enquiry of *SSM*), giving clues to the discovery of systems of confirmation that stand in the way of the learning process. During this stage, the alternating observations on respectively social interfaces and structural environments helped me to focus on relevant issues.

The following steps to find out about technical images and misunderstandings are recommended:

1) Find situations where farmers' practices seem to be at odds with the design engineers' design (look for clues in the hardened history of practices in a scheme)

2) Reconstruct what happened on the social interfaces of farmers and design engineers, by means of interviews with different actors (design engineers, farmers, extension officers, etc). This often results in colourful stories with different perspectives and hypothesis about:

   a) The technical perspective of farmers, which makes them consider the design engineer 'stupid'

   b) The technical perspective of design engineers, which make them consider the farmers 'stupid'

   c) Possible misunderstandings on the social interfaces

3) Check hypothesis a) and b) with practices of farmers and engineers in their structural environments

4) Check hypothesis c) with interactions on present social interfaces

By comparing and/or combining the two different types of technical knowledge, a more informed technical knowledge will be obtained. Equally, one will be better informed about the mechanisms of misunderstandings in the communication process. These 'grounded' perspectives can be used to define systems that are relevant to change. In this way I moved from the cultural stream to the logic-driven stream of enquiry.

The logic-driven stream of enquiry of *SSM* fits in fairly well with the design engineers' solution-oriented and model-minded dispositions. It is a useful methodology that deserves more attention in the Department of Irrigation and Soil and Water Conservation. The systems' models as proposed by Checkland have a built-in scientific way of looking at reality, as modelling language requires a logical contingency and precision. However, discussions about future situations based on such abstract and formal models of irrigation systems would place Senegalese farmers at a disadvantage. Consequently, these should (also) be based on other types of explicit models. In this way, the debate about change becomes accessable to farmers.

Box 17.4 Some feedback to the initial perspectives of this thesis their terms of reference leave little room for communication with farmers, design engineers should try to find ways to convince planners, or use the freedom they have, in order to learn as much as possible.

Scale models are so instructive to farmers and design engineers, that these should be constructed without too much hesitation, whenever irrigation development is relevant and design processes or maintenance programmes are planned. It is a effective tool for design engineers and farmers to learn together and to 'construct' a shared irrigation technology. Likewise, scale models can be used for training design engineers to communicate with farmers. In this way, they also get a feel for the day-to-day practices that are required, and this counterbalances their own technical ideas, which are often disconnected from the user's reality. Even far away from irrigating farmers, for instance at the Department of Irrigation and Soil and Water Conservation in Wageningen, the idea of role plays in scale models may be used to gain insight into the specific position of farmers, alternative patterns of water distribution, etc.

Design engineers should be trained to express themselves clearly in intelligible models, that allow for a discussion, right from the start of a design process (e.g. site selection and siting of main canals). Training for design engineers to become familiar with the use of these diagrams and models for shared learning is probably relatively easy and will not require much time. It may be even more important for the design engineer to open his or her mind to other forms of technical knowledge and forgo the question whether he or she is right. It is crucial to be open-minded. The use of models and repeated reflection may do the rest.

The participatory design process would more or less follow the pattern of box 17.3, but never rigidly, because flexibility is needed for inner cycles, 'short cut' cycles and re-cycles, or maybe even entirely new activities. In fact, the system of box 17.3 is no more than a first model. The circular pattern of the system should be repeated several times, until a system has sufficient learned relevance to be implemented, and even during implementation the learning process should continue. Of course, the model has its own 'blind spots'. These will become obvious when it has been put into practice. Some questions that need to be solved in the process of adapting this learning system to reality, are for instance: How to translate different irrigation problems (water wastage in large scale systems, drainage problems, erosion problems, organizational problems beyond village level, etc) in a scale model? Should a scale model be built 'right away', to be used for learning afterwards, or should it be constructed after the irrigation problem situation has become more or less clear? What contribution can role plays in scale models make to 'organizational design'? How can the interaction between the technical design process and the organizational design process be stimulated? How should contractors, extension officers and professionals from other disciplines participate in the design? To what extent should farmers be in control of 'technical decisions', when they disagree with design engineers, in other words, are they, the farmers, allowed to make mistakes? But then again: to what extent are design engineers allowed to make mistakes when they implement their plans without the consent of farmers?

Final remarks

A blind spot of the participants of the international workshop *Design for sustainable farmer-managed irrigation schemes in sub saharan Africa*, was hidden in their desire to account for certain *social* characteristics in *technical* design choices. This wish can be regarded as a result of the history of the Department of Irrigation and Soil and Water Conservation in Wageningen, during which social and economic disciplines were included, in addition to the existing technical disciplines. Beyond doubt, the workshop's question how to relate *social* factors to a *technical* design remains important, because it may help lower the barriers between technical and social disciplines. However, I hope to have shown that this theme may not be particularly interesting to farmers who deal with design engineers. Farmers are certainly more interested in directly 'meeting' the design engineer in the area which he or she, as a professional, knows most about. It is ironic, that the blind spot is found right in the middle of the professional heartland of the design engineers, but this is exactly the 'speciality' of habitus and technical images: they are hidden in unexpected places!

ANNEX

Overview of differences with regard to technical knowledge (I)

Design engineer	***Farmer***
General aspects of design	
Based on scientific theory and abstract thinking.	Based on doing and learning by trial and error.
Universal and general. Overview on alternative concepts and design elements.	Specific and highly adapted to the local physical situation.
Oriented towards canals and structures.	Usually oriented towards the plot.
Oriented towards generating ideas and solutions.	Oriented towards a daily use.
Despite the fact that many different design elements can be discerned, there is a risk to overlook the dynamics of the interrelationship between these elements.	Many design elements that a design engineer discerns are not (strictly) separated (e.g. irrigation and drainage, topography and water flow, maintenance and water distribution).
After data gathering (land survey, soil survey, etc) a model of reality is made, which is later on realised in the field.	The design is done by trial and error. It most often concerns simple adaptations. A broad experience lacks.
Oriented towards idea generation. Problems occur when the model needs to be adapted to the local physical conditions in practice (survey- and construction errors).	The 'technical design' of design engineers is considered to be inaccessible and disconnected from reality. Design is done directly in the field.
The model of reality is easily taken for the reality itself (reification).	The qualities of the known local irrigation system are easily assumed to be valid in new situations.

