Drainage in Developing Countries:
A review of institutional arrangements

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November 2000
This paper was commissioned by the World Bank through the World Bank-Wageningen University Cooperative Programme. It was first printed in India as a CWP Working Paper Series. This paper carries the name of the author and should be used and cited accordingly. The findings, interpretations, and conclusions are the author’s own and should not attributed to the World Bank, its Board of Directors, its management, or any member countries.
## Contents

**Preface** ..............................................................................................................................................................................................................................................................vii

**Acknowledgements** .................................................................................................................................................................................................................ix

**Abbreviations & Acronyms** ..............................................................................................................................................................................................................xi

**Executive Summary** ................................................................................................................................................................................................................xiii

- Bangladesh ..........................................................................................................................................................................................................................xiv
  - Drainage management in FCD systems ..................................................................................................................................................................xv
  - Drainage management in canal irrigation systems ...........................................................................................................................................xvi
  - Proposed institutional arrangement in water management systems ..............................................................................................................xvi
- Egypt ...........................................................................................................................................................................................................................................xviii
- India .............................................................................................................................................................................................................................................xx
  - Drainage management in canal irrigation systems in Rajasthan ............................................................................................................xx
  - Drainage management in land reclamation in Kerala ..............................................................................................................................xxi
- Japan ............................................................................................................................................................................................................................................xxii
- Pakistan ........................................................................................................................................................................................................................................xxiii
- Winding up .............................................................................................................................................................................................................................xxv

**Introduction** .........................................................................................................................................................................................................................1

- Structure of the report ........................................................................................................................................................................................................1
- Research methodology ........................................................................................................................................................................................................2
- Orientation phase ...........................................................................................................................................................................................................2
- Elaboration phase ........................................................................................................................................................................................................2

**Conclusion and Discussion** ...........................................................................................................................................................................................................5

- Agricultural land drainage: Diverse objectives and a variety of settings ...........................................................................................................5
  - Agricultural land drainage .................................................................................................................................................................................5
  - The role of agro-ecology and technology ..................................................................................................................................................6
  - Actors in drainage ................................................................................................................................................................................................9
- Institutional development in agricultural land drainage ....................................................................................................................................10
  - Flood control: Institutional development in Bangladesh ............................................................................................................................10
  - Land drainage in irrigated agriculture in (semi) arid zones .........................................................................................................................12
  - Land drainage in rainfed agriculture in temperate zones ..........................................................................................................................16
  - Land reclamation: Institutional development in India (Kerala) ............................................................................................................16
  - General discussion ................................................................................................................................................................................................17

**Drainage Development in Bangladesh** ........................................................................................................................................................................20

- Introduction ....................................................................................................................................................................................................................20
  - The need for drainage and flood control ..................................................................................................................................................20
  - Current status of irrigation, drainage and flood control development ..................................................................................................21
- Drainage and flood control development ..................................................................................................................................................21
  - Flood Control and Drainage Systems ..........................................................................................................................................................23
  - Development of flood control and drainage systems ..................................................................................................................................24
  - Differences between FCD and irrigation systems, and types of FCD systems ..........................................................................................25
  - Management of FCD systems: Conflicting interests ..................................................................................................................................26
- Institutional framework ................................................................................................................................................................................................27
  - Government institutions ................................................................................................................................................................................................28
List of tables

Table 2.1: General typology of agricultural land drainage ................................................................. 5
List of figures

Figure 4.1: Organisational structure agricultural drainage development in Egypt .............................................................42
Figure 4.2: Part of EPADP’s organisational structure ........................................................................................................44

List of boxes

Box A: Relations in drainage development in FCD systems in Bangladesh .................................................................xv
Box B: Relations in drainage development in irrigation systems in Bangladesh ..............................................................xvi
Box C: Proposed relations in water management systems in Bangladesh ................................................................. xvii
Box D: Relations in drainage development in irrigation systems in Egypt .................................................................xix
Box E: Relations in drainage development in canal irrigation systems in Rajasthan ........................................................xxi
Box F: Relations in drainage development in land reclamation in Kerala .................................................................xxii
Box G: Relations in drainage development in Japan .................................................................................................xxiii
Box H: Relations in drainage development in canal irrigation systems in Pakistan ........................................................xxiv
Box 3.1: The Flood Action Plan (FAP) .........................................................................................................................22
Box 3.2: The Systems Rehabilitation Project (SRP) .........................................................................................................28
Box 3.3: The Guidelines for People’s Participation in Water Development Projects ..................................................32
Box 4.1: Impact of subsurface drainage on crop yield: An example from Dakahlia .........................................................49
Box 7.1: SCARP deep public tubewells in Punjab ........................................................................................................77
Box 7.2: The National Drainage Programme: Pakistan’s water sector policy reforms ...............................................78
Box 7.3: Experiences with farmers’ participation: FESS ............................................................................................80
Preface

This paper is one of a series of products created under a collaborative work program between the Rural Development Department of the World Bank, Washington D.C., and the Irrigation and Water Engineering Group at Wageningen University, the Netherlands. The program ran from 1999 to 2002 and was headed by Dr. Geert Diemer (World Bank) and Dr Peter P. Mollinga (Wageningen University). Dr. Mollinga served as primary editor for the series of products coming from this program.

This paper is one of two papers on drainage institutions: One on developing countries (No.2) and one on Western Europe (No. 3). In this paper the countries studied are Bangladesh, Egypt, India, Pakistan, and one country that is not a developing country – Japan. The literature on drainage is mostly technical in nature. This is a survey of the literature to find out what is known about the institutional aspects of drainage. The two reports form the basis for further research on drainage in the context of IWRM under the (World) Bank – Netherlands Partnership Programme.

The views expressed in the research papers are those of the authors, and do not necessarily reflect the views of the program coordinators; Wageningen University; or the World Bank or its Board of Executive Directors.
Acknowledgements

The subject of this report is institutional arrangements in drainage development in developing countries. In conducting research and writing the report, the guiding questions have been: How is drainage managed, why is it managed as such, and how does this management perform?

Since no field visits were undertaken, I have been very dependent on obtaining access to appropriate literature and human resources for conducting this desk-research.

ARCADIS Euroconsult has played a facilitating role in this research. This consulting agency, based in the Netherlands, has built up substantive experience with drainage development in many countries of the world. The library of Euroconsult proved a valuable source of information, not in the least because of the excellent help of the librarian, Moniek van de Ven. Furthermore, Rens Verstappen, Caroline Bäcker and Frank van Steenbergen of Euroconsult shared their experiences and provided valuable feedback on preliminary drafts.

The library of Wageningen University and Research Centre proved another important source of written information. Philippus Wester and Gerardo van Halsema contributed to this research by their critical reflection on preliminary drafts of sections of this report. Support was also given by Niranjan Pant, Avdhesh Chandra and Wouter Wolters, who spent parts of their time to discuss drainage management.

Lastly, a first draft of the report at hand has been discussed at a workshop. Both the workshop and the research have been conducted in the scope of the Collaborative Work Programme of the World Bank and Wageningen University. Thanks goes to both institutes, and more specifically to Geert Diemer and Peter Mollinga, and to the participants of the workshop for their constructive remarks and support.
### Abbreviations & Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AWB</td>
<td>Area Water Board (Pakistan)</td>
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<tr>
<td>BCM</td>
<td>Billion Cubic Metres</td>
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<td>BWDB</td>
<td>Bangladesh Water Development Board</td>
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<td>CADA</td>
<td>Command Area Development Authority (India)</td>
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<td>CCA</td>
<td>Culturable Command Area</td>
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<td>CPP</td>
<td>Compartmentalisation Pilot Project (Bangladesh)</td>
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<tr>
<td>CUA</td>
<td>Collector User Association (Egypt)</td>
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<td>DAS</td>
<td>Drainage Advisory Services (Egypt)</td>
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<td>DRI</td>
<td>Drainage Research Institute (Egypt)</td>
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<tr>
<td>EGP</td>
<td>Egyptian Pound</td>
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<td>EPADP</td>
<td>Egyptian Public Authority for Drainage Projects</td>
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<td>EPWAPDA</td>
<td>East Pakistan Water and Power Development Authority (Bangladesh)</td>
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<td>FAO</td>
<td>Food and Agriculture Organisation of the United Nations</td>
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<td>FAP</td>
<td>Flood Action Plan (Bangladesh)</td>
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<td>FC</td>
<td>Farmer Committee</td>
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<td>FCD</td>
<td>Flood Control and Drainage (Bangladesh)</td>
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<td>FESS</td>
<td>Fordwah Eastern Sadiqia South (Project in Pakistan)</td>
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<tr>
<td>FO</td>
<td>Farmer Organisation (Pakistan)</td>
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<td>FPCO</td>
<td>Flood Plan Coordination Organisation (Bangladesh)</td>
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<tr>
<td>GPP</td>
<td>Guidelines for People’s Participation in Water Development Projects (Bangladesh)</td>
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<tr>
<td>GOB</td>
<td>Government of Bangladesh</td>
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<td>GOE</td>
<td>Government of Egypt</td>
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<tr>
<td>GOP</td>
<td>Government of Pakistan</td>
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<tr>
<td>HYV</td>
<td>High Yielding Variety</td>
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<td>IBIS</td>
<td>Indus Basin Irrigation Systems</td>
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<tr>
<td>ICID</td>
<td>International Commission on Irrigation and Drainage</td>
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<tr>
<td>ICSD</td>
<td>Interceptor-cum-Subsurface Drain</td>
</tr>
<tr>
<td>ID</td>
<td>Irrigation Department</td>
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<tr>
<td>IGNP</td>
<td>Indira Gandhi Nahar Pariyojna (Irrigation project in Rajasthan)</td>
</tr>
<tr>
<td>ILRI</td>
<td>International Institute for Land Reclamation and Improvement</td>
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<tr>
<td>LBOD</td>
<td>Left Bank Outfall Drain (Pakistan)</td>
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<tr>
<td>LID</td>
<td>Land Improvement District (Japan)</td>
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<tr>
<td>MAFF</td>
<td>Ministry of Agriculture, Forestry and Fisheries (Japan)</td>
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<tr>
<td>MALR</td>
<td>Ministry of Agriculture and Land Reclamation (Egypt)</td>
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<tr>
<td>MPWWR</td>
<td>Ministry of Public Works and Water Resources (Egypt)</td>
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<td>MWRI</td>
<td>Ministry of Water Resources and Irrigation (Egypt)</td>
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<td>NDP</td>
<td>National Drainage Programme (Pakistan)</td>
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<td>NGO</td>
<td>Non Governmental Organisation</td>
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<td>NWFP</td>
<td>North Western Frontier Province (Pakistan)</td>
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<td>OFD</td>
<td>On Farm Development</td>
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<td>OFWM</td>
<td>On Farm Water Management</td>
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<tr>
<td>O &amp; M</td>
<td>Operation and Maintenance</td>
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<tr>
<td>PAP</td>
<td>Project Affected People</td>
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<td>PC</td>
<td>Project Committee</td>
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<td>PID</td>
<td>Provincial Irrigation Department (Pakistan)</td>
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<td>PIDA</td>
<td>Provincial Irrigation and Drainage Authority (Pakistan)</td>
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<td>PIM</td>
<td>Participatory Irrigation Management</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>PSO</td>
<td>Punja Special Officer (Revenue Department, Kerala, India)</td>
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<td>RAJAD</td>
<td>Rajasthan Agricultural Drainage Research Project</td>
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<td>SADAS</td>
<td>Sectors Affairs and Drainage Advisory Services (Egypt)</td>
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<tr>
<td>SCARP</td>
<td>Salinity Control and Land Reclamation Project (Pakistan)</td>
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<tr>
<td>SRP</td>
<td>Systems Rehabilitation Project (Bangladesh)</td>
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<tr>
<td>UNPD</td>
<td>United Nations Development Programme</td>
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<tr>
<td>WAPDA</td>
<td>Water and Power Development Authority (Pakistan)</td>
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<td>WUA</td>
<td>Water User Association</td>
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<tr>
<td>WUC</td>
<td>Water User Committee</td>
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<td>WUG</td>
<td>Water User Group</td>
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Executive Summary

This desk-study on institutional arrangements in agricultural drainage in developing countries has been conducted out of the World Bank's specific concern with deteriorating performance of large-scale canal irrigation. Widespread waterlogging and soil salinity in irrigation canal commands threaten the sustainability of irrigated agriculture. Outside the sphere of irrigated agriculture, areas in the humid tropics experience large natural excess water flows that result in floods and hamper agricultural and rural development. Agricultural land drainage is an important strategy in controlling such problems.

Aim of the study has been to produce an overview of institutional arrangements in various countries, and to provide an analysis of the effectiveness of these institutions. This report includes a general review of institutions in five countries: Bangladesh, Egypt, India, Japan and Pakistan. To facilitate appropriate reflection on institutional arrangements in drainage development, 'agricultural land drainage' has been defined and four types of agricultural land drainage have been distinguished.