Overview of differences with regard to technical knowledge (II)

Design engineer	***Farmer***
Topography and earthworks	
Topographical conditions considerably limit the degrees of freedom of a design, since costs should to be low.	The topography is easily adaptable by machines, that "take the soil from the high parts down to the low parts".
The protection dike is laid out in such a way that the earth works remain limited. Only a part of the surface will be used to lower the costs.	The whole surface within the protection dikes can be used. In the case of *PIVs* the whole surface within the mark stones can be used.
For an overview of the topographical situation, a contour map - based on the principle of a fixed reference height - is necessary.	High and low parts can be compared by alternately choosing canal bottom, (slides of) structures, plot surfaces, etc. as reference points.
Most contour maps cannot be used to assess the topographical situation on plot level.	Once they irrigated, farmers know where to find the high and low parts of their plots.
Plot levelling is easily assumed to be done by the farmers	A lack of plot levelling is considered to be the major irrigation problem.
The notion of *"planage"* is most often limited to plot levelling. *Planage* and *preplanage* are distinguished.	The notion of *"planage"* is translated in *"ngesa potani"* (unequal fields) and is often much broader than plot levelling. The distinction between *planage* and *preplanage* is unclear
Soil suitability	
In design processes of PIVs, the farmers' knowledge on soil suitability is used. In design processes of *AIs* it is preferred to use teledetection techniques.	Farmers can make use of their precise knowledge of soil qualities and aptitude - which is based on their experience with crop husbandry and which is closely related to patterns of surface run off.

Overview of differences with regard to technical knowledge (III)

Design engineer	*Farmer*
	Water flow
Water flows because of an energy gradient. The gradient is provided by the GMP between the river and the stilling basin. From the stilling basin on, the water flows by gravity and the energy gradient is provided by a downslope in the water level.	Water flows in some cases because of a (*pushing* or *driving*) force in the water, which is often connected to the *GMP*, and it can flow uphill - at least over a limited distance - but in case of clearly visible differences in height observable farmers may also use explanations that refer to the topography.
In a given topographical situation the canals can be laid out in such a way that water flows gravitationally.	Water flow and topography are not clearly separated and likewise the idea that water can flow uphill and the notion of an easily adaptable topography.
Heights and types of structures are designed to control the gravitational water flow.	Thresholds of structures are seen to block or push back the water.
The lay out of irrigation canals is made such that the highest parts of the locality are connected, and elevated canals or crossing with drains are to be avoided. To lower costs, the number of canals is limited.	With regard to the canal lay out, the shortest water track is preferred, and long winding canals are disliked, because it takes too much time for the water to reach the plots. If necessary, depressions need to be crossed.
Drains are laid out by connecting the lowest points in the environment.	Drains are often used as irrigation canals, to keep the water track as short as possible.

Overview of differences with regard to technical knowledge (IV)

Design engineer	*Farmer*
Water distribution and maintenance	
The designed water distribution requires the water levels to only fluctuate between certain upper and lower limits, has a fixed plot-to-plot sequence and does not change from year to year.	Water distribution depends on the state of the canals. Water distribution is based on a flexible sequence from plot to plot, and depends on interactions within the irrigation groups.
Maintenance is *preventive* and is a most important factor to the stability of the system.	Maintenance is *curative* and is related to short term production instead of long term stability.
The irrigation system has to remain in its original state to guarantee the designed water distribution.	When the state of the canals changes, maintenance may be necessary, but also the water distribution can be adapted.
Irrigation and drainage requirements	
Low plots that cannot be drained need to be left out of the design	In a situation of water scarcity, low and fertile plots are preferred even when drainage problems occasionally occur.
Water scarcity should to be avoided by adapting the surface to the capacity of the *GMP*.	Water scarcity is considered as a given, and related to break-downs of the *GMP*.
The drainage system is separated from the irrigation system. Norms of water requirements are applied to the irrigation system and norms of water discharge to the drainage canals.	Irrigation and drainage are two sides of the same medal: a plot that suffers from an excess of water will automatically have less water scarcity problems and vice versa.

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RESUME

Introduction

Les aménagements hydro-agricoles du monde entier se caractérisent le plus souvent par un grand nombre de problèmes interdépendants et à dimension humaine. Ces problèmes sont trop complexes pour pouvoir leur appliquer des solutions standard. Cette thèse part du principe que ces problèmes ne peuvent être résolus que par un processus d'apprentissage impliquant tous les groupes et organisations qui participent à l'aménagement. Cette thèse met en lumière la façon dont communiquent les paysans du nord du Sénégal et les ingénieurs chargés de la conception des aménagements hydro-agricoles, l'objectif étant de découvrir comment les deux parties peuvent tirer des enseignements l'une de l'autre.

Une étude bibliographique plus approfondie sur ce sujet met en évidence l'existence de deux zones d'ombre, au sein des connaissances des ingénieurs d'irrigation (ou ingénieurs du génie rural), qui compliquent le processus d'apprentissage. La première concerne la prise de conscience de l'importance cruciale des connaissances qu'ont les paysans des phénomènes physiques comme l'écoulement de l'eau, la composition du sol et la topographie. Dans cette thèse, ces connaissances seront appelées les connaissances techniques. L'autre zone d'ombre concerne les éventuelles méthodes pouvant être utilisées par les ingénieurs pour faire en sorte que les paysans participent au processus de conception.

La prise en considération de ce qui précède amène à baser la recherche sur les questions suivantes:

1. En quoi les connaissances techniques des paysans diffèrent-elles de celle des ingénieurs?
2. Dans quelle mesure tirent-ils des enseignements de l'échange de ces connaissances, comment et pourquoi le font-ils, ou pourquoi, justement, ne le font-ils pas?
3. Quel est l'effet de cet échange (ou de l'insuffisance d'échange) sur la qualité des projets d'aménagement?
4. Comment l'échange de connaissances techniques peut-il être optimalisé?

La recherche peut être qualifiée de qualitative et exploratoire. Des observations approfondies, des interviews informelles, des interviews semi-structurées ainsi que des entretiens et des discussions de groupes ont fourni les données de la recherche. La réflexion engendrée par ces données a débouché sur de nouvelles perspectives concernant la problématique, perspectives qui se sont révélées utiles pour l'élaboration d'expériences dans une phase ultérieure. Certaines expériences ont fait partie d'un programme de formation sur le projet d'irrigation à petite échelle "*Ile à Morphil*", rendant ainsi indispensable une forte interaction entre les paysans et moi-même, dans mon rôle

d'ingénieur. Le suivi scrupuleux des expériences a apporté de nouvelles données à la recherche, ce qui a, à nouveau, débouché sur de nouvelles perspectives. Plusieurs cycles d'apprentissage ont été ainsi suivis pendant la recherche sur le terrain au Sénégal. Enfin, au cours de la dernière phase, la perspective de la recherche a été élargie par la visite de plusieurs projets d'irrigation dans le nord du Sénégal. Dans tous les cas, des paysans aussi bien que des ingénieurs ont été interviewés.

Dans cette thèse, les données de la recherche ont été examinées sous différents angles. Le terme *habitus* de Bourdieu (1977) est utilisé pour indiquer pourquoi les paysans et les ingénieurs ne tirent pas des enseignements les uns des autres. L'habitus peut être décrit comme le regroupement de tendances ou d'orientations propres aux hommes, comme une seconde nature. Cet habitus ne peut être approché qu'indirectement, en étudiant l'environnement de sa genèse. Pour ce faire, il faut également analyser les actes visibles des hommes (leurs *pratiques*). Le concept d'*interface sociale* (*social interface*) de Long (1989) propose des clés pour l'étude de rencontres entre des personnes présentant un habitus radicalement différent. Enfin, la méthodologie des "Systèmes doux" (*Soft Systems*) de Checkland (1988, 1989, 1990) offre une ouverture pour l'élaboration d'un processus d'apprentissage commun dans le cas de situations problématiques humaines complexes, qui se retrouvent dans le cas des aménagements hydro-agricoles.