Agricultural land drainage is understood to be the disposal of water from a place where it is considered to be in excess, to a place where it represents a more neutral meaning. Drainage processes comprise a large part of the natural hydrologic cycle. For example, river flows are often employed for irrigation, while rivers themselves are a form of natural drainage. Rivers convey surface runoff that occurs as a consequence of precipitation and snowmelt from higher to lower areas and ultimately to seas and oceans. After use for irrigation or other purposes, excess water can be disposed of or re-used. In the processes of use, re-use and disposal, water quality often changes as compared to the quality before use. In short, drainage is intrinsically linked to other forms of water control and water use.

Four types of drainage are distinguished: (1) Flood control, (2) drainage in irrigated agriculture, (3) drainage in rainfed agriculture, and (4) land reclamation. This typology not only relates to the agro-ecological settings of drainage. Moreover, it relates to particular groups of stakeholders and their specific water management demands and practices. Here, stakeholders are understood to be the people and organisations involved in drainage development, and the people who are affected by drainage.

Drainage development can be hampered by a number of factors, one of which is an inefficient and ineffective institution for its management. Reviews of institutional arrangements in five different countries are summarised in the following sections. The executive summary is winded up with a brief reflection on the findings of this desk-study.

The country specific institutions are sketched in several diagrams using the following arrows to indicate the nature of relationships:

1 To shed some light on possible (future) scenarios of drainage development in developing countries, also Japan has been included in this review although it is not a developing country.

2 Arrows are based on Dicke (forthcoming: Institutional options for irrigation and drainage, W. Dicke). In accordance with Dicke, it was proposed to also include in this executive summary a number of tables reflecting statutory responsibility and execution of tasks of organisations. However, the author decided not to include these tables. Participation of private companies and/or users in drainage management above the level of the tertiary outlet (or even above field intake), is generally limited. Furthermore, because of different drainage technologies and subsequent different responsibilities and tasks that would have had to be included in the tables, the tables' purpose of clarification would have been violated.
Define: Who has the statutory responsibility for the provision of the service?

Provide: Who provides the service?

Pay: Who pays for the service?

Regulate: Who regulates (and monitors) the service?

Elect: Who composes a body or who is elected in a body?

Bangladesh

Water management infrastructure in Bangladesh can roughly be divided into canal irrigation systems, and flood control and drainage (FCD) systems. FCD systems represent more than 80% of Bangladesh's water management infrastructure, and from a rural development point of view are more important than canal irrigation systems. Both types of systems differ considerably from each other. The users of drainage in canal irrigation systems are farmers, whereas the users of drainage in FCD systems can be farmers, fishers, salt producers and/or others. Within the same system, these groups often have conflicting water management demands. Furthermore, the service provided differs per system. In irrigation systems water is provided to the users, while in FCD systems the service provided to users consists of structures for drainage and flood protection. Out of concern with low performance of the prevailing management structures, the Government of Bangladesh wishes to introduce an alternative water management structure, which is facilitated by the Guidelines for People's Participation in Water Development Projects (GPP). Box A, B and C present the management structures in FCD systems, canal irrigation systems, and the proposed structure for water management, respectively.
**Institutional arrangements in drainage development**

**Drainage management in FCD systems**

**Box A: Relations in drainage development in FCD systems in Bangladesh**

The Government of Bangladesh (GOB) levies taxes to finance public expenses. In the form of loans and grants, the GOB receives funding from foreign multi- and bilateral donors for the implementation of projects. These loans and grants can be accompanied by conditions imposed by the donors, or otherwise influence the country's internal operation. The Flood Action Plan (FAP) and the Systems Rehabilitation Project (SRP) are examples of such projects. After several severe floods, both projects emerged out of international concern with the well being of millions of people living on Bangladesh's flood plains. Both projects were to support construction of flood control measures, but subsequently emerged as major driving forces behind institutional reform of the country's water sector.

The main water management organisation in Bangladesh is the Bangladesh Water Development Board (BWDB). The BWDB is responsible for planning, construction (and rehabilitation), operation and maintenance (O & M) of larger structures in FCD systems like embankments, sluice gates and others. Users do not contribute to the required capital investments. Operation and maintenance are largely executed by the users of the FCD systems, without consulting the BWDB, or without the BWDB
intervening. Management is often not conducted in a participatory manner, but rather in a competitive fashion. There is no tangible accountability between the service provider (BWDB) and the recipients of the service (users).

**Drainage management in canal irrigation systems**

**Box B: Relations in drainage development in irrigation systems in Bangladesh**

The BWDB is responsible for the planning, construction (and rehabilitation), operation and maintenance (O & M) of the physical infrastructure of large-scale irrigation systems up to tertiary level. The BWDB supplies water to the tertiary units, after which the farmers can pump water from the tertiary canals. Although farmers are supposed to pay water charges to cover (a part of) the system's O & M costs, this only occurs at a modest scale. The low rate of revenue collection contributes to the overall low rate of cost recovery, which again contributes to the low budgetary allocation for system O & M.

**Proposed institutional arrangement in water management systems**

The absence of strong relations of accountability that result in poor management, and the largely insufficient budgets for O & M, has urged the GOB and international organisations to reconsider the BWDB and turn it into a water management organisation rather than an engineering organisation. This has taken shape in the formulation of the Guidelines for People's Participation in Water Development Projects (GPP). Although not an Act, the GPP is the single most important text guiding today's water sector policies in Bangladesh. Despite its formulation in 1994, here it is still presented as a 'proposed' water management structure for the near future since so far it has not actually been employed in management of FCD systems. The GPP are based on general experiences with irrigation management, and simply do not fit management of FCD systems.
Box C: Proposed relations in water management systems in Bangladesh
In the new water management structure, the BWDB remains largely responsible for the planning, construction (and rehabilitation), operation and maintenance (O & M) of the physical infrastructure of large-scale irrigation systems up to tertiary level, and of larger structures within FCD systems. The BWDB also remains the supplier of water to the tertiary units. A project committee (PC) is to be formed. Next to representatives of the GOB and non-governmental organisations, also farmers, fishers and other project beneficiaries or project-affected people will be represented in the PC. In the early stages of a project, the PC is to take policy decisions, and coordinate and monitor project activities.

The GPP facilitates the constitution of water user groups (WUGs) at tertiary level, water user committees (WUCs) at secondary level, and water user associations (WUAs) at system or project level. The GPP furthermore defines their respective tasks and responsibilities. Farmer representatives comprise the user bodies. The WUGs, WUCs and WUAs form a kind line of communication between the system users and the BWDB consisting of elements like conflict resolution and drafting of rules. Along the same line, demands are forwarded to the BWDB in order to guide operation and maintenance. The BWDB is responsible and executes O & M up to the tertiary offtake. To finance part of the O & M at main and secondary system level, WUGs are to contribute from the fees levied from their farmer-members.

The WUGs are to levy fees from their members and use these fees to pay a part of O & M at secondary and main level, but also to fully finance development, and O & M of their respective unit.

This new water management structure is expected to bring about clear relations of accountability between service provider and recipients, more efficient water use (in irrigation systems) and better targeted system management because of increased user involvement. However, especially with respect to FCD systems, this structure may fail to achieve its objective. First, other FCD users than farmers are only represented in the project committee and not in the water user groups, committees and associations. Second, in many FCD systems hydraulic system levels substantially differ from the generally recognised hydraulic levels in irrigation systems. Third, how are WUGs to levy fees when water is not supplied?

**Egypt**

Drainage in Egypt is generally performed within surface irrigation systems and reclaimed lands (also under irrigation). With the completion of the Aswan High Dam in 1968, the seasonal floods of the river Nile were eliminated, allowing for more land to be brought under irrigation and for higher cropping intensities. With the rise in cropping intensities, waterlogging and soil salinity started to occur. In 1973 the Egyptian Public Authority for Drainage Projects (EPADP) was constituted to install pipe drains and mitigate the effects of rising groundwater tables. EPADP subsequently emerged as the major drainage organisation in the country, largely responsible for planning, construction and O & M of drainage projects. Despite the fact that by 1995 some 86% of the irrigated area in Egypt is served by a network of open drains and 54% of the irrigated lands is equipped with pipe drains, still around 19% of these lands is waterlogged and around 32% is affected by soil salinity. In addition, Egypt is experiencing increasing water shortages as a result of continuous enlargement of the irrigated area, a development driven by a political imperative: "The greening of the Sinai". Re-use of used irrigation water (drainage effluent) is a measure to compensate for the water shortages, requiring meticulous water management. EPADP, however, is an engineering organisation rather than a water management organisation.
Box D: Relations in drainage development in irrigation systems in Egypt

The Government of Egypt (GOE) levies taxes to finance public expenses. In the form of loans and grants, the GOE receives funding from foreign multi- and bilateral donors for the implementation of projects.

The main drainage organisation in Egypt is the Egyptian Public Authority for Drainage Projects (EPADP). The EPADP is an autonomous agency constituted under the Ministry of Water Resources and Irrigation (MWRI), which again is constituted, regulated and financed by the GOE. The EPADP is largely responsible for planning, construction, O & M of drainage infrastructure, and the disposal of drainage effluent. Farmers are generally not involved in these activities. Construction of open drains up to tertiary level is done by the EPADP that also maintains the open drains by using its own staff or through service contracts with private contractors.

Construction and maintenance of open field drains are entirely the responsibility of farmers. Subsurface (pipe) drains are manufactured in plants that are financed by the Government and managed by the EPADP. The pipes are transported and installed in farmers' fields by contractors who are hired by the EPADP on a service contract basis. Maintenance of subsurface drains is specialised and performed by the EPADP. The effectiveness and efficiency of pipe drain maintenance is observed to be rather low, however. Farmers pay a part of the expenses for pipe drainage installation, and they pay land taxes annually. Both however, appear grossly insufficient to cover EPADP's expenses for construction and O & M of the country's drainage systems. Drainage is thus largely subsidised. All in all, there is little accountability from the EPADP to the farmers, instead accountability is directed upwards within the EPADP organisation.

Law 32/1964 facilitates farmer organisation and thus for farmers to form groups with a legal status. These groups are called Collector User Associations (CUAs), and are to be responsible for and execute O & M of drainage at the level of the collector drain ('tertiary' level). By collecting fees from their (voluntary) members, CUAs can finance their activities. This will release the financial burden on the EPADP and
make drainage services for farmers more efficient and effective. However, as the dotted arrows in box D suggest, so far farmers' participation in drainage remains rather limited. And the EPADP, which is an engineering and construction oriented rather than a management and maintenance oriented organisation, is still largely carrying out O & M.

To address the three problems of (1) a low rate of cost recovery for O & M, (2) the low efficiency and effectivity of pipe drain maintenance, and (3) the increasing pressure on the surface water resources, there are calls for increased users' participation in O & M and for more integrated management of water distribution, delivery, drainage and groundwater management at the local level.

Two questions stand out with respect to these proposed reforms: (1) How are farmers supposed to perform highly specialised maintenance of tile drains, i.e. are farmers to take up tile drain maintenance themselves or should accountability be redirected in another way? And, (2) can integrated water management be performed without redirecting the engineering bias of the EPADP, i.e. should the EPADP or even the MWRI be reorganised, and if so, how?

**India**

India has a large variety of agro-ecological and socio-economical settings. As a result, most types of agricultural land drainage can be found in India. A general review would provide little insight in the sector's functioning and the problems it experiences. To handle the variety of settings, the institutional arrangements in land drainage have been investigated in relation to irrigated agriculture in two large canal irrigation projects in the (semi) arid State of Rajasthan (the IGNP and Chambal projects), and in relation to land reclamation in the more humid State of Kerala.

**Drainage management in canal irrigation systems in Rajasthan**

No structural drainage development is undertaken as yet within the IGNP. Problems of waterlogging and soil salinity in the IGNP prove to be an extremely hard nut to crack when it comes to achieving effective disposal of excess water and salts. The system's users and managers face a lack of financial means and drainage outfall, and continue to struggle with local measures that may resort some local or temporary relief. In the mean time, the sandy 'bowl' that forms the IGNP is 'filled' with water that is supplied in excess.

Contrary to the IGNP, in the Chambal Command Area, an extensive drainage system has been constructed. It mainly consists of open drains, and is enhanced in a smaller area with horizontal subsurface drains. The construction of the open drains was a government initiative supported by foreign donor organisations and the World Bank. The subsurface drains were also installed at government initiative and with foreign (Canadian) technical and financial assistance. The drainage facilities are generally poorly operated and maintained, however, as is also illustrated by the large area of land still being waterlogged and/or saline.
Box E: Relations in drainage development in canal irrigation systems in Rajasthan

In Rajasthan, there is no specific organisational set up developed for the sole purpose of looking after and tackling the two problems of waterlogging and soil salinity/alkalinity. Conceptually, the Irrigation Department is responsible for drainage development and operation and maintenance within canal irrigation systems. But, the construction of drainage infrastructure in the Chambal Command Area has been financed with foreign assistance, while the IGNP entirely lacks basic drainage facilities. Operation and maintenance of the drainage facilities in Chambal are a responsibility and a task of the Irrigation Department. If provided, the farmers generally receive the drainage service without payment.

A number of Water User Associations or 'Chaks' (for irrigation management) and Catchment Committees (for drainage management) have been formed in the past in the Chambal Command Area. There is, however, no legislation to facilitate their functioning. Therefore, their participation in system management has remained limited, especially with regards to drainage management where it can even be considered negligible.