Pratiques et environnements

Depuis déjà de nombreuses années, le climat du nord du Sénégal ne facilite en rien la survie des paysans *Haalpulaar*. L'agriculture ne leur assure pas une nourriture suffisante et ce n'est donc pas sans raison si, depuis quelques générations, le travail migratoire constitue une source de revenus importante. Au cours d'une période de sécheresse exceptionnelle au début des années soixante-dix, les paysans ont saisi l'occasion offerte par le soutien national et international - sous forme d'aménagements hydro-agricoles - et ont réussi à faire de l'agriculture irriguée un élément permanent de leurs entreprises. Les paysans Haalpulaar sont attachés à la répartition des risques et partagent leurs efforts entre le travail migratoire, l'agriculture traditionnelle et l'agriculture irriguée. Bien que les paysans soient dépendants des pouvoirs publics pour la construction d'aménagements hydro-agricoles et l'entretien des groupes moto-pompes, ils gèrent leurs propres réseaux et ils ont développé leurs propres connaissances techniques d'après un petit nombre de rudiments fournis par les ingénieurs. Ce processus d'apprentissage a été facilité par un certain soutien apporté par leur organisation villageoise d'origine. Et il a été adapté aux caractéristiques spécifiques locales des premiers périmètres irrigués villageois à petite échelle.

Les eaux du fleuve Sénégal, le climat sec et la politique des bailleurs de fonds et des pouvoirs publics pour l'augmentation de la production de riz au niveau national ont contribué à fournir du travail aux ingénieurs d'irrigation. Lorsque ces derniers conçoivent leurs projets, ils agissent généralement comme un allié naturel des pouvoirs publics ou du bailleur de fonds, pas seulement parce que ce sont leurs donneurs d'ordre, mais aussi parce que cela cadre parfaitement avec leur formation axée sur la finalité. Cela n'empêche pas qu'ils essaient souvent de penser pour les paysans. De nombreux projets de conception ont vu le jour depuis le début des années 70. Si les anciens concepts ne semblaient pas adaptés, ou étaient jugés peu satisfaisants par les pouvoirs publics, de nouveaux projets ont été conçus. Dans la pratique, cela a entraîné des aménagements de plus en plus "étudiés" et de plus en plus coûteux. Les aménagements ont aussi été réalisés à une échelle de plus en plus grande. En outre, les ingénieurs se sont principalement adressé aux planificateurs. Au cours de ce processus, le fossé entre la conception technique des ingénieurs et les connaissances techniques des paysans s'est creusé davantage.

Différences au sein des connaissances techniques

Des exemples dans cette thèse montrent que les paysans et les ingénieurs ont des points de vue nettement différents en ce qui concerne l'irrigation. Les phénomènes liés aux aménagements hydro-agricoles ne reçoivent pas la même priorité, ils sont décrits et classés différemment. Il est également plus ou moins fait abstraction de ces phénomènes, et ceux-ci sont, ou ne sont justement pas, répartis en unités plus petites.

Les connaissances techniques des ingénieurs d'irrigation reposent sur une logique scientifique. Des règles d'application générale, dissimulées derrière des phénomènes tels que la topographie et l'écoulement de l'eau, sont utilisées pour la conception de projets correspondant à des situations très diverses. A ces fins, les ingénieurs se servent de modèles abstraits de la réalité (des cartes par exemple) et se concentrent sur le développement d'idées pour des situations futures. Beaucoup d'éléments conceptuels techniques et de phénomènes physiques sont étudiés isolément, pour, éventuellement, les associer plus tard au sein d'un même projet. Malgré leur habileté à combiner ces éléments au sein d'un même projet, les ingénieurs d'irrigation demeurent dans la pratique bien souvent trop axés sur une prise en considération isolée des éléments. Et cela signifie qu'ils oublient parfois comment de très bonnes idées peuvent naître lorsque l'accent est mis sur une certaine imbrication ou corrélation de ces éléments.

En comparaison avec celles des ingénieurs, les connaissances techniques des paysans *Haalpulaar* sont beaucoup plus proches des phénomènes physiques des aménagements hydro-agricoles. Leurs connaissances s'accordent parfaitement non seulement à la composition du sol et à la topographie, mais aussi au concept des périmètres irrigués villageois simples. Les paysans s'occupent également de conception et par tâtonnements, ils peuvent s'apercevoir si leurs actions procurent bien les résultats voulus. Cependant, lorsqu'il s'agit de réaliser un concept entièrement nouveau, ils manquent de recul, non seulement parce que leurs connaissances sont très conditionnées par un endroit déterminé, mais aussi parce qu'elles sont trop fixées sur leur propre parcelle et non sur l'aménagement dans son ensemble. De nombreux phénomènes et éléments, différenciés par l'ingénieur d'irrigation, sont considérés comme indissociables par les paysans. Néanmoins, une telle approche leur permet de réagir avec efficacité en cas de problèmes dans le réseau d'irrigation (comme par exemple un débordement ou un problème de distribution de l'eau).

Echange insuffisant de connaissances techniques

Dans le nord du Sénégal, la communication entre les ingénieurs et les paysans demeure limitée. Dans les quelques situations où la communication est meilleure, les sujets techniques ne sont que très peu abordés; l'ingénieur garde donc le contrôle de l'information technique et prend les décisions. Dans le meilleur des cas, l'ingénieur essaie de penser pour les paysans et l'aménagement hydro-agricole, une fois terminé, est alors le seul "message" laissé par l'ingénieur aux paysans. Ceci peut s'expliquer, entre autres, par le fait que le donneur d'ordre stimule rarement la communication avec les paysans, bien au contraire. Néanmoins, il faut aussi chercher la raison de cette insuffisance de communication auprès des ingénieurs: la plupart d'entre eux ne sont pas véritablement ouverts à la communication. Et les paysans ne le sont guère non plus pendant le processus de conception. Ils préfèrent ne pas poser trop de questions, de peur que le bailleur de fonds se retire ou se retourne contre eux. Ils adoptent dès le début une attitude de dépendance, car c'est ainsi qu'ils essaient d'obtenir des projets. Cette thèse montre comment l'attitude des paysans vient conforter celle des ingénieurs et des planificateurs, et inversement. Autrement dit, l'habitus de l'un étaie et renforce l'habitus de l'autre.

Il existe de nombreux malentendus entre les ingénieurs et les paysans sur le plan technique. Cela concerne le plus souvent la topographie, les propriétés du sol, l'écoulement de l'eau, les ouvrages d'art, la distribution de l'eau et l'entretien, ainsi que les besoins en irrigation et en drainage. Ces malentendus peuvent se produire en même temps à différents niveaux et sont difficiles à solutionner. Leur origine peut à nouveau être localisée dans les mécanismes de l'habitus, qui fait que les connaissances techniques deviennent une *image technique* qui se renforce elle-même, sans que les ingénieurs ni les paysans en soient conscients. Il en résulte une situation où paysans et ingénieurs ne tirent pas d'enseignements les uns des autres, et ce qui est encore pire, où ils concluent qu'il vaut mieux ne pas prendre l'autre au sérieux dans le domaine technique. Ils estiment justifié leur refus de communiquer avec l'autre. Ainsi se crée un cercle vicieux: dans les nouveaux processus de conception, la communication entre les ingénieurs et les paysans restera superficielle s'il n'en tient qu'à eux.

Effet de l'insuffisance de communication

A bien des égards, les connaissances techniques des paysans et des ingénieurs sont complémentaires. Toutefois, à cause de l'insuffisance de communication, ils sont tous deux perdants pour ce qui est de la qualité du projet. Les paysans maintiennent les pratiques qu'ils connaissent et ne sont pas réceptifs aux suggestions innovatrices de l'ingénieur, alors que celles-ci pourraient être utiles. Les ingénieurs continuent à concevoir des projets peu adaptés aux pratiques des paysans, alors qu'ils pourraient s'en servir pour réaliser des projets adéquats. Dans cette thèse, il est clairement démontré que l'insuffisance d'adaptations, présente chez les deux parties, est coûteuse et a un effet négatif sur la durabilité. Des exemples de paysans qui détruisent des ouvrages d'art ou y apportent des transformations radicales, des exemples de détérioration rapide due à des pratiques paysannes inadaptées, ainsi que des exemples de projets ne convenant pas à la topographie, à la composition du sol ou aux pratiques d'irrigation sont là pour en témoigner. Les paysans et les ingénieurs se rejettent la responsabilité des problèmes qui apparaissent.

Que faire alors?

La méthodologie "Soft Systems" de Checkland offre un support utile pour transformer la situation actuelle - où ingénieurs et paysans renforcent leurs propres images - en une situation où il est possible qu'ils tirent des enseignements les uns des autres. La méthodologie vise à mettre en place un processus d'apprentissage commun et continu, grâce à un processus répété où alternent la réflexion, la discussion, l'action et encore la réflexion. La réflexion et les discussions sont structurées par l'utilisation d'un certain nombre de modèles de systèmes, qui représentent par exemple des situations futures souhaitables. Les modèles sont tellement explicites qu'ils incitent à la discussion.

Cette thèse décrit un certain nombre d'expériences utilisant ces modèles. Une maquette concrète en trois dimensions, représentant un périmètre irrigué villageois et permettant la simulation de l'irrigation, s'est en particulier révélée un excellent outil pour l'apprentissage en commun. L'échange des connaissances techniques dans le domaine de la distribution de l'eau, de l'entretien, de l'écoulement de l'eau, des ouvrages d'art et de la topographie s'en est trouvé facilité. L'utilisation de la maquette permet d'éviter les problèmes de langue puisque les ingénieurs, tout comme les paysans, peuvent expliquer clairement leurs idées ou leurs pratiques en montrant ce qu'ils veulent dire. D'autres types de modèles, comme des cartes adaptées, des (combinaisons de) dessins, un niveau à eau simple, mais aussi par exemple des visites sur le terrain d'autres aménagements hydro-agricoles y sont également décrits. En règle générale, ces modèles sont utiles pour rompre la glace lors de la rencontre entre les ingénieurs et les paysans.

Un modèle de système d'apprentissage pour les ingénieurs et les paysans

La perspective dans laquelle se termine la thèse est également traduite sous forme de modèle. Un système d'apprentissage pouvant finalement conduire à la mise en place d'un aménagement hydro-agricole souhaitable et réalisable y est proposé sous forme d'un diagramme. Le système d'apprentissage vise à éviter le plus possible les malentendus et se compose d'un certain de nombre de phases successives et répétitives.

La phase au cours de laquelle l'aménagement hydro-agricole (ou des parties du projet) est discuté d'après des modèles explicites a une importance cruciale, car elle relie entre eux les cycles d'apprentissage isolés des paysans et des ingénieurs. A ce stade, les expériences d'apprentissage sont partagées par les deux parties, posant ainsi les bases des connaissances techniques communes nécessaires. La recherche appliquée fait également partie de ce système d'apprentissage. La méthodologie de recherche décrite dans cette thèse peut être utilisée à ces fins.

D'après Checkland, les modèles doivent être considérés comme exploratoires et ne peuvent jamais remplacer la réalité. Le modèle de système d'apprentissage donné en conclusion de cette thèse, doit donc être considéré comme un modèle préliminaire, servant en premier lieu à animer la discussion sur la façon d'aborder les problèmes complexes des aménagements hydro-agricoles.

SAMENVATTING

Inleiding

Irrigatiestelsels in de hele wereld worden doorgaans gekenmerkt door een groot aantal onderling samenhangende problemen met een menselijke dimensie. Standaardoplossingen zijn er niet. Het uitgangspunt van dit proefschrift is dat deze problemen alleen opgelost kunnen worden in een leerproces dat alle groepen en organisaties omvat die een rol spelen in het stelsel. Het proefschrift belicht communicatie tussen boeren in Noord Senegal en de ingenieurs die daar irrigatiesstelsels ontwerpen, met als doel uit te vinden hoe beide zijden van elkaar kunnen leren.

Een nadere beschouwing van literatuur over dit onderwerp maakt duidelijk dat er twee blinde vlekken zijn in de kennis van irrigatie-ingenieurs (of tropische cultuurtechnici), die het leerproces bemoeilijken. De eerste betreft het bewustzijn over het cruciale belang van boerenkennis over fysische verschijnselen zoals de stroming van water, de bodemgesteldheid en de topografie. Deze kennis wordt in dit proefschrift aangeduid als technische kennis. De tweede blinde vlek betreft de mogelijke methoden, die ingenieurs kunnen gebruiken om participatie van boeren in het ontwerpproces te bewerkstelligen.

Overweging van het bovenstaande leidt tot de volgende onderzoeksvragen:

1. Wat zijn de verschillen in technische kennis van de boeren en de ingenieurs?
2. In hoeverre leren ze van elkaar door deze kennis uit te wisselen, hoe en waarom doen ze dat, of: Hoe en waarom doen ze dat juist niet?
3. Wat is het effect van (het gebrek aan) deze uitwisseling op de kwaliteit van het ontwerp van de stelsels?
4. Hoe kan de uitwisseling van technische kennis geoptimaliseerd worden?

De aard van het onderzoek was kwalitatief en verkennend. De onderzoeksgegevens zijn verkregen door gedetailleerde observaties, informele interviews, halfgestructureerde interviews en groep-interviews en -discussies. Reflectie naar aanleiding van die gegevens leidde tot nieuwe perspectieven op de probleemsituatie, die nuttig waren voor het ontwerp van experimenten in een later stadium. Sommige experimenten waren een onderdeel van een voorlichtingsprogramma van het kleinschalige irrigatieproject *'Ile à Morphil'*. Dat maakte een intensieve interaktie tussen de boeren en mijzelf, in de rol van ingenieur, noodzakelijk. De experimenten zijn nauwkeurig gevolgd en voorzagen het onderzoek van nieuwe gegevens, die weer leidden tot nieuwe perspectieven. Op deze manier werden meerdere leercirkels gevolgd tijdens het veldonderzoek in Senegal. In de laatste fase werd het onderzoeksperspectief verbreed door meerdere irrigatieprojekten in Noord Senegal te bezoeken. In alle gevallen zijn zowel boeren als ingenieurs geïnterviewd.