Despite the large problems of waterlogging and soil salinity in canal irrigation systems in Rajasthan, efforts to control the problems (by further developing and adequately managing the existing drainage) are undertaken at a modest scale or appear rather ineffective. Drainage development seems to be 'low on the agenda', and that has resulted in the absence of an institutional framework that is targeted towards drainage development, and organisations that have clearly defined responsibilities and tasks. In Rajasthan, both government and farmers have restricted financial means to invest and to operate and maintain a drainage system. Clear relations of accountability and a system of cost recovery for operation and maintenance of drainage works are absent.

Drainage management in land reclamation in Kerala

Kuttanad, in the State of Kerala, is the name of a coastal area covering around 110,000 hectares. In Kuttanad, more than 30,000 hectares are located at an elevation of 1.0 metre above mean sea level or higher, while some 50,000 hectares are located between 0.6 and 2.2 metres below mean sea level. Four rivers discharge water into this area of dry lands, wet lands and open water. A particular area of Kuttanad is known as the Kayal lands. Kayal covers a land area of some 9,464 hectares, which are entirely reclaimed from Vembanad Lake. The Kayal lands are situated at some 2 metres below mean sea level, and paddy is cultivated here by pumping water out of embanked polders.
Through committees (FCs) farmers organise collective and simultaneous dewatering and subsequent drainage in each polder. In the Kayal areas, there are some 123 FCs, which each cover an average area of around 83 hectares. Coordination between FCs, and thus between the different polders in the Kayal lands, is taken up by the Punja Special Officer (PSO) of the Revenue Department. After having consulted the farmers, the PSO decides upon a specific time when private contractors should install pumps and execute pumping at the start of the growing season and during its subsequent days. Contractors are paid through the PSO. Farmers contribute around 15% of the costs involved in operation and maintenance of polder drainage. The remaining 85% can be considered a government subsidy. FCs supervise pumping and drainage and if contractors do not perform their duties adequately, the FCs can inform the PSO who can take action accordingly.

Accountability of the contractor is thus directed more towards the PSO and less to the farmers. It remains unclear whether this has particular effects on the functioning of the contractors. The accountability of the PSO towards the farmers seems limited from an institutional point of view, but also this does not seem to affect the effectiveness and efficiency of the polder drainage. The non-participation in drainage management of drainage affected people like fishers remains a matter of concern.

**Japan**

Already for centuries have farmers in Japan collectively taken up drainage and irrigation development through the ‘mura’ (traditional farmer organisations). The mura have provided the basis for today’s Land Improvement Districts (LIDs): Farmers' bodies that largely manage irrigation and drainage facilities.
Several ministries in Japan are involved in drainage development. The most prominently involved in agricultural land is the Ministry of Agriculture, Forestry and Fisheries that is responsible for the construction and/or rehabilitation of main irrigation and drainage canals and structures. Land Improvement Districts are mainly responsible for operation and maintenance of the systems, and for smaller scale construction works. LIDs are composed of farmers entirely. The office bearers are elected farmers. LIDs have a clear legal status, and can collect fees from their members to cover expenses, and can hire contractors or staff for their operations. Accountability is clearly directed from the LID to the farmers.

Over the years, LIDs appear to have increased in size (the area under command) and reduced in number. This trend is incited by the need to address the generally increasing gap between the LIDs’ income and expenditure. This is mainly the consequence of increasing expenditures for operation and maintenance, which again are mainly a result of advancing technological development and reducing importance of farming as the sole source of income. However, today drainage expenses are no longer of concern to the LIDs. Drainage has been recognised to serve wider societal interests than only farming interests, and subsequently the government has taken over the responsibility for and financing of drainage development and operation.

**Pakistan**

Drainage in Pakistan is generally executed with canal irrigation commands. The enormous protective canal irrigation systems of Pakistan experience a number of problems: (1) Due to rising groundwater tables as a result of many years of irrigation, some 14% of the irrigated lands are affected by soil salinity, while around 44% of the irrigated lands suffer from waterlogging, (2) water delivery and use are inefficient, (3) water distribution is inequitable, and (4) the level of cost recovery is grossly insufficient with drainage cess for instance covering only around 20% of the actual expenses for O & M.

To address these problems, which are partly drainage and partly irrigation related, the World Bank has argued for reforming the irrigation and drainage sector in Pakistan. In 1997, Provincial Irrigation and Drainage Acts were issued in all four provinces and Provincial Irrigation and Drainage Authorities (PIDAs) were established. System management is to be decentralised and farmers’ participation in O & M
to be increased. Farmers are to take part in system development and take over O & M activities and funding through the establishment of Area Water Boards (AWBs) and Farmer Organisations (FOs). PIDAs, AWBs and FOs are all to become financially autonomous, and can achieve this through levying water charges and drainage cess. This situation is presented in box H.

Planning, construction, operation and maintenance of drainage systems within canal irrigation commands is the responsibility of the respective Provincial Irrigation and Drainage Authorities (PIDAs). These authorities are created under the PIDA Acts, that also facilitate more users (farmers) participation in system management. To finance its operations, PIDAs receive money from the government, but can also engage in development projects funded by multi- or bilateral donors, or can obtain loans from international financial and development institutions like the World Bank. That these forms of assistance are accompanied by conditions has been clearly illustrated in Pakistan.

Box H: Relations in drainage development in canal irrigation systems in Pakistan

Planning, construction, operation and maintenance of drainage systems within canal irrigation commands is the responsibility of the respective Provincial Irrigation and Drainage Authorities (PIDAs). These authorities are created under the PIDA Acts, that also facilitate more users (farmers) participation in system management. To finance its operations, PIDAs receive money from the government, but can also engage in development projects funded by multi- or bilateral donors, or can obtain loans from international financial and development institutions like the World Bank. That these forms of assistance are accompanied by conditions has been clearly illustrated in Pakistan.

3 Using the possible withdrawal of a loan for the National Drainage Programme (involving USD 785 million) as an incentive, the World Bank 'convinced' the Government of Pakistan to agree with institutional reforms in the irrigation and drainage sector.
Institutional arrangements in drainage development

international financial and development institutions like the World Bank. That these forms of assistance are accompanied by conditions has been clearly illustrated in Pakistan.

PIDAs are to facilitate and promote the formation of AWBs, which again are to facilitate and promote formation of FOs. An AWB is formed by the government and is composed of farmers, government representatives, and a PIDA representative. An AWB is responsible for planning, construction, operation and maintenance of a system’s irrigation and drainage structures at main and secondary level. At the tertiary level FOs are responsible for operation, maintenance and improvement of these structures. FOs should collect water charges and drainage cess from their respective members to cover their expenses and pay the AWB for their delivered services.

However, apart from a few pilot projects, no FOs or AWBs have actually been set up, let alone are functioning as envisioned by the World Bank and the GOP. Reasons for this centre around (1) a lack of farmers' involvement in the policy reforms, (2) the fact that farmers have developed strategies to deal with the system's problems, (3) the shift of focus of multilateral donors from engineering to institutional solutions, which has a bearing on the being and functioning of the irrigation establishment and on those disproportionately benefiting from the previous arrangement, and (4) the acceptance of a weak legal framework (the PIDA Acts) for implementation of the irrigation and drainage sector reforms.

The overall performance of past drainage interventions in Pakistan has been quite uneven and mixed. The brighter side of the picture includes partial control of waterlogging and salinity, reclamation of some of the affected areas, and development of conjunctive (ground)water use. The major concerns include the disposal of drainage effluent, declining or low performance of existing drainage facilities, and the lack of financial viability and sustainability of drainage projects.

Winding up

To counteract the problems of waterlogging, soil salinity or flooding, drainage measures have already been employed for many decades or sometimes even centuries. However, in many countries or projects, drainage performance is considered to be below levels required or expected. Reasons for this low performance appear to centre around insufficient financial means for system construction, operation and management, a lack of involvement of stakeholders' (rather than drainage users), and inadequate consideration of the technological dimensions of drainage.

Initially, large investments were made in development of drainage technology to upgrade the effectiveness and efficiency of drainage. Later, and especially during the 1990s, focus largely shifted from technology development towards institutional development. Drainage institutions were to be reformed, and these reforms have often been moulded in a similar fashion as is and has been done in irrigation sector reforms.

However, it should be seriously questioned whether the models of irrigation sector reform and models of irrigation institution can be applied to the drainage sector. Furthermore, a discussion on drainage should involve a broader concept of water use and stakeholders' interests in order to effectively identify service

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4 Using the possible withdrawal of a loan for the National Drainage Programme (involving USD 785 million) as an incentive, the World Bank ‘convinced’ the Government of Pakistan to agree with institutional reforms in the irrigation and drainage sector.

5 Irrigation sector reforms are generally based on three pillars: (1) Pricing the use of water resource units, (2) create financially autonomous agencies, and (3) turnover of system management to users or user groups (decentralisation).
recipients (and their water management demands) and to bring about relations of accountability. Drainage is to be included in the debate on integrated water management. Lastly, institutional reform may fail to achieve its objectives when the technological dimensions of drainage in its local agro-ecological context are overlooked. The findings of this desk-study show that it is important to recognise the sociotechnical nature of drainage, as to understand system dynamics and linkages between drainage and other elements of the hydrologic cycle.

Interdisciplinary and integrated research\(^6\) are required in investigating drainage and do justice to it\(^7\).

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\(^6\) Interdisciplinarity is understood as 'cutting across borders of disciplines like technology and sociology', while integration is considered to involve, for example, multiple water uses or geographical variations.

\(^7\) Unfortunately, drainage is regularly viewed as only having negative effects on the (natural) environment. This image of drainage is clearly expressed in the phrase 'to go down the drain', meaning 'to be wasted'.
Introduction

Widespread waterlogging and soil salinity threaten sustainable irrigated agriculture and are a cause for increasing alarm in developing countries. Economic development specifically in countries with a semi-arid or arid climate is largely depending on agricultural production from irrigated agriculture. For instance, in Pakistan 75% of the population depends directly or indirectly on agriculture, and this sector contributes 50% to the gross national product (Knops et al., 1997). Production from irrigated agriculture makes up more than 90% of the agricultural production in Pakistan (World Bank, 1994).

Out of concern with deteriorating performance of large-scale canal irrigation, the World Bank has requested Wageningen University in the Netherlands to conduct a desk-study with respect to institutional arrangements in agricultural drainage development in several developed and developing countries. The objective of the study was to produce an overview of the institutional arrangements developed in various countries, and provide an analysis of the effectiveness of these institutions in their particular contexts. The paper at hand specifically deals with agricultural drainage development in developing countries.

The World Bank (2000) notes that the state of drainage development varies from one country to another. It reaches 30% to 40% of the irrigated or rainfed agricultural lands in developed countries and about 7% in developing countries. The performance of agricultural drainage is often not up to a satisfactory or adequate level. Progress in drainage development seems tied to the level of agricultural development in the country, but there are other factors as well, which delay development of drainage. Among these are institutions with a clear mandate to make such development happen. Success of institutional arrangements cannot be measured only by the area with drainage development. The ability of institutions to make this service reliable and sustainable is evidently just as vital (World Bank, 2000).

Structure of the report

This report consists of four main sections: (1) The executive summary, (2) chapter one with the introduction to the research and the methodology employed, (3) chapter two where the conclusion and points for discussion are presented, and (4) chapters three to seven with the country reports.

The executive summary gives an overview in a nutshell of the research findings, the conclusion and discussion. The introduction to this research and its objective are included in chapter one.

Chapter two consists of two subsections: section 2.1 where the general conclusions of the research are formulated, and section 2.2 where several points for discussion are introduced. The points for discussion can be considered a starting point for re-thinking the management of drainage with respect to its multiple functions and it being intrinsically linked to other parts of the hydrological cycle.

8 To shed some light on possible (future) scenarios of drainage development in developing countries, also Japan has been included in this research although it is not a developing country.
Country reports on Bangladesh, Egypt, India, Japan, and Pakistan form the basis of this report. These country reports are presented in chapter three to seven, respectively. In general, each country report comprises the following sections: (1) Introduction, (2) Drainage and irrigation development, (3) Institutional framework, (4) Legal framework, (5) Financing drainage, (6) Integrated water resources management, (7) Impact of drainage on agriculture, and (8) Institutional performance.

Research methodology

This desk-research can be divided according to two main stages or phases:
1. Orientation phase: June and July 2000;

Orientation phase

In the first phase of the research, a professional librarian who used a number of key words has browsed several catalogues and Internet-sites. Both the librarian and the researcher suggested the key words. The results of this search, as well as the key words used, are presented in annex 1. The catalogues and Internet-sites searched are:
- AGRALIN (Wageningen University and Research Centre Catalogue)
- AGRICOLA 1991 – 2000/05
- AGRIS 1991 – 2000/05
- CAB Abstracts 1995 – 2000/05
- TROPAG & RURAL 1975 – 1999/12
- www.IILRI.nl/drainnet.html
- www.FAO.org/IPTRID
- www.IILRI.nl/ICID

During the first phase of the research, the author also browsed the library of ARCADIS Euroconsult in search of specific project related literature. Some drainage specialists of Euroconsult were interviewed in order to cross check the then accumulated and compiled information. The results of this initial search yielded a number of references that introduced the researcher with the exact topic of this study. The search was expanded after a first period of literature review, where new references and potentially ‘successful’ additional key words had come to the fore.

Elaboration phase

During the second phase of the research, most of the writing was done. This has been a continuous and recurrent process of writing, forwarding requests to international experts on drainage and irrigation (mainly from the Netherlands) for additional information, additional literature review, and again writing. The literature used for compiling this report is listed in the references of this report, whereby the references are presented separately for chapter one and two, and for each country. As much as a desk-study allows for, the author intended to focus this study on actual institutional arrangements and management practices rather than on what management is intended (for example in certain acts).

This desk-research has not been confined to the five before-mentioned countries. Especially during the orientation phase of this study, information has been collected on several other countries: Argentina, Malaysia, Indonesia, Turkey, and some countries from the former Soviet Union. However, readily available information on drainage development and especially on institutional arrangements in these countries was considered to be too limited for presenting substantive and coherent country reports. Whatever information collected through literature search and interviews on these countries was therefore left out of this report. This leaves the report at hand with a number of lacunae, and this makes it a discussion-paper rather than an authoritative study.
Institutional arrangements in drainage: Introduction

Clearly, this should not mean that a discussion on drainage institutions better be limited to the countries incorporated in this final presentation. Examples from other countries may provide interesting information and reveal innovative ways of organising drainage development. Furthermore, practically every country in the world, not to mention other administrative or geophysical or climatological units, provides a different setting in which drainage is conducted. If there is one thing that stands out from the report at hand, it is the need to address drainage development in a ‘tailor-made’ and integrated approach.
Conclusion and Discussion

Agricultural land drainage: Diverse objectives and a variety of settings

Agricultural land drainage

Land drainage can be conducted in urban or rural settings, and it can be agricultural or non-agricultural. The Encarta Encyclopaedia (2000) describes land drainage as follows:

“… removal of surface or subsurface water from a given area by natural or artificial means. The term is commonly applied to the removal of excess water by canals, drains, ditches, culverts, and other structures designed to collect and transport water either by gravity or by pumping. A drainage project may involve large-scale reclamation and protection of marshes, underwater lands, or lands subject to frequent flooding”.

In this research, the focus is on land drainage in rural areas that has a strong impact on or is initiated by the agricultural sector. Ochs et al (in: Jensen, 1983) define agricultural land drainage as:

“… the removal and disposal of excess water and salt from agricultural land to provide a good environment in the soil for plant growth”.

In addition to this definition, agricultural drainage can also facilitate lower production costs, broaden the range of crops that can be grown, overcome farm management constraints, and advance rural welfare and well being. With respect to the advancement of rural welfare and well being, Van Steenbergen (1999) identifies the following ‘other’ benefits of land drainage, i.e. gains outside of agricultural production: Drainage can improve water supply and sanitation, drainage can help to protect buildings, and drainage can contribute to the reduction in the transmission of vector-borne diseases like malaria. In relation to the latter, in South East Asia it may even be the case that drainage development has started as an initiative to fight health hazards (Snellen, 2000, personal communication). Drainage can also be an important practice in relation to fisheries, as for example is the case in the flood control and drainage systems of Bangladesh. With respect to irrigated agriculture, it is essential to realise that drainage is not only a practice of removing excess water and salts, but also a practice of elaborate control of groundwater levels, of control over the retention of water for use during more water scarce periods and in order to allow for more flexibility in water distribution, and for reuse of (often lower quality) drainage effluent.

On the basis of a particular need for agricultural land drainage, the main objectives it serves, and the forms this land drainage takes, drainage can be categorised according to general types. This typology of land drainage in rural areas is presented in table 2.1, whereby it is noted that also mixtures of certain types can occur. This, for example, is the case in Bangladesh where Flood Control and Drainage (FCD) systems form the most important water management infrastructure. These FCD systems often include flood control, drainage and irrigation practices.

<table>
<thead>
<tr>
<th>Need (as a result of)</th>
<th>First or main objective</th>
<th>Occurrence</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Floods</td>
<td>Prevent or control (excessive) flooding of lands in river or coastal plains to</td>
<td>River and coastal plains: For example in Bangladesh, and parts</td>
<td>Flood control</td>
</tr>
</tbody>
</table>
enable human settlement and farming of India

<table>
<thead>
<tr>
<th>2</th>
<th>Unsustainable irrigated agriculture as a result of waterlogging and salinity</th>
<th>Control groundwater table levels to control waterlogging and soil salinity and to ultimately enhance agricultural sustainability and even levels of production</th>
<th>Agricultural areas in semi-arid and arid zones: For example in Egypt, India, Pakistan</th>
<th>Land drainage in irrigated agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Low production of non-irrigated agriculture</td>
<td>Enhance potential of agricultural production by controlling soil moisture contents</td>
<td>Agricultural areas in temperate zones: For example in Europe</td>
<td>Land drainage in rainfed agriculture*</td>
</tr>
<tr>
<td>4</td>
<td>Need for increasing agricultural production (for example as a result of population increases)</td>
<td>Expand the agricultural area through reclaiming lands</td>
<td>Low-lying coastal areas: For example in Japan, Europe, India (Kerala)</td>
<td>Land reclamation</td>
</tr>
</tbody>
</table>

* This can include possible supplementary irrigation in dry periods of the year. For instance sprinkler irrigation in the Netherlands during the summer.

Clearly, this typology not only relates to the agro-ecological settings of drainage. Moreover, it relates to particular groups of actors (or stakeholders) and their specific water management demands and practices. Here, actors are understood to be the people and organisations involved in drainage development, but also the people affected by drainage. For instance, fishermen in the floodplains of Bangladesh who are affected by embankments that are constructed to control inland water levels for rice production.

**The role of agro-ecology and technology**

In general, specific agro-ecological settings or human requirements necessitate drainage, i.e. a certain ‘level of disaster’, ‘immediateness of need’, or crisis seems a *conditio sine qua non* for substantive (government) action in drainage development. The same agro-ecological settings and human requirements put demands on drainage technology, which again puts demands on drainage management.

Drainage technologies can be divided in two types: (1) Surface drainage, and (2) subsurface drainage. Subsurface drainage can again be subdivided into vertical and horizontal subsurface drainage. Surface drainage is generally understood to consist of field ditches and open canals to collect and convey surface and/or subsurface run-off for disposal. The term vertical subsurface drainage generally refers to tubewells, while the term horizontal subsurface drainage generally refers to tile drainage. The choice to use a specific technology depends on a number of factors: Construction costs, scale of drainage development, intensity of land use, slopes, soils, the occurrence of rainfall and floods, availability of pumping technology and available sources of energy required for pumping, among others.

Like irrigation technology, drainage technology requires certain inputs. For instance, vertical drainage puts other demands on management than tile drainage, and pumped drainage puts other demands on management than gravity systems. Not treating drainage technology as a black box is required for understanding drainage management practices and for designing interventions.9

**Flood control**

Flood control is about keeping excessive quantities of water out of a designated area, while at the same time not obstructing the drainage of water accumulating within the area (as a result of rain or seepage). Flood control systems generally start with the construction of embankments to keep out seasonal river or

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9 See Mollinga (1998) for a presentation of irrigation systems as sociotechnical systems.
Institutional arrangements in drainage: Bangladesh

tidal flows. Then over time, flood control systems can become increasingly more complex and sophisticated with, for instance, the construction of adjustable gates in the embankments to release (or take in) water. As a result of increasing control over water, farming intensities may increase. With intensified farming practices, a need may rise for retention of water within the system during the dry season, again putting additional demands on water control technology. Examples of such a development of rather simple flood control systems towards complex systems, can be found in Bangladesh. Bangladesh is the delta of an enormous natural drainage basin covering parts of or entire countries. Furthermore, Bangladesh receives high rainfall during the monsoon season. The seasonal river flows, tidal flows and rainfall can submerge large tracts of this flat and low (generally lower than 30 metres above mean sea level) country. Flood control in Bangladesh has been set off by the frequent occurrence of life threatening floods, like there were in 1954, 1955, 1987 and 1988. To protect the many people living on the Bangali flood plains, flood control measures were a necessity. Today, the cultivated area in Bangladesh covers around 7.74 million hectares. Some 3.75 million hectares are irrigated, while around 1.5 million hectares of agricultural land are drained. An area of approximately 4.2 million hectares of land in Bangladesh is flood protected (FAO, 1999). Khan (1993, in: Wester et al, 1997, pp. 2) notes that ‘only’ some 440,000 hectares are irrigated under commands of large-scale canal irrigation systems. The other irrigation is thus likely to be practised as a part of the water management practices within flood control and drainage (FCD) systems, representing some 80% of the Bangladesh Water Development Board’s water management infrastructure.

Land drainage in irrigated agriculture in (semi) arid zones

Arid or semi-arid regions are characterised by quantities of rainfall that are insufficient to sustain (high-level) agricultural production. To grow crops in these areas, irrigation is required. Large tracts of arid and semi-arid areas have come under irrigation through the construction of canal systems. Unfortunately, much of today’s irrigation combines poor water distribution and application management with inadequate drainage. This renders irrigated areas at risk of becoming waterlogged, or degraded due to a gradual build-up of salt concentrations.

In countries like Egypt and Pakistan, large-scale problems of waterlogging and soil salinity in the command areas of canal irrigation systems have induced drainage development. In a country like India, drainage development in irrigated canal commands has not (yet) taken off at a similar scale as in Pakistan or Egypt. The need for adequate agricultural land drainage in canal commands seems less urgent with ‘only’ some 5% of the irrigated land affected by waterlogging and some 6.5% affected by soil salinity. During the last decades, drainage development in the arid and semi-arid Near East countries was concentrated in the Nile Valley and delta of Egypt, the Mesopotamian Plain of Iraq, and the Indus Valley of Pakistan. These areas have a comparable climate, land slope and irrigation water quality. The method of drainage varies greatly, however, for instance due to differences in soil conditions. In the Nile delta, the soils are heavy and poorly permeable, while the aquifer conditions are not suitable for vertical drainage.

10 Within these regions considerable variation is abound. For instance, the slopes in North Western Frontier Province (NWFP) of Pakistan are much steeper than the land slopes in the Provinces of Punjab and Sindh. Furthermore, water supplies in NWFP are much more abundant than in Punjab and Sindh.
drainage. The Iraqi soils of medium to heavy texture offer better permeability, but aquifer conditions are not suitable for vertical drainage since groundwater is generally saline. In Pakistan soils are generally medium textured, well permeable and underlain by permeable aquifers which often contain good quality water. These conditions favour vertical subsurface drainage (Wahab F. Sheikh, 1992).

It is regarded unlikely that much more arid or semi-arid lands will come under irrigation in the future. The world’s increasing demand for agricultural produce is more likely to be met through maintaining the existing crop lands, and through increasing the productivity of these lands. Drainage or improved drainage is one of the means to fulfil this need (Safwat Abdel-Dayem, 2000).

**Land drainage in rainfed agriculture in temperate zones**

An increasing demand for food, especially after the Second World War, has been the main driving force behind large-scale tile and later pipe drainage installation in Europe. Here, agricultural lands can be drained through a network of surface drains, while fields can be equipped with horizontal subsurface drains that discharge on to the surface drains. Smaller and bigger pumping stations are often a part of the drainage system. Drainage serves to maintain the required soil moisture balance to optimise crop growth. Irrigation is generally not practised, although it can be applied supplementary during periods of drought (summers).

**Land reclamation**

By creating physical barriers in the form of embankments, low-lying areas\(^{11}\) can be excluded from direct tidal influences or floods by large water bodies. By using periods of low tide in combination with gated outlets, or by using mechanical pumps, water can be released from the embanked area. To compensate for water accumulating within that area as a result of seepage and rainfall, (pumped) drainage remains an essential requirement throughout the existence of the created polder. The reclaimed land can be used for agricultural purposes.

A similar kind of event as in the temperate regions, an increasing demand for food as a result of a growing population, has induced the reclamation of low-lying lands. Examples of reclaimed low-lying areas or polders can be found in Europe, as well as in India (State of Kerala), Japan, and South East Asia (Indonesia, Malaysia, among others). Be it that the climatological circumstances under which the polders have to be maintained differ substantially\(^{12}\). Also the soil conditions can differ from region to region. Certain soils can put extra demands on the degree of water control, and thus on the technology used.

With respect to Malaysia for example, rainfall induced drainage has become increasingly important with the introduction of high yielding rice varieties\(^{13}\), and with a shift towards crop diversification (Kitamura *et al*, 1997, in: Abdullah, 2000). Furthermore, a rapid increase in population brought the pressure to enhance agricultural production and the need to improve the living environment. A shift of agricultural land use and food production into marginal lands is taking place, i.e. large areas of tropical wetlands have been and are being reclaimed for rice and commodity crops (Abdullah, 2000). Land reclamation in humid tropical regions can be problematic because of soils like peat, acid sulphate, bris soils and tin tailings, and saline soils. These problem soils inhibit drainage development. In Malaysia, land reclamation was traditionally aimed at the removal of surface water from lands. Drainage technology was designed to create flood-free situations and lower groundwater levels; coastal levees, river bunds, earth drains, drainage gates and crossings were constructed. However, as a consequence of free draining, moisture stress occurred and

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\(^{11}\) In this report, ‘low-lying areas’ are understood to be land surfaces that on average are below mean sea level (MSL). They can of course also be areas bordering (freshwater) lakes. In that case, not the MSL but the mean water level in the lake is the reference level.