In dit proefschrift worden de onderzoeksgegevens benaderd vanuit verschillende invalshoeken. Het begrip *habitus* van Bourdieu (1977) wordt gebruikt om aan te geven waarom boeren en ingenieurs niet van elkaar leren. De habitus kan omschreven worden als de verzameling van 'neigingen' of 'orientaties' die mensen als een soort tweede natuur in zich hebben. Deze habitus kan alleen indirect benaderd worden door de *omgeving* waarin het tot stand gekomen is te bestuderen. Ook de zichtbare handelingen van mensen (hun *praktijken*) dienen daartoe onderzocht te worden. Het concept *sociaal raakvlak* ('*social interface*') van Long (1989) geeft mogelijkheden om de ontmoeting van mensen met een duidelijk verschillende habitus te bestuderen. Tenslotte biedt de '*Soft Systems*' methodologie van Checkland (1988, 1989, 1990) een ingang voor het tot stand brengen van een gezamelijk leerproces in het geval van complexe menselijke probleemsituaties, zoals die zich voordoen in irrigatiestelsels.

Praktijken en omgevingen

Al sinds lange tijd maakt het klimaat in Noord Senegal het niet eenvoudig voor de *Haalpulaar* boeren om te overleven. Landbouw voorziet hen niet van voldoende voedsel en het is niet voor niets dat migratie-arbeid al sinds een paar generaties een belangrijke inkomstenbron vormt. Tijdens een uitzonderlijk droge periode in het begin van de jaren '70 grepen de boeren de nationale en internationale steun - in de vorm van irrigatiestelsels - met beide handen aan, en zij slaagden er in om de geïrrigeerde landbouw een blijvend onderdeel van hun bedrijf te maken. Haalpulaar boeren zijn gericht op het spreiden van risico en verdelen hun aandacht over migratie-arbeid, traditionele landbouw en geïrrigeerde landbouw. Hoewel boeren afhankelijk zijn van de overheid voor de constructie van de irrigatiestelsels en het onderhoud van de motorpomp, beheren ze hun eigen stelsels en hebben ze een eigen technische kennis ontwikkeld, door voort te bouwen op een beperkt aantal basisregels die ingenieurs hen gaven. Dit leerproces werd vergemakkelijkt doordat hun bestaande dorpsorganisatie een zekere bedding bood. Het werd afgestemd op de specifieke lokale eigenschappen van de eerste kleinschalige dorpsirrigatiestelsels.

Het water van de Senegalrivier, het droge klimaat en het beleid van donoren en overheid om de nationale rijstproduktie te verhogen betekende werk voor irrigatie-ingenieurs. Wanneer zij hun ontwerpen maken, handelen ze gewoonlijk als een natuurlijke bondgenoot van de overheid of de donor, niet alleen omdat dit hun opdrachtgevers zijn, maar ook omdat het zo past bij hun oplossings-gerichte opleiding. Dit neemt niet weg, dat ze vaak *voor* boeren proberen te denken. Meerdere ontwerp-concepten zagen het licht sinds het begin van de jaren '70. Wanneer oude concepten niet geschikt leken, of niet bevredigend waren voor de overheid, werden nieuwe concepten bedacht. Dit hield in de praktijk in, dat de stelsels steeds meer 'bestudeerd' en steeds duurder werden. Ook werd de schaal van de stelsels groter. De meeste ingenieurs richtten zich daarbij sterk op planners. Tijdens dat proces werd het gat tussen het technische ontwerp van ingenieurs en de technische kennis van boeren steeds groter.

Verschillen in technische kennis

Voorbeelden in dit proefschrift geven aan dat boeren en ingenieurs duidelijk verschillende technische perspectieven op irrigatie hebben. Fysische verschijnselen in irrigatiestelsels krijgen andere prioriteiten, worden verschillend beschreven en worden anders geordend. Ze worden ook in meer of mindere mate geabstraheerd of worden wel of juist niet onderverdeeld in kleinere eenheden.

De technische kennis van irrigatie-ingenieurs is gebaseerd op een wetenschappelijke logica. Algemeen toepasbare regels die verscholen zijn achter verschijnselen zoals de topografie en de stroming van water worden gebruikt om in uiteenlopende situaties te kunnen ontwerpen. Om dit doel te bereiken, gebruiken ze abstracte modellen van de werkelijkheid (bijvoorbeeld kaarten) en richten zich op de ontwikkeling van ideeën voor toekomstige situaties. Veel technische ontwerpelementen en fysische verschijnselen worden afzonderlijk beschouwd om mogelijk later weer te combineren in één ontwerp. Ondanks hun vaardigheid deze elementen te kunnen combineren in één ontwerp, blijven ze in de praktijk vaak te veel gericht op het afzonderlijk beschouwen ervan. Dit betekent dat ze soms vergeten welke goede ideeën kunnen ontstaan wanneer een zekere overlap of verbinding tussen die elementen centraal staat.

Vergeleken met ingenieurs staat de technische kennis van *Haalpulaar* boeren dichter bij de fysische verschijnselen in irrigatiestelsels. Het is niet alleen in hoge mate aangepast aan de aard van de bodemgesteldheid en de topografie, maar ook aan het concept van de eenvoudige dorps-irrigatiestelsels. Boeren ontwerpen ook en ontdekken door 'trial' en 'error' of hun acties werkelijk de gewenste resultaten hebben. Wanneer een geheel nieuw ontwerp gemaakt moet worden ontbreekt hen echter een zeker overzicht, niet alleen omdat hun kennis zo gebonden is aan één bepaalde plaats, maar ook omdat de kennis zo gericht is op hun eigen plot en niet op het stelsel als geheel. Meerdere verschijnselen en elementen die een irrigatie-ingenieur van elkaar onderscheidt, zien de boeren als onlosmakelijk verbonden. Niettemin, een dergelijke invalshoek maakt het voor hen mogelijk om accuraat te reageren wanneer probleemsituaties (bijvoorbeeld watergebrek of kanaaldoorbraken) zich voordoen in het irrigatiestelsel.