\(^{12}\) Europe and Japan have temperate climates, whereas Indonesia and Malaysia have humid tropical climates with high rainfall in the monsoon season.

\(^{13}\) High Yielding Varieties are more sensitive to water levels (Kitamura *et al*, 1997, in: Abdullah, 2000).
crop production decreased\textsuperscript{14}. To optimise crop production, crop water requirements were to be met. This meant that instead of just lowering groundwater tables, groundwater tables needed to be optimised, requiring judicious drainage management.

\textbf{Actors in drainage}

\textit{Understanding the term institution}

In this research, an institution or an institutional arrangement in drainage development is understood to comprise people and organisations, peoples’ and organisations’ interaction, and the legal or other normative frameworks within which interaction takes place. Institutional or managerial control over drainage systems is about regulation and control of human behaviour, particularly with regard to forms of cooperation required to make drainage systems function.

\textit{The hydrological cycle}

From a global perspective, there is one general hydrologic cycle that is powered by the sun\textsuperscript{15}. The general hydrologic cycle can be divided into a number of subcycles, which depend on air currents, and that result in regional variation in precipitation. A country like Bangladesh receives considerably more rain than does Pakistan or Egypt. Furthermore, water is distributed according to natural drainage lines. Bangladesh is basically a delta where the natural drainage effluent of a number of countries (China, Bhutan, India, Myanmar, and Nepal) ends up and flows into the Bay of Bengal. Considering the relatively insignificant rainfall, Egypt has one major source of water, which is the River Nile. The Nile flows are fed from large catchments in Eastern and Central Africa, starting in Uganda (Lake Victoria) and in Ethiopia, and flows through Sudan before it ends up in Egypt. Water flows are indifferent to administrative boundaries, but water use or disposal of water is often a topic of debate between countries.

\textit{Main groups of actors in agricultural land drainage}

It is out of the scope of this research to consider cross boundary water institutions. The sketched hydrologic cycle is merely to illustrate the indifference of water to human boundaries, and the existence of higher than just national levels at which people interact in relation to water management. From a country specific perspective, three main levels can be distinguished at which certain actors play their roles\textsuperscript{16}:

1. National level;
2. FCD-system, irrigation system, or polder level;
3. Users’ or (local) level.

In relation to agricultural land drainage, several main groups of actors can be distinguished:

\textsuperscript{14} Studies by Mohd Zahari \textit{et al} (1982, in: Abdullah, 2000) on acid sulphate soil in Western Johore, Peninsular Malaysia, has shown that the yield of coconuts dropped by 35\% when field drainage (draining free) was introduced.

\textsuperscript{15} The hydrologic cycle is explained on the Internet site of Environment Canada (www.ec.gc.ca/water/en/nature/prop/e_prop.htm).

\textsuperscript{16} Moreover, hydraulic levels can be distinguished. Boundaries of hydrologic (river) basins or watersheds can cut through country boundaries or irrigation/drainage system boundaries.
1. Government agencies;
2. Multi- and bilateral donors;
3. Private companies like contractors and consultants;
4. Non-governmental organisations;
5. Drainage users and people affected by drainage development.

These actors are present at the three main institutional levels in different and varying numbers and with different and varying powers. Moreover, institutional arrangements are dynamic arrangements, i.e. actors change and their roles change.

Often, drainage is largely a government affair when it comes to construction, maintenance and operation. In Egypt, the Egyptian Public Authority for Drainage Projects is responsible for construction, maintenance and operation of all major drainage works as well as tile drainage. In Pakistan, drainage similarly originated as a government initiative through the construction of storm drains, and Salinity Control and Land Reclamation Projects (SCARPs), among others. The flood control and drainage systems (FCDs) in Bangladesh provide yet another situation. Water management is characterised by many different stakeholders, each with different and often conflicting water management demands. The infrastructure has to cater for many and often mutually exclusive demands (Wester and Bron, 1998). There are farmers, which can be subdivided into low land and high land farmers. While the low land farmers demand early drainage at the end of the monsoon, the high land farmers demand the retention of water in the low-lying areas of the system. Other stakeholders include fisheries (which demand flooding of the floodplain during specific periods for fish production), the transport sector, domestic water users, and the sectors of salt and shrimp production.

Within countries, regional differences in climate, topography or other may result in a variety of users’ interests and technologies used in drainage, which again are interrelated with institutional arrangements and their performance. As mentioned before, the different actors have varying objectives in drainage, and drainage is practised in varying environmental, social and political contexts. Moreover, actors have varying resources at their disposal and varying strategies to achieve their objectives. People are knowledgeable and capable actors, whose rationality can not be reduced to a single characteristic, such as ‘people are profit maximisers’ (Mollinga, 1998).

**Institutional development in agricultural land drainage**

*Flood control: Institutional development in Bangladesh*

Severe floods in 1954, 1955, and later in 1987 and 1988, have induced the construction of large infrastructural works to check flood hazards in Bangladesh. To develop water resources in the country and to implement flood control, irrigation, drainage and power projects, the East Pakistan Water and Power Development Authority (EPWAPDA) was established in 1959. In 1972, this authority was split up and the Bangladesh Water Development Authority (BWDB) was constituted. With the constitution of EPWAPDA and later on the BWDB, substantial investments have been forwarded to flood control and drainage projects. These investments have largely been financed through loans and grants of multilateral and bilateral donors.

Today, the BWDB is responsible for construction, operation and maintenance of the physical infrastructure of large-scale irrigation systems up to tertiary level. The BWDB supplies water to the tertiary units, after which farmers can pump water from the tertiary canals. Farmers are supposed to contribute to the costs of operation and maintenance by paying water charges.

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Construction of larger structures in FCD systems, such as embankments, sluice gates and others, is executed by the BWDB. Operation and maintenance of FCD systems is, however, largely a users’ affair. The BWDB only plays a substantive role in frequent rehabilitation of larger structures such as the embankments of hoar systems, after these have been flooded. Otherwise, farmers and other users take up the construction, operation and maintenance of the system’s infrastructure.

Water management in Bangladesh, including drainage management, is a complex affair. Especially in the FCD systems, the different stakeholders often have mutually exclusive water management demands. Use of water management infrastructure is generally not coordinated by the BWDB or other (user) organisations, and users do not participate in the construction and management of infrastructural works. There is no tangible accountability from the BWDB to the users of water management infrastructure.

During the early 1990s, multi- and bilateral donors came in to support Bangladesh’s water sector development through projects like the Flood Action Plan (FAP) and the Systems Rehabilitation Project (SRP). Initially, these projects were construction oriented, but gradually shifted their focus towards water management when the different water management demands of the users came to the fore. The performance of FCD systems often remained below expectations. Moreover, they have negative impacts such as loss of fisheries, navigation and soil fertility. This low performance has been attributed to inadequate management. Furthermore, although the BWDB’s budget for operation and maintenance (O&M) has increased in the last years, it is still largely insufficient to cover the involved expenses.

With the recognition of the complexity of managing water control infrastructure, the wish to change the BWDB’s focus became an important element of the project interventions. Rather than to remain an engineering organisation, the BWDB was to become a water management organisation. Furthermore, because of the problems of inefficient management and insufficient funds for O&M, also users’ participation in management of water control infrastructure was to be enhanced, and cost recovery systems in irrigation and FCD systems to be developed.

Although not having the legal status of an Act, the Guidelines for People’s Participation in Water Development Projects (GPP) have been formulated in order to facilitate users’ participation in water resources management, and as such have been the dominant text guiding today’s water sector policies in Bangladesh. The GPP have resulted from initiatives undertaken in the SRP, the Ganges-Kobadak Project and the FAP. The GPP, however, are based on general experiences with irrigation management (transfer) and do not apply to the context of FCD systems. As far as developing cost recovery systems in FCD systems, the question should be raised how this is to be achieved since water is not supplied as in irrigation systems.

The BWDB constructs infrastructural works, but is hardly able to maintain them. Management of the systems centres on local groups of stakeholders, and there is little or no accountability between government and users of water and control infrastructure. All in all, water use in the FCD systems of Bangladesh remains people managed and conflict prone.

Duyne (1998) highlights an opportunity that may deserve further attention: Build on existing local (government) institutions to facilitate coordination between water uses in order to achieve more users participation in water management and integration of water management demands.
Land drainage in irrigated agriculture in (semi) arid zones

Egypt

With the completion of the Aswan High Dam in 1968, the seasonal floods of the River Nile in Egypt were finally eliminated. The dam allowed for more agricultural lands to be brought under irrigation, and cropping intensities could rise. With an increase of irrigation intensities, waterlogging and salinity occurred and introducing and enhancing drainage was recognised as the way to fight these problems and achieve sustainable agriculture. In 1973, the Egyptian Public Authority for Drainage Projects (EPADP) is established to install tile drainage in some 1.1 million hectares of agricultural land. The World Bank financed these projects.

Due to an ongoing increase of the irrigated area in Egypt, increasing water shortages have become apparent over the years. The increase in irrigated area is given in by political imperative: The greening of the Sinai, using water saved by more efficient use of irrigation water in Upper and Middle Egypt. The savings mentioned, however, appear to be only ‘paper’ savings, because water not used in Upper and Middle Egypt remains in the Nile basin and is already used elsewhere.

Of the 3.15 million hectares of irrigated land in Egypt, 2.7 million hectares were equipped with a network of open drains by the year 1995, and some 1.7 million hectares were equipped with horizontal subsurface drains.

EPADP is an autonomous organisation within the Ministry of Water Resources and Irrigation (MWRI), and it is vested with all power over financial, administrative and technical aspects of drainage systems: Design, implementation, O&M, and development of public drainage systems at the national level. Farmers generally do not participate in any of these activities. Accountability within EPADP is thus directed upwards and not to the farmers. Farmers are informed of the construction of drainage projects and receive some explanation on the benefits of drainage and the procedure of implementation. After construction, farmers may be demonstrated how to perform simple maintenance. More important is that farmers are then explained how to communicate with EPADP’s maintenance centres. Farmers need to contact EPADP to inform officers of specific maintenance requirements. But EPADP, being an engineering organisation, has few staff available to perform maintenance of tile drains, and farmers do not always recognise the need for maintenance. As a result, efficiency and effectivity of tile drainage maintenance is low.

Through a 20-year interest-free loan, farmers are supposed to contribute to the investment costs for installing tile drainage in their fields. By doing so, they contribute to less than 50% of the actual investments in tile drainage. Otherwise, all construction, operation and maintenance of drainage works, except open field drains, are financed by EPADP. Land taxes are the only revenue for funding government drainage services like maintenance, and the current recovery of O&M expenses is thus low.

To address the three problems of a low rate of cost recovery for O&M, the low efficiency and effectivity of tile drainage maintenance, and the increasing pressure on the surface water resources, more users’ participation in O&M and more integration of water delivery, distribution, drainage and groundwater management at the local level are called for. Current experiences with farmer participation in O&M of drainage has shown that forming groups of farmers to take up O&M is troublesome. This is largely explained by the fact that water users groups as being established in irrigation, are used as a kind of ‘model’ for drainage groups. On the basis of several experiments, Verstappen et al (1997) suggest to organise irrigation user groups first and then integrate tasks and responsibilities for O&M of drainage into these groups.

The focus on formation of water user or collector user groups again entails two more fundamental questions: (1) How are farmers supposed to perform highly specialised maintenance of tile drains, i.e. are farmers actually the proper group to take up tile drainage maintenance, or should accountability be redirected in another way? For example, by farmers paying EPADP for maintenance services. And, (2) can water management be performed and integrated without a redirection of the (engineering) focus of EPADP, i.e. should EPADP or even the MWRI be reorganised, and if so, how?

India: The Case of Rajasthan
In the (semi) arid State of Rajasthan in India, land drainage is conducted within the command areas of two large canal irrigation projects: the IGNP and the Chambal Command Area. Within the State of Rajasthan, considerable variation exists in agro-ecological settings.

The 'Indira Gandhi Nahar Pariyojna' (IGNP) is located in the Thar Desert in the western part of the state. It is a very dry (average annual rainfall some 200 to 300 millimetres) and sandy area with no natural drainage and very limited outfall opportunities. The area is underlain by an impermeable layer at relatively shallow depth, turning the command area in a kind of 'sandy bowl'. The project consists of two stages that involve an irrigation potential of 550,000 and 760,000 hectares, respectively. The first stage is about completed.

The 'Chambal Command Area' project is located in the southeast of the state. Here, the average annual rainfall is around 740 millimetres, the soils have a much higher clay content than in the IGNP, and there is natural drainage ('nallas'). The project covers an area of around 385,000 hectares, of which 229,000 hectares are located within the State of Rajasthan and 156,000 hectares in the State of Madhya Pradesh.