Gebrek aan uitwisseling van technische kennis

In Noord Senegal blijft de communicatie tussen ingenieurs en boeren beperkt. In de enkele situaties waar uitgebreider gecommuniceerd wordt, krijgen technische onderwerpen toch weinig aandacht en blijft de ingenieur de controle houden over de technische informatie en neemt de beslissingen. In het beste geval probeert een ingenieur voor de boeren te denken en is het irrigatiestelsel zelf, nà aanleg, in feite de enige 'boodschap' van de ingenieur aan de boeren. Eén van de verklaringen hiervoor is dat de opdrachtgever communicatie met boeren zelden stimuleert en meestal ontmoedigt. Niettemin moet de oorzaak voor het gebrek aan communicatie ook bij de ingenieur gezocht worden: de meerderheid van hen staat niet werkelijk open voor communicatie. Ook boeren zijn niet gericht op communicatie tijdens het ontwerpproces. Zij stellen liever niet te veel vragen omdat ze bang zijn dat de donor dan vertrekt of zich tegen hen keert. Vanaf het begin hebben zij een afhankelijke houding, omdat ze op die manier proberen projecten te verkrijgen. In dit proefschrift wordt aangetoond hoe de houding van boeren de houding van ingenieurs en planners, en omgekeerd, versterkt. Met andere woorden, de habitus van de één bevestigt en versterkt de habitus van de ander.

Er bestaan veel misverstanden tussen boeren en ingenieurs over technische zaken. Deze betreffen meestal de topografie, de bodemgeschiktheid, de stroming van water, de kunstwerken, waterverdeling en onderhoud, alsmede de irrigatie- en drainage-behoefte. De misverstanden kunnen zich tegelijkertijd op verschillende vlakken afspelen en zijn moeilijk te ontrafelen. De oorzaak van die misverstanden kan weer gevonden worden in de mechanismen van habitus, waardoor de technische kennis verwordt tot een *technisch beeld* dat zichzelf bevestigt, zonder dat boeren en ingenieurs zich daarvan bewust zijn. Dit leidt tot de situatie, dat boeren en ingenieurs niet van elkaar leren, sterker nog, ze trekken de conclusie dat de ander maar beter niet serieus genomen kan worden op technisch gebied. Ze voelen zich gerechtvaardigd om afwijzend te staan tegenover communicatie met de ander. Op deze manier ontstaat een vicieuze circel: in nieuwe ontwerpprocessen zal communicatie tussen ingenieurs en boeren, als het aan hen ligt, op een oppervlakkig niveau blijven steken.

Effect van het gebrek aan communicatie

In vele opzichten is de technische kennis van ingenieurs en boeren complementair. Door het gebrek aan communicatie leiden beiden echter verlies ten aanzien van de kwaliteit van het ontwerp. Boeren handhaven de voor hen bekende praktijken en staan niet open voor vernieuwende suggesties van de ingenieur, ook al kunnen die suggesties nuttig kunnen zijn. Ingenieurs gaan door met ontwerpen die weinig aangepast zijn aan de praktijken van boeren, ook al zouden ze goede ontwerpen kunnen baseren op die praktijken. In dit proefschrift wordt duidelijk dat het wederzijdse gebrek aan aanpassing kostbaar is en een negatieve uitwerking op duurzaamheid heeft. Voorbeelden van boeren die kunstwerken kapot maken of aanzienlijke aanpassingen doen, voorbeelden van snelle achteruitgang door onaangepaste boerenpraktijken alsmede voorbeelden van ontwerpen die niet aangepast zijn aan topografie, bodemgeschiktheid of irrigatie-praktijken maken dat duidelijk. Boeren en ingenieurs geven elkaar de schuld van de problemen die ontstaan.

Hoe dan wel?

De '*Soft Systems*' Methodologie van Checkland biedt nuttige houvasten om de huidige situatie, waarbij ingenieurs en boeren hun eigen beelden bevestigen, te transformeren in een situatie waarin het mogelijk wordt dat ze van elkaar leren. De methodologie beoogt een continu gezamelijk leerproces op gang te brengen dat plaats vindt door een iteratief proces waarin reflectie, discussie, actie en wederom reflectie elkaar afwisselen. De reflectie en de discussies worden gestructureerd door het gebruik van een aantal modellen van systemen, die bijvoorbeeld wenselijke toekomstige situaties representeren. De modellen zijn zo expliciet, dat ze uitnodigen tot discussie.

In dit proefschrift wordt een aantal experimenten beschreven met deze modellen. Vooral een tastbaar drie-dimensionaal schaalmodel van een dorps-irrigatiestelsel waarmee irrigatie nagebootst kon worden bleek een uitstekend middel te zijn om gezamelijk te leren. Het vergemakkelijkte de uitwisseling van technische kennis op het gebied van waterverdeling, onderhoud, waterstroming, kunstwerken en topografie. Het gebruik van het schaalmodel voorkomt taalproblemen, omdat zowel ingenieurs als boeren hun ideeën of praktijken kunnen verduidelijken door voor te doen wat ze bedoelen. Ook andersoortige modellen, zoals aangepaste kaarten, (combinaties van) tekeningen, een eenvoudig waterpas-instrument maar ook bijvoorbeeld veldbezoeken aan andere irrigatiestelsels worden beschreven. In het algemeen zijn de modellen nuttig om het ijs te breken, wanneer ingenieurs en boeren elkaar ontmoeten.

Een model van een leersysteem voor ingenieurs en boeren

Het perspectief waarmee het proefschrift eindigt is ook weergegeven in een model. Het stelt een leersysteem voor dat uiteindelijk kan leiden tot de implementatie van een wenselijk en haalbaar irrigatiesysteem. Het leersysteem is bedoeld om technische misverstanden zoveel mogelijk te vermijden en bestaat uit een aantal opeenvolgende en steeds terugkerende stadia.

Het stadium waarin het irrigatiesysteem, of delen daarvan, bediscussieerd wordt aan de hand van expliciete modellen is cruciaal, want het verbindt de afzonderlijke leercirkels van boeren en ingenieurs. In dit stadium worden leerervaringen door beide zijden gedeeld, hetgeen de basis legt voor de gezamelijke technische kennis die nodig is. Ook toegepast onderzoek vormt een onderdeel van het leersysteem. De onderzoeks-methodologie die u hier beschreven vindt in dit proefschrift, kan daarvoor worden gebruikt.

Volgens Checkland moeten modellen gezien worden als tentatief en kunnen ze de werkelijkheid nooit vervangen. Het model van het leersysteem waarmee dit onderzoek afgerond wordt, moet daarom worden gezien als een voorlopig model. Het dient in de eerste plaats om de discussie over de manier waarop de complexe problemen in irrigatiestelsels aangepakt kunnen worden, levendig te houden.

SUMMARY

Introduction

Irrigation schemes all over the world are often marked by a large number of related problems that have an important human dimension and are too complex to be straightforwardly solved. A starting point of this thesis is that these problems have to be dealt with in a learning process that involves all groups and organizations that are relevant to the irrigation scheme. This thesis explores communication processes between irrigation design engineers and farmers in North Senegal and aims at finding out how they can learn from each other.

A closer look at the literature about the subject shows that there are two blind spots in the knowledge of design engineers. Both stand in the way of learning. The first concerns a lack of consciousness about the crucial importance of farmers' knowledge of physical phenomena in irrigation schemes such as water flow, soils, topography, etc. (i.e. *technical knowledge* of farmers). The second concerns a lack of knowledge about the procedures and methods that design engineers could use to improve farmers' participation in the design process.

Consequently, the following questions for research arise:

1. What is the difference between the technical knowledge of design engineers and that of farmers?
2. To what extent do engineers and farmers learn through exchange of technical knowledge, why and how does this exchange take place, and if not why not?
3. What is the effect, of the exchange or non-exchange, on the design?
4. How can the exchange of technical knowledge be optimized?

The research was exploratory and qualitative in nature. The research material was based on detailed observations, informal interviews, semi-structured interviews and group interviews and discussions. Reflection on the collected material led to new perspectives that were useful for experiments at a later stage. Some experiments were part of the development and implementation of a canal maintenance programme for the *Ile à Morphil* small-scale irrigation project. This required intensive interaction between farmers and myself as an irrigation engineer. The experiments were closely monitored and became, in due course, new research material, which provided in turn a base for new perspectives. In this way several learning cycles were completed during the field research. In the final stage I broadened my perspective and visited several project areas in northern Senegal, where I conducted semi-structured interviews with irrigation engineers as well as groups of farmers.

In this thesis, I approach the research material from different angles. I use Bourdieu's concept of *habitus*, 'a set of dispositions which incline people to act and react in certain ways', in order to explain why design engineers and farmers do not learn from each other. The habitus can be approached indirectly by studying the environments where it developed, as well as by studying peoples' *practices*, their visible actions. The *social interface* concept of Long provides clues for what may happen when people who belong to a certain group or category have to deal with 'strangers'. The *Soft Systems Methodology* (*SSM*) of Checkland indicates how a learning process can evolve when one faces problems in complex human situations.

Practices and environments of farmers and design engineers

The climate in northern Senegal makes it difficult for the *Haalpulaar* farmers to make a living out of the natural environment. Agriculture often did not provide them with enough to live on and already for some generations, migration work has become an important source of extra income. During a particularly dry period at the beginning of the seventies, farmers were eager to benefit from the extra support of government and donors and managed to integrate irrigated agriculture into their farming system. The *Haalpulaar* farmers are keen to spread risk and most often divide their efforts between irrigated as well as traditional agriculture and migration work. Although farmers are dependent on the government for the construction of their irrigation schemes and the repair of their pumps, they manage their own schemes and have developed their own technical knowledge, based on some simple initial rules of design engineers. The learning process was facilitated by the existing traditional organization and was adapted to the specific characteristics of the first village schemes.

The water potential of the *Senegal* river, the dry climate and the policy of government and donors to stimulate the Senegalese rice production meant that there were many Senegalese and foreign irrigation engineers in the valley. Irrigation design engineers usually act as natural allies of the government and donors, not only because they depend on them, but also because it is conform their solution-orientated education. This does not alter the fact that they may try to find ways of thinking *for* the farmers. Several design concepts have evolved since the early seventies. When old concepts seemed to fail or did not satisfy the planners, new concepts were designed. This meant that increasingly more sophisticated and more expensive irrigation concepts evolved. In this process, the gap between the technical design of the engineers and the technical knowledge of farmers gets wider and wider.

Differences in technical knowledge

Examples in this thesis make it clear that farmers and design engineers have very different perspectives on irrigation. Irrigation phenomena or design elements are given other priorities, are described differently and are arranged in other ways. They are also embodied at different levels of abstraction and may be or may not be split up into smaller parts.

The technical knowledge of design engineers is based on a scientific logic. Generally applicable rules regarding phenomena such as water flow and topography are used in order to be able to design in different localities. To this end, engineers frequently work with abstract models (maps, plans) and are orientated towards generating ideas for future situations. Many technical design elements and physical characteristics are considered separately and may be combined in a design later on. Despite their ability to combine these elements into the design, engineers often attach too much value to discerning these elements. Consequently they may lose sight of the fruitful ideas resulting from an orientation towards interrelationships between the elements. This is illustrated with examples of: water distribution and maintenance, of irrigation, drainage and soil characteristics and of water flow and topography.

Compared to engineers the technical knowledge of farmers is closer to physical phenomena in irrigation schemes. It is highly adapted to the specific qualities of the environment (soils, topography) and the simple concept of the village irrigation schemes (*PIVs*). Farmers sometimes use trial and error methods in the field to improve their scheme. In this way they have direct feedback to their design actions. However, in the case of an entirely new design, farmers lack a general overview, not only because their knowledge is bound to a locality, but also because they are so clearly focused on their own plot that most of them do not bother to look at an entire irrigation scheme. Farmers regard physical phenomena and elements as closely connected which often permits them to respond accurately when problematic situations like canal breaching or water scarcity occur.

(Non) exchange of technical knowledge

In northern Senegal communication between design engineers and farmers is limited. With regard to the few situations where communication takes place beyond a superficial level, technical issues receive little attention and the design engineer remains in control of the technical information. At best, a design engineer thinks *for* the farmers and the irrigation scheme itself often turns out to be the only 'message' of design engineers. One explanation for this is that their employers rarely stimulate and most often discourage communication with farmers. But the lack of communication can also be traced back to design engineers, of whom the majority are not interested in communicating with the farmers. Likewise farmers are not inclined to communicate beyond a superficial level. They prefer not to ask questions because they reason that they may lose the entire project if they do. Besides, their attitude is often a dependent one, as they try to attract new irrigation projects. It is shown that this attitude of farmers strengthens the attitude of planners and design engineers. The reverse is also true. In other words, the habitus of the one triggers and reinforces the habitus of the other.

Misunderstandings between design engineers and farmers about technical subjects occur frequently. It has been shown that these most often concern topography, soil suitability, irrigation and drainage requirements, water flow, structures, water distribution and maintenance. The misunderstandings have many dimensions and are difficult to unravel. The explanation for these misunderstandings can be found in the mechanisms of habitus, causing the technical knowledge to change into a *technical image* that reconfirms itself without engineers or farmers being conscious of it. This implies that design engineers and farmers do not learn from each other, even worse, both draw the conclusion that the technical knowledge of the other should not be taken seriously. They feel justified to be reticent towards the idea of communication about technical issues. A vicious circle occurs: in further design processes communication between design engineers and farmers will only be superficial.

Result of the non-exchange

In many ways the technical knowledge of design engineers is complementary to that of the farmers. Therefore, both are losers with regard to the quality of the technical design. Although new practices could be useful for them, farmers continue with old practices and are not open to suggestions from the design engineer. The new technical designs of engineers are not adapted to the practices of farmers, although these could certainly be useful in a new locality. This thesis shows that the mutual lack of adaptation is costly and has a negative impact on sustainability. It provides examples of farmers who destroy structures or have to adapt the lay out considerably, examples of deterioration of new schemes due to old practices, as well as of designs that are not adapted to the soils and topography of a site. Of course farmers and design engineers blame each other for the resulting problems.

How can the exchange of knowledge be optimized?

The *Soft Systems Methodology* (*SSM*) of Checkland is useful to achieve the shift that is required to deal with the lack of exchange of technical knowledge. It can be used to bring about improvement by activating in design engineers and farmers a learning cycle which ideally is never ending. Learning takes place by means of the iterative process of reflection, discussion, action and again reflection. The reflection and discussion are structured by a number of system models, which may represent desirable future situations. Because of their explicit character the models invite to discuss.