Since the start of irrigation in both systems in the early 1960s, problems of waterlogging and soil salinity have developed within their respective command areas. In the IGNP some 150,000 hectares are affected by waterlogging or salinity. In the Chambal Command Area, some 161,000 hectares are affected by waterlogging and 25,000 hectares are affected by soil salinity.

Within the IGNP no structural drainage development is undertaken as yet. Problems of waterlogging and soil salinity in the IGNP prove to be an extremely hard nut to crack when it comes to achieving effective disposal of excess water and salts. The system's users and managers face a lack of financial means and drainage outfall, and continue to struggle with local measures that may resort some local or temporary relief. In the mean time, the sandy 'bowl' that forms the IGNP is 'filled' with water that is supplied in excess.

Contrary to the IGNP, in the Chambal Command Area, an extensive drainage system has been constructed. The construction of the existing main open drains (that serve an area of around 167,000 hectares) and the construction of the carrier and field open drains (serving an area of some 72,000 hectares) has been a government initiative supported by foreign donor organisations and the World Bank. The existing subsurface drains, serving an area of some 15,000 hectares, were installed at government initiative and with foreign (Canadian) technical and financial assistance. The drainage facilities are generally poorly operated and maintained, however, as is also illustrated by the large area of land still being waterlogged and/or saline.

Generally in India, there is no specific organisational set up developed for the sole purpose of looking after and tackling the two problems of waterlogging and soil salinity/alkalinity. Agriculture and Irrigation Departments at the level of State Government have been undertaking some works on drainage, however adequate institutional arrangements are lacking in most states. The same is the case in Rajasthan. Despite the large problems of waterlogging and soil salinity in canal irrigation systems in Rajasthan, efforts to
control the problems (by further developing and adequately managing the existing drainage) seem to have
been undertaken only at a modest scale or seem to be rather ineffective. Drainage development appears to
have been too 'low on the agenda', and that has resulted in the absence of an institutional framework that
is targeted towards drainage development, and organisations that have clearly defined responsibilities and
tasks. In Rajasthan, both government and farmers have restricted financial means to invest and to operate
and maintain a drainage system. Clear relations of accountability and a system of cost recovery for
operation and maintenance of drainage works are absent.

Pakistan

Figures presented by the Food and Agriculture Organisation of the United Nations (1997), indicate that
Pakistan has a cultivated area of around 16.56 million hectares, of which some 15.73 million hectares are
irrigated. Almost 1.5 million hectares are irrigated through spate irrigation, while most of the irrigated
area is supplied with water through surface canal systems. Pakistan has the distinction of having the
largest contiguous gravity flow irrigation system in the world; the Indus Basin Irrigation Systems or IBIS.
The IBIS covers a gross area of 16.8 million hectares, of which some 14.2 million hectares are culturable.
By 1993, the artificially drained area in Pakistan covered some 6 million hectares. As from 1993, another
2.2 million hectares have been considered for or supplied with drainage facilities through ongoing
projects (Tarar, 1995).

The large-scale canal irrigation in Pakistan has induced problems of waterlogging and salinity. Asrar-ul-
Haq et al (1999) report that approximately 6% of the gross canal command in Pakistan is severely
affected by salinity, about 8% is moderately affected, while around 30% of the gross canal command
suffers from waterlogging and that some 14% of the gross canal command area can be considered as
highly waterlogged. The lack of provision for drainage in development of these systems has been
identified as the most important reason. Furthermore, both surface and subsurface natural drainage has
been restricted due to the construction of infrastructural facilities (such as roads, railways, flood
embankments and irrigation systems) and due to the flat topography of the Indus Plains (especially in
Punjab and Sindh). Other problems in irrigated agriculture, related to waterlogging and salinity and the
management of drainage, are the inequitable and inefficient distribution and use of water, and the low
agricultural production per unit of land18.

In order to control salinity, measures taken by the Government of Pakistan have largely focussed on
controlling groundwater table levels with the idea to contain the salinisation process. These measures
included the prevention of seepage through canal lining (from 1895 onwards), tree plantations, surface
and interceptor drains (from 1930 onwards), irrigation management (lowering of full supply levels in
canals and temporary canal closures from 1930 onwards), and vertical drainage through tubewells from
1940 onwards. However, none of these measures provided more than local or temporary relief. All in all,
vertical drainage by means of tubewells yielded the best results and considerable investments have been
made towards public and private tubewell development.

To replace water ‘lost’ to India after Independence, large-scale water works were to be constructed in
Pakistan. An engineering organisation called Water and Power Development Authority (WAPDA) was
established. The World Bank became and later on remained the primary lender for the enormous capital
required to undertake the water sector works. WAPDA subsequently emerged as the pre-eminent national
agency for the execution of all water sector projects in Pakistan, including drainage. WAPDA attracted
many of Pakistan’s most promising and ambitious bureaucrats, civil engineers and other professionals.
This resulted in a decline in quality and professionalism of the officer cadre comprising the West Pakistan
Irrigation Department and the Provincial Irrigation Departments (PIDs).

18 The production per unit of water, on the other hand, is relatively high.
To tackle waterlogging and salinity, in the 1960s, WAPDA launched the provision of 51 Salinity Control and Land Reclamation Projects (SCARPs), involving vertical subsurface drainage through the installation of public tubewells in large areas. Although WAPDA was responsible for design, construction, initial operation and monitoring of the deep tubewells, the PIDs were responsible for the continuing O&M of the SCARPs. The public tubewells performed poorly, because of several reasons:

- Poor coordination of canal and tubewell operations resulting in ineffective conjunctive water use;
- The annual expenditures for O&M of the tubewells proved enormous, and finally the O&M of public tubewells became unsupportable.

From the 1960s to the mid-1970s, research was carried out in central Punjab canal commands. The studies revealed that dilapidated and poorly maintained water distribution infrastructure at tertiary level (below watercourse outlet) was responsible for a significant portion of overall system water losses. The water losses contributed to the growing problems of waterlogging and salinity, and were a primary cause for shortages in tail-end water supplies. In 1976 a USAID-assisted pilot On-Farm Water Management Project (OFWMP) was implemented to demonstrate the effect of improved watercourses and farm water management (through agricultural extension). A nation-wide series of OFWMPs were funded by the World Bank, the Asian Development Bank, and bilateral assistance programmes. Farmers were to participate in the physical works and were to remain as the primary contact point for continuing agricultural extension activities. To achieve this, water user associations (WUAs) were formed, and they were provided a legal basis through adoption of legislation in all four provinces. The work of the WUAs marked a significant shift in irrigation policy in Pakistan.

In order to address the problems of waterlogging and salinity, low efficiency in water delivery and use, inequitable water distribution, and insufficient cost recovery (for example, receipts from drainage cess only cover some 20% of actual expenses), the World Bank argued for irrigation water to be commercialised and later to be privatised instead of treating irrigation water as a public good. As a result, in 1997 all four provinces of Pakistan effected a Provincial Irrigation and Drainage Authority (PIDA) Act, replacing the PIDs with PIDAs and enabling farmer participation in system management.

Today, Provincial Irrigation and Drainage Authorities are responsible for planning, design, construction, rehabilitation, maintenance and operation of irrigation and drainage facilities. Participatory Irrigation Management (PIM) is the strategy of the ongoing irrigation and drainage sector reforms, meaning that irrigation and drainage management is to be decentralised and farmers’ participation increased. The intended vehicle is the National Drainage Programme (NDP). Farmers are to take part in this sector’s development and take over O&M, including funding of O&M, through the establishment of Area Water Boards (AWBs) and Farmer Organisations (FOs). PIDAs, AWBs, and FOs are to become financially autonomous with respect to irrigation and drainage, and can achieve this through levying water charges and drainage cess.

However, apart from a few pilot projects, no FOs or AWBs have actually been set up, let alone are functioning as envisioned by the World Bank and the Government of Pakistan. Van der Velde and Tirmizi (1999) list a number of reasons that centre around a lack of farmers’ involvement in the policy reforms and the fact that farmers have learned to ‘deal with the situation’, the shift of focus of the
multilateral donors from engineering to institutional solutions which has a bearing on the being and functioning of the irrigation establishment and on those disproportionally benefiting from the previous arrangement, and the acceptance of a weak legal framework for implementation of irrigation reforms.

Land drainage in rainfed agriculture in temperate zones

Already for centuries have farmers in Japan collectively taken up drainage and irrigation development through the ‘mura’ (traditional farmer organisations). This kind of farmers initiative appears to be partly provoked by force of the respective rulers. Be that as it may, the mura have provided the basis for today’s Land Improvement Districts (LIDs): Farmers’ bodies that largely manage irrigation and drainage facilities.

Japan has a cultivated area of around 4,776,000 hectares. Of this agricultural acreage, 3,128,079 hectares are irrigated, either with surface irrigation techniques (90%), sprinkler irrigation (8%) or micro irrigation (2%) (FAO, 1999). Paddy is the staple food of the Japanese people, and it is this crop that covers the largest part of the agricultural area (Okamoto, 1997). Drainage is generally performed to dispose of excess water from rice production, and to reclaim land and maintain reclaimed land.

In Japan, several ministries are involved in drainage development: the Ministry of Construction (management of large scale basin wide flood control, and the management of sewerage projects), the Agency for Home affairs (small rivers and ditches not managed by central or prefectural governments), and the Ministry of Agriculture, Forestry and Fisheries (construction and/or rehabilitation of main irrigation and drainage canals and structures).

LIDs apply for construction works to national, prefectural or municipal governments, after which engineers of these governments prepare a project plan and then notify the respective farmers. Around 50 to 80% of the construction costs used to be born by national and prefectural governments, while the farmers paid for the balance. After construction, the responsibility for financing and executing O&M of basic irrigation and drainage facilities is transferred to the respective LIDs. O&M of drainage is one of the main activities of the LIDs, which can employ their own staff, collect members’ fees, and elect office bearers (who are punishable as though they are civil servants). Accountability is thus directed towards the users of irrigation and drainage systems.

Today, the costs involved in operation and maintenance of irrigation facilities are still largely born by the beneficiary farmers as a ‘water charge’. However, drainage facilities have been recognised to serve not only private interests, but also public safety and welfare. Consequently, today the central and/or prefectural governments bear all costs involved in construction, operation and maintenance of drainage facilities. These expenses are covered from general state revenue. Unfortunately, no information has come to the fore on today’s role of LIDs in identifying future construction works, and how the full financing of drainage by the government has influenced the performance of drainage in Japan.

What can be observed in Japan is a trend of scale enlargement with respect to the LIDs. This trend seems incited by the need to address the increasing gap between LIDs’ income and expenditure, and make operation and maintenance activities of LIDs more cost effective.

Land reclamation: Institutional development in India (Kerala)

Kuttanad, in the State of Kerala, is the name of a coastal area covering around 110,000 hectares. In Kuttanad, more than 30,000 hectares are located at an elevation of 1.0 metre above mean sea level or higher, while some 50,000 hectares are located between 0.6 and 2.2 metres below mean sea level. Four rivers discharge water into this area of dry lands, wet lands and open water. A particular area of Kuttanad is known as the Kayal lands. Kayal covers a land area of some 9,464 hectares, which are entirely reclaimed from Vembanad Lake. The Kayal lands are situated at some 2 metres below mean sea level.

In order to prevent ingress of saline water from the adjoining sea, Vembanad Lake is ‘separated’ from the sea through the Thanneermukkum barrier, constructed in 1975. The Kayal agricultural fields, used to
cultivate paddy, are protected from the lake by permanent embankments. Despite these embankments, the fields are flooded annually during the southwest monsoon. The fields are grouped in polders (‘padasekharams’) that vary in size from 2 to 1,000 hectares.

Without drainage, cultivation of crops would be a hazardous or even impossible affair in the Kayal lands. As such the impact of drainage on agriculture is obvious and tangible. However, the local land reclamation and drainage activities also produce non-benefits in the form of water pollution and a change of the natural water regimes. These non-benefits especially affect fishers who inhabit and fish the areas surrounding the polders.

Through committees (FCs) farmers organise collective and simultaneous dewatering and subsequent drainage in each polder. In the Kayal areas, there are some 123 FCs, which each cover an average area of around 83 hectares. Coordination between FCs, and thus between the different polders in the Kayal lands, is taken up by the Punja Special Officer (PSO) of the Revenue Department. After having consulted the farmers, the PSO decides upon a specific time when private contractors should install pumps and execute pumping at the start of the growing season and during its subsequent days. Contractors are paid through the PSO. Farmers contribute around 15% of the costs involved in operation and maintenance of polder drainage. The remaining 85% can be considered a government subsidy. FCs supervise pumping and drainage and if contractors do not perform their duties adequately, the FCs can inform the PSO who can take action accordingly.

Accountability of the contractor is thus directed more towards the PSO and less to the farmers. It remains unclear whether this has particular effects on the functioning of the contractors. The accountability of the PSO towards the farmers seems limited from an institutional point of view, but also this does not seem to affect the effectiveness and efficiency of the polder drainage. The non-participation in drainage management of drainage affected people like fishers remains a matter of concern.