This thesis treats a number of experiments with these models. Especially a three-dimensional scale-model of a village irrigation scheme that allowed for the imitation of irrigation practices served beyond expectations. It facilitated the exchange of technical knowledge, covering a broad range of technical issues such as water distribution, maintenance, water flow, structures and topography. The scale model bypasses language problems because it is so tangible that it allows both farmers and design engineers to explain their points of view: they just demonstrate what they mean. Other useful explicit models like adapted maps and plans, combinations of drawings, a simple levelling instrument, as well as field visits to other irrigation schemes, may structure a discussion about change. In general, it appears that these models have unfreezing effects that facilitate the communication between design engineers and farmers.

Model of a learning system of engineers and farmers

The emerging perspective of my thesis is condensed in a model. The (diagrammatic) model represents a learning system that may eventually lead to the implementation of an irrigation system that is feasible and desirable. The system is meant to avoid the technical misunderstandings as much as possible.

The model makes explicit several stages of the learning process. The stage during which the irrigation system, or parts of it, is discussed by means of system models is crucial, because it connects the separate learning cycles of design engineers and farmers. During this stage, the learning experiences of both sides are shared, providing a basis for the joint technical knowledge that is required for quality design. Applied research is another stage of the learning system. For this stage, the research methods and the concepts that I presented in this thesis may be useful.

In the view of Checkland, models should be tentative, can never replace reality and should not be followed rigidly. The emerging model in this thesis should therefore be seen as a preliminary model that, in the first place, serves to continue a discussion about how to proceed in the context of complex situations in irrigation schemes.

Curriculum Vitae

Steven Scheer was born in Eindhoven, the Netherlands, in 1961. After completing high school in 1980, he studied irrigation at the Wageningen Agricultural University (WAU). During a seven month's internship at the Secretariat of Rural Integrated Development in Ecuador he did field research, comparing 'traditional' to 'modern' irrigation and studying field irrigation methods. Later on, he did field research in Tunisia, supported by the Office de Mise en Valeur de Périmètres Irrigués in Sidi Bouzid, studying water management in 'traditional' and 'modern' spate irrigation systems. He was supervised by Jan Ubels. In 1988 he obtained his M.Sc. degree. His major subjects were Irrigation (water management) and Extension science.

He commenced his professional career as a junior researcher, supervised by Niels Röling, Luc Horst and Frans Huibers. The research was based on previous water management research of the West African Rice Development Association and the WAU, which aimed at a better integration of socio-economic factors into the irrigation design. During the preparation phase of the research he followed several subjects that were part of the M. Sc. course 'Management of Agricultural Knowledge Systems' at the WAU. During field research he stayed for 25 months in North Senegal. Apart from researching, he also developed a canal maintenance extension programme for the *Ile à Morphil* small scale irrigation project. The interrelations between practical work and field research were fruitful.

In 1991 he returned to the Netherlands, where the writing process started, which was occasionally alternated by lecturing at the WAU. From 1994 onwards he works as a free-lance trainer and lecturer in the fields of irrigation, (intercultural) communication and development. In 1994 and 1995 he contributed to a course on Diagnostic Analysis and Participatory Rural Analysis at the ETSHER (Ecole Inter-Etats des Techniciens Supérieurs de l'hydraulique et de l'Equipement Rural) in Burkina Faso.

Stellingen

1 De communicatie tussen boeren en irrigatie-ingenieurs in Noord Senegal wordt in het algemeen niet gekenmerkt door het leren van de ander, maar door vicieuze circels van aktie en reflektie, leidend tot een bevestiging van wat men al dacht te weten (dit proefschrift).

2 Hoewel zowel boeren als ingenieurs een te grote eigenwijsheid verweten kan worden met betrekking tot hun kennis over technische aspecten, is het in de eerste plaats aan de ingenieurs om daar verandering in te brengen. Dat betekent echter niet dat boerenkennis niet kritisch beschouwd moet worden (dit proefschrift).

3 Het idee dat ervaringen van boeren in kleinschalige eenvoudige dorpsirrigatiestelsels nuttig zijn als 'opstapje' voor het kunnen omgaan met irrigatie in grootschalige, meer ingewikkelde systemen lijkt logisch en voor de hand liggend, maar is in feite verraderlijk in zijn eenvoud (dit proefschrift).

4 Water kan wel degelijk van beneden naar boven stromen. Daarom is het niet verwonderlijk dat ingenieurs die in de praktijk betogen dat water 'alleen van boven naar beneden stroomt' door boeren soms niet serieus genomen worden (dit proefschrift).

5 Het gebruik van modellen om wederzijds leren te stimuleren is juist voor professionals die zich toeleggen op 'tastbare' eindprodukten, zoals irrigatie-ingenieurs, ideaal (dit proefschrift, vgl. Checkland (1989), Hamilton (1995)).

6 Kritische vragen over technische aannames, hoe onbelangrijk ook, liggen bij veel ingenieurs gevoeliger dan kritische vragen over sociaal-economische aannames, hoe belangrijk ook (eigen ervaring).

7 Professionals die zich *breder* willen oriënteren dan alleen hun vakgebied, omdat daar 'het wezenlijke probleem niet ligt' zouden er wellicht goed aan doen om de hypothese te toetsen dat er *binnen* het eigen vakgebied een blinde vlek bestaat.

8 Vanuit onderzoeksoogpunt zijn de 'technische aspecten' van irrigatie waarschijnlijk een goede taktische ingang om sociale-, economische en politieke aspecten van irrigatiesystemen aan de orde te stellen.

9 Veel wetenschappers weten misschien dat wat 'wetenschappelijk bewezen' is net zo weinig aanspraak op *de* waarheid kan maken als niet-wetenschappelijke overtuigingen (cf Gellner (1992)). Het is jammer dat ze zich daarvan vaak weinig rekenschap geven wanneer ze met niet-wetenschappers te maken hebben.

10 Onoplettendheid van degenen die een spellings-controle programma gebruiken kan tot gevolg hebben dat collega-onderzoekers onbedoeld beledigd worden.

11 Op zichzelf goede ontdekkingen verworden in beleid en uitvoering vaak tot modewoorden die tenslotte alleen nog maar versluieren dat er in feite geen vooruitgang is.

12 Het woord 'ownership' dat nu gangbaar is bij ontwikkelingssamenwerking is een onmogelijke term voor ontwikkelingswerkers die verantwoording af moeten leggen over het geld wat uitgegeven wordt.

13 Ontwikkelingshulp wordt alleen *gegeven* wanneer de donor geen enkele voorwaarde stelt ten aanzien van wat er vervolgens verder mee gebeurt.

14 Wat meer Afrikaanse elementen in het beleid zou de Nederlandse ontwikkelingsinspanningen wel eens goed kunnen doen.

Stellingen behorende bij het proefschrift van Steven Scheer: 'Communication between irrigation engineers and farmers: The case of project design in North Senegal'.

Wageningen, 14 juni 1996