General discussion

Apparently, development of agricultural drainage as a core topic of attention does not necessarily result in appropriate interventions and thus sustainable agriculture or reduced flood hazards. Drainage performance in countries like Bangladesh, India and Pakistan remains rather poor and (too) expensive to support, and much of this can be attributed to inappropriate institutional arrangements. There is little or no accountability between service providers (generally government agencies) and recipients of that service (generally farmers) and other people affected by drainage (for example fisheries in Bangladesh and India). Although the (technical) performance of drainage in Egypt appears to be better, a creeping crisis of water scarcity and insufficient levels of cost recovery for O&M in drainage can be observed, which call for interventions.

The previous observations and conclusions are not new and were made similarly with respect to performance of large-scale canal irrigation systems. Poor performance of irrigation or financially unsupportable irrigation systems have resulted in irrigation sector reforms in countries like Mexico and
India. These reforms basically consist of: (1) Pricing the use of resource units like water, (2) create financially autonomous agencies, and (3) turnover of system management to users or user groups (decentralisation). The reforms are largely based on economic mechanisms that are expected to bring about: (1) More efficient water use as a result of pricing the water resource, (2) enhanced relationships of accountability between the service providers and recipients as a result of the service providers being financially dependent on the charges levied from the recipients, and (3) better targeted (more effective) system management as a result of users participation.

Currently, these type of irrigation sector reforms are similarly advocated and implemented in the drainage sector. There it becomes most evident in the call for the creation of user groups (see Bangladesh, Egypt, India, Pakistan), and in the model opted for user groups and their tasks and responsibilities. But, can the model of irrigation sector reform be employed in the drainage sector?

Through pricing of irrigation water to its users, irrigation system’s operation and maintenance are to be financed. But, how to charge for drainage, which cannot be related to individual users as ‘easy’ as irrigation water? Obviously, this question also relates to the issue of financial autonomy. How to achieve financially autonomous service providers when pricing of the service is not adequately addressed? Lastly, the formation or functioning of user groups in drainage management is more difficult than in irrigation, because:

- Tile drainage (mainly Egypt) is less ‘visible’ than are canals and ditches, and since these drains generally require little or no operation, they tend to be neglected. This lack of frequent attention can result in serious maintenance problems;
- Drainage in irrigation, flood control and drainage systems (Bangladesh) involves a great variety of users with often conflicting interests. Not only farmers, but also other users or project affected people need to take part in management;
- Drainage technology differs substantially from irrigation technology, and it thus puts different demands on the mode of organisation. Tile drainage for example requires specialised equipment to be flushed frequently;
- The boundaries of drainage management units often do not coincide with those of irrigation management units.

Apart from the limited applicability of irrigation ‘management-models’ for drainage management, two more issues have come to the fore that deserve attention in a debate on drainage performance and institutional arrangements in drainage: Integrated water resources management, and the technological dimensions of drainage (interdisciplinarity).

A question whether separate organisations for drainage and other water sectors should be established, does not fundamentally address the problems of many of today’s water sectors in developing countries (increasing number of water users, changing pattern of water use, and increasing water scarcity). What seems to be required is an integrated approach to management of water resources, including drainage. This calls for a serious consideration of institutional reforms in entire sectors of water resources development and management. In the case of Egypt, Merrey (1998) argues for the integration of water delivery, distribution, drainage and groundwater management at the local level, and for a reorganisation of the Ministry Water Resources and Irrigation. The reorganisation would entail the separation of policy-making, planning and regulatory functions from the construction and operational functions. A discussion

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19 This model of policy reform is widely criticised. See for example Moore (1990), Oorthuizen (1995), and Mollinga (1998).

20 Just as fundamental is the question whether the transfer of models from one setting (country) to another can at all be justified, considering the great variety of contexts in the countries included in this research.

21 It must be remarked that measuring resource use and paying per resource-unit also has practical limitations. In groundwater irrigation for example, each pump requires a water or electricity meter and those meters require frequent and accurate reading, recording, billing, and collection of revenue. Furthermore, meters are subject to sabotage. More fundamentally however, pro-rata pricing may induce equity problems, since not all resource users can afford to bear the full costs of the resource.
on integrated water management should involve a broader concept of water use and stakeholders’ interests, in order to effectively identify service recipients (and their water management demands) and to design accountability relations. In short: Who as an interest in drainage, what is that interest, who does what, and who is to pay?

Policy makers and researchers should mind not to overlook the technological dimensions of drainage by focussing on institutions. Clear in the cases of Pakistan and Rajasthan, is that reforming drainage management may in itself not enhance its performance, since a lack of drainage outfall remains a problem. Principally, technological dimensions of drainage should not be treated as a ‘black box’. As Wilson et al (1998, in: Burke et al, 1999, pp. 309) state:

“Widespread public participation is no panacea. Hydrologic complexity and poor public understanding of (ground)water systems has, in some cases, led to widespread public support for – and the implementation of – management approaches that are technically unworkable”.

This desk-study reveals that drainage can best be understood as a sociotechnical phenomenon. This implies that drainage not only requires integrated but also interdisciplinary approaches for investigation and for design of interventions.
Drainage Development in Bangladesh

Introduction

Bangladesh constitutes the eastern two-thirds of the Ganges-Brahmaputra deltaic plain, which stretches northward from the Bay of Bengal. The most significant feature of the Bangladesh landscape is provided by the rivers, which have moulded its physiography and the people’s way of life (Encyclopaedia Britannica, 2000). Three major river systems, the Ganges, the Brahmaputra and the Meghna, have historically developed this active delta with agriculture as its mainstay. The rivers in Bangladesh drain a catchment of approximately 1.72 million square kilometres, out of which an area of only some 7% is located in Bangladesh. The other 93% of the catchment area is located in China, India, Nepal, Bhutan and Myanmar. The rivers carry enormous quantities of water and sediment from outside the country, resulting in floods and drainage congestion, which are the dominant hazards to the people and the economy. Heavy rainfall within Bangladesh, and the influence of high tide in the Bay of Bengal further aggravates the situation by retarding drainage efficiency, and increasing flood intensity and duration. During the last decades, the Government of Bangladesh (GOB) has therefore constructed flood control, drainage and irrigation infrastructure throughout the country (Shamsul Hoque, 1997). Due to these interventions, more than 37% of the net cultivable area is protected by Flood Control and Drainage (FCD) systems. The crucial importance of FCD systems for the livelihoods of many millions of people makes it necessary to understand water management practices in FCD systems and to develop appropriate institutions and management strategies for them (Wester and Bron, 1998).

Many studies of the water sector in Bangladesh conclude that the intended benefits from FCD systems have not materialised. This is attributed in part to institutional weaknesses and to a lack of understanding of the functions and local utilisation of FCD systems. One of the key approaches for tackling these institutional weaknesses is increasing people’s participation in water resources management. Although a serious attempt has been made to include people’s participation in water management through the formulation of the Guidelines for People’s Participation in Water Development Projects (GPP), the participatory procedures do not adequately address the water management issues prevailing in FCD systems (Wester and Bron, 1998).

The need for drainage and flood control

Bangladesh has a typical monsoon climate characterised by rain-bearing winds, moderately warm temperatures, and high humidity. It receives heavy rainfall, of which most occurs during the monsoon period, from June to September or early October. Except for some parts in the west, rainfall generally exceeds 1,500 millimetres annually. Large areas of the south, south-east, north, and north-east receive from 2,000 to 2,500 millimetres, and the north and north-western parts of the Sylhet area receive from 3,800 to 5,000 millimetres (Encyclopaedia Britannica, 2000).

Except for small higher areas of jungle-covered old alluvium (rising to about 30 metres) in the north-west and north, the plain is a flat surface of recent alluvium with a gentle slope and generally with an elevation of less than 10 metres above sea level (Encyclopaedia Britannica, 2000).

22 Nearly 80 million people live and farm on the floodplains of Bangladesh (Wester and Bron, 1998).
In Bangladesh, the most problematic lands with respect to agricultural utilisation are its wetlands, which cover some 6,300,000 hectares (nearly 50% of Bangladesh) and encompass the floodplains of the Ganges, Meghna and Brahmaputra rivers (Wester et al., 1997). Although an area of some 100,000 hectares in Bangladesh is affected by salinity (FAO, 1999), drainage and flood control are largely about control over excessive river and tidal flows as consequences of heavy rainfall and cyclones.

In Bangladesh, flood control and drainage (FCD) systems are by far the most common type of water management system, representing more than 80% of the Bangladesh Water Development Board’s (BWDB) water management infrastructure (GOB, 1997). The term ‘FCD’ often also refers to irrigation practices within the system (Wester et al., 1997) and can thus also be written as ‘FCDI’. Monsoon floods in the wet season and water scarcity during the dry season are major challenges for water resources management in Bangladesh. In coastal areas, salinity and cyclones are additional factors influencing farming systems. To provide a measure of protection against the floods, FCD systems were constructed (Wester et al., 1997).

**Current status of irrigation, drainage and flood control development**

The cultivated area in Bangladesh covers around 7.74 million hectares. Some 3.75 million hectares are irrigated, while around 1.5 million hectares of agricultural land are drained. An area of approximately 4.2 million hectares of land in Bangladesh is flood protected (FAO, 1999). Khan (1993, in: Wester et al., 1997, pp. 2) notes that ‘only’ some 440,000 hectares are irrigated under commands of large-scale canal irrigation systems. The other irrigation is practised as a part of the water management practices within FCD systems, and should thus be considered in an entirely different context.

**Drainage and flood control development**

Water sector development was very limited during British colonial rule. Large-scale water development in Bangladesh began after Independence in the 1950s, after several studies had been undertaken and following severe floods in 1954 and 1955. By 1957, a report, known as the ‘Krug Mission Report’, recommended that water resources development was essential for higher agricultural production in East Pakistan and that drainage improvement and flood control were to be the core issues. Following the report, the East Pakistan Water and Power Development Authority (EPWAPDA) was created in 1959. Its aim was to integrately develop water resources in the country and to implement flood control, irrigation, drainage and power projects. The authority was split up in 1972, leading to the constitution of the Bangladesh Water Development Board (BWDB) and the Bangladesh Power Development Board.

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23 As from the day Pakistan became independent from India, Bangladesh was known as East Pakistan and today’s Pakistan as West Pakistan. This situation changed in 1972. East and West Pakistan separated and East Pakistan became what is known today as Bangladesh.
Since then, the BWDB has been responsible for the overall development and management of flood control, drainage and irrigation projects in Bangladesh. With the constitution of the EPWAPDA and later the BWDB, substantial investments have been forwarded to flood control and drainage projects, whereby especially after the disastrous floods of 1987 and 1988 the flood hazard has become the major concern (Shamsul Hoque, 1997). Following these severe floods, a number of studies were undertaken, supported by funds from UNDP and the Chinese, French, Japanese and US governments. This led to donor meetings in mid 1989 in Paris and Washington and a request from the GOB to the World Bank to coordinate international efforts. A proposal to prepare the Flood Action Plan (FAP), involving a set of 26 studies and pilot projects, was endorsed at a meeting convened by the World Bank in London in December 1989. The GOB set up the Flood Plan Coordination Organisation (FPCO) in 1990 to supervise and coordinate FAP activities (GOB, 1995). See box 3.1 for a more detailed description of the FAP.

Box 3.1: The Flood Action Plan (FAP)

The FAP started with 26 components, comprising 11 main components and 15 supporting studies and pilot projects. The main components were made up of regional and urban planning studies, feasibility studies for projects, and special programmes on flood forecasting, early warning and flood preparedness. The supporting studies were intended to provide the planning principles, criteria and data input for the planning studies. In addition, the FPCO prepared guidelines on project assessment, participatory planning and environmental impact assessment (GOB, 1995).

During its execution between 1990 and 1995, the FAP shifted from its original focus on physical flood control interventions to a more comprehensive water management focus. Among its achievements have been the formulation of standard guidelines for project assessment, participatory planning and environmental impact assessment (GOB, 1995). Although the FAP ended after 1995, a number of its components continued with the support of separate donors. For example, FAP-20 was continued with support of the Government of the Netherlands and became known as the Compartmentalisation Pilot Project (CPP).

Implementation of FAP has faced a number of difficulties and received due criticism. The most important difficulties were the differences in approach among the regional studies, weaknesses in inter-agency coordination and involvement of local government, insufficient attention to the integration of structural and non-structural measures for water management, and limited progress in addressing institutional issues (GOB, 1995). Already during the first phase of the FAP, an IOV24 publication (1993) summarised substantial critique:

- The FAP projects will lead to increasing inequity among the population and to marginalisation of small farmers, fishermen and landless people;
- It remains unsure whether FAP will contribute to improved agricultural production;
- FAP will have negative consequences for fisheries, which are the main source of

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24 'Inspectie Ontwikkelingssamenwerking te Velde', Ministry of Foreign Affairs, Government of the Netherlands
protein for poor people in Bangladesh;

• The flood control and drainage works envisaged in the FAP, require a higher standard of planning, design, construction and maintenance than is common in Bangladesh. Moreover, the costs for maintenance of these works are equally high and cannot be born by the Government of Bangladesh alone;

• The BWDB and the FPCO are not equipped to adopt an integrated approach to water management;

• Despite the fact that the FAP will have far reaching consequences for the people of Bangladesh, the population is largely unaware of the plans.

The performance of FCD systems has often remained below expectations. Furthermore, FCD systems have several negative impacts such as loss of fisheries, navigation and soil fertility, and exacerbation of drainage problems. International development agencies and the Government of Bangladesh have expressed increasing dissatisfaction with the performance and with the agencies responsible for their management. This situation has led to the privatisation of minor (pumped) irrigation systems. Viable solutions to improve the performance of large FCD systems (more than 1,000 hectares) are still to be developed, however (Wester et al., 1997).

Flood Control and Drainage Systems

To adequately assess institutional performance in Bangladesh’s water management sector, it is essential to understand the entity ‘FCD system’ and its fundamental differences with canal irrigation systems.

Wester and Bron (1998) understand FCD systems to be all areas in the floodplains of the rivers in Bangladesh and in the coastal plains that are utilised by people, and that contain some or all of the following infrastructure: Khals, beels, cross dams, canals, embankments and regulators. Beels are field depressions that contain water during most or all of the year. These are often connected to rivers through a network of natural channels (khals). Although irrigation is often practised in FCD systems, they do not qualify as irrigation systems, as the infrastructure in FCD systems does not provide the same level of control over the flow of water from source to field as in irrigation systems. They further classify FCD systems according to their particular management intensity levels and characteristics such as the type of infrastructure, the main water management challenges and the typical conflicts:

1. Hoar systems (floodplains);
2. Coastal plain polder systems (coastal plain);

3. Deltaic plain polder systems (deltaic plain);

4. Beel systems (Pleistocene terraces/floodplains);

5. Floodplain systems (floodplains).

Development of flood control and drainage systems

Apart from the variety of FCD system characteristics (see 3.2.1), FCD systems can be in a different stage of development. These different stages further diversify local water management issues. Wester et al. (1997) describe the development of FCD systems according to four phases:

1. There is no government intervention, people control water through small embankments, cross dams and drainage canals. The cropping pattern and practices of cultivation are adapted to the fairly predictable seasonal river floods. The crop yields are generally low, also due to the use of plant varieties that are adapted to the prevailing hydrological conditions;

2. In order to increase crop security on the floodplains, the government intervenes by trying to control river floods and tidal flooding by the sea. Peripheral and some smaller embankments are constructed to isolate the agricultural lands from the source of flooding. The same embankments, however, prove to be obstacles to the drainage of accumulated rainwater from within the protected area. And thus, drainage openings in the embankments are constructed (generally flap gates on the side of the river). Still, a problem remains especially during the post-monsoon season because water from within the protected area cannot drain as fast as river water levels fall, and because water can get trapped in pockets behind the embankments. People sometimes intervene by cutting embankments;

3. The smaller drainage channels are also equipped with regulators, and surface drainage outlets are constructed to evacuate accumulated water from pockets behind the embankments. Furthermore, the conveyance capacity of drainage channels is improved;

4. With the improved (technical) water control, farmers may now invest in High Yielding (crop) Varieties, and an additional crop per year becomes possible. Cropping patterns shift slightly on the calendar, and as a result crops are grown beyond original cropping periods, into the dry period. The consequence is a higher demand for water within the system during the dry season. Means are devised to retain water within the system at the end of the rainy season: Water users attempt to block flap gates in drainage outlets when water has reached the desired level (sometimes causing damage to the structure, and when a storm occurs water cannot readily be drained off causing damage to standing crops), regulators are modified by adding vertical lift gates on the country side of the structures, and in sloping terrain control structures (weirs) are constructed to retain water in different parts of the system. With improved possibilities to retain water in the system, traditional water lifting devices and low-lift pumps come into use for irrigation.

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25 See Wester et al (1997) and Wester and Bron (1998) for a detailed description of the features of these systems. The author does not consider it relevant to present and discuss these systems any further in this report. The point is that individual FCD systems can fundamentally differ from other FCD systems or from ‘conventional’ irrigation systems, and that they similarly put different demands on the institutional arrangements.
The numerous water management options in FCD systems make water management in FCD systems quite complex. In comparison, water management in surface irrigation systems is relatively ‘easy’ (Wester et al, 1997). Table 3.1 presents the differences between FCD systems and (large-scale) surface irrigation systems.

<table>
<thead>
<tr>
<th>Table 3.1: Differences between FCD Systems and Irrigation systems</th>
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<tbody>
<tr>
<td><strong>Infrastructure</strong></td>
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<tr>
<td>The infrastructure has to cater for many demands. Moreover, the demands placed on the infrastructure gradually change, increase and diversify.</td>
</tr>
<tr>
<td><strong>Design</strong></td>
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<tr>
<td><strong>Users</strong></td>
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<tr>
<td><strong>Operation</strong></td>
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<td><strong>Main Management Challenge</strong></td>
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</tbody>
</table>

(source: Wester and Bron, 1998)

In order to address the inherently more complex and different nature of water management in FCD systems as compared to surface irrigation systems, Wester et al (1997) suggest to distinguish between FCD systems (flood control, drainage, and irrigation) and surface irrigation systems.
Management of FCD systems: Conflicting interests

FCD systems do not only affect agricultural practices. Also other water uses may be affected by FCD systems or have particular demands with respect to water management, and consequently have their own specific objectives in managing (controlling) water.

Wester et al (1997) distinguish the following objectives of FCD systems from an agricultural point of view:

- Protect standing (late dry season/early monsoon) paddy against early river floods;
- Reduce salt intrusion (in the coastal belt);
- Expand the area under (monsoon) paddy by excluding monsoon water floods from the system;
- Retain water in the system during the post-monsoon period.

Wester et al (1997) distinguish the following conflicting interests within the agricultural sector with respect to water management demands:

- Low land farmers demand early drainage at the end of the monsoon;
- High land farmers demand the retention of water in the low lying areas of the system;
- Low land farmers demand the retention of rainwater and overland flow on the high lands during the pre-monsoon, as the release of this water floods their land early;
- High land farmers demand drainage of excess rainwater and overland flow from their lands.

Lastly, Wester et al (1997) distinguish the following objectives of FCD systems from non-agricultural stakeholders’ points of view:

- Fisheries: fish production demands flooding of the floodplain during specific periods;
- Transport: water transport is an important means of communication;
- Domestic: surface water is important for domestic purposes;
- Salt production: demands the entry of salt water into the system;
- Shrimp production: demands the entry of salt water into the system;
- Livestock: surface water is important for watering and washing of livestock.

Many of the before-mentioned objectives are conflicting or even mutually exclusive, complicating water management in FCD systems. Fishermen require high water levels from the start of the monsoon, while farmers require low water levels to harvest their early-monsoon-paddy, and to grow monsoon-paddy (Wester et al, 1997). However, maybe even more crucial is that fisheries are dependent on frequent flooding of plains for fish reproduction. Youssouf Ali (2000) presents several examples of cases whereby the construction of embankments and drainage canals have negatively influenced open water fish production and fish habitats. The problem of construction of FCD infrastructure on fisheries, centres
around the infrastructure’s influence on the rhythm and amplitude of monsoon flooding. Monsoon-inundated floodplains play a crucial role in the continuation and expansion of open water fish production. As inundation commences, fish and prawn resident in stagnant waters breed in the dissolved oxygen-rich water of the floodplains. Hatchlings and fry of such fishes and larvae and juveniles of prawns remain in the floodplain to feed and grow. Hatchlings and fry of river-breeding fish also move laterally on to inundated floodplains to feed and grow in biomass in the food-rich but less turbulent environment of the floodplains. Thus, inundated floodplains contribute fish biomass to rivers and beels (Youssouf Ali, 2000). Subsistence fishing plays a crucial role in cushioning poverty (ODA-UK, 1990, in: Youssouf Ali, 2000). Fish is a crucial resource for the many Bangali who live in and around the floodplains of Bangladesh, and it is particularly crucial for the rural poor. FCD system embankments, river closures and sluice gates break up the continuity between rivers and floodplains, disrupting thereby the breeding, feeding and early growth of many fish and prawns. Poor people will suffer most from this destruction by FCD projects of floodplain capture fisheries (Youssouf Ali, 2000).

Many more examples of conflicting interest can be presented. What is the most essential characteristic of water management in and around FCD systems and floodplains is that there are many water management stakeholders, each with different and often conflicting water management demands.

**Institutional framework**

When discussing organisations that deal with water management in Bangladesh, it is essential to make distinctions on the basis of water management systems. Within these systems, one can distinguish two main groups of actors: The Government and the system users.

The role of the Government of Bangladesh in drainage and other water sector related matters is largely taken up by the BWDB. The BWDB is again assisted through all kinds of projects that often involve foreign technical and financial assistance.

Generally, the BWDB is responsible for construction, operation and maintenance of the physical infrastructure of (large-scale) irrigation systems up to tertiary level. The BWDB supplies water to the tertiary units, after which farmers can pump water from the tertiary canals. Farmers are supposed to contribute to the costs of operation and maintenance by paying water charges.

Construction of larger structures in FCD systems, such as embankments, sluice gates and other structures, is executed by the BWDB. Operation and maintenance of FCD systems is largely a users’ affair. The BWDB only plays a substantive role in frequent rehabilitation of larger structures such as the
embankments of hoar systems, after these have been flooded. Otherwise, farmers and other users generally take up the construction, operation and maintenance of the system’s infrastructure.

**Government institutions**

The main government agency involved in construction, operation and maintenance of FCD systems is the BWDB. Originally an engineering or construction oriented organisation, it is to become a water management organisation. This change in focus has been one of the main targets of the Systems Rehabilitation Project (SRP). The focus of the SRP was on the development of improved and sustainable operation and maintenance capacities within the BWDB (Soussan and Datta, 1998). See box 3.2 for a more detailed description of the SRP.

**Box 3.2: The Systems Rehabilitation Project (SRP)**

In 1991, the revised Inception Report for the Systems Rehabilitation Project (SRP) was presented. The main objective of this project was “to protect and increase agricultural production and income and to raise the standard of living … through rehabilitation and improved operation and maintenance of Bangladesh Water Development Board’s flood control, drainage and irrigation projects” (SRP, 1991a).

The SRP included the following components:

- Rehabilitation, improvement and maintenance of around 80 sub-projects, covering a gross area of approximately 600,000 hectares;
- Improved operation and maintenance of 3 existing surface irrigation projects covering a net irrigable area of around 60,000 hectares, and 7 small flood control and drainage subprojects covering some 40,000 hectares;
- On-farm development works in 2 subprojects covering 17,000 hectares;
- Training of BWDB staff and beneficiaries in operation and maintenance;
- Benchmark and evaluation studies of 10 selected subprojects;
- Technical assistance for planning, design and monitoring of construction, rehabilitation and improvement works. And technical assistance for planning and implementation of improved operation and maintenance, on-farm development works, training, and benchmark and evaluation studies (SRP, 1991a).

The SRP was financed by the International Development Association (IDA), the European Economic Community (EC), the Government of the Netherlands, and the Government of Bangladesh. The lead consultant was Euroconsult from the Netherlands (SRP, 1991a).

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26 See Duyne (1998) for an extensive account of local water and system management practices.
Institutional arrangements in drainage: Bangladesh

The focus of the SRP was to include users in water management, whereas previously the BWDB used to manage water resources. For example, it was felt that the operation and maintenance of irrigation systems was not sufficiently geared towards agricultural requirements: Canal water levels based on agricultural needs were not met. Within the BWDB there is no clear distinction between operation and maintenance (O & M) tasks, and construction, which results in a confused O & M budgeting, objectives, responsibilities, authority and priority setting (SRP, 1991b).

Some of the reasons for under performance of FCD systems in Bangladesh are considered to be the insufficient consultation of intended beneficiaries, no agreements with users on operation and maintenance, and no responsibilities for the users with respect to operation and maintenance. Unfortunately, so far it remains unclear what tangible results the SRP has yielded with respect to innovative and effective institutional arrangements, although it did contribute to a changed way of thinking about water management.

Soussan and Datta (1998) describe how SRP has been involved in institutional change within the BWDB. The engineering focus of the BWDB is reflected in the fact that the BWDB has never had and still does not have a revenue budget allocation sufficient to meet the cost of maintaining the structures under its control. A first step to re-orientate the BWDB, was to separate rehabilitation from operation and maintenance activities. This process was completed in 1997. The SRP has also been central to the focus of O & M. This focus has been changed from a water control structure-centred focus to a more system oriented focus. O & M has been defined by SRP more precisely, whereby operation was defined as control of the canal water levels (to meet farmers demands), while maintenance referred to measures to upkeep the hydraulic infrastructures so that these do not constrain agriculture, on-farm water management or navigation, and to preserve the infrastructure.

But, how are the results of SRP evaluated? Although the budgetary allocation for O & M has been enhanced from 1990, it still does not meet all O & M needs. Furthermore, the improved procedures for O & M have not been fully institutionalised, and their use has largely been confined to SRP sub-projects (Soussan and Datta, 1998).

**Users participation**

The following has been stated with regard to water management in FCD systems in Bangladesh:
“At present, FCD systems in Bangladesh are not managed in a participatory manner, even though they are more or less ‘people-managed’. Rather, they are managed in a competitive manner. Operation in most FCD systems is controlled by small powerful groups serving their own interests, to the detriment of the majority of its inhabitants. Maintenance is largely controlled by the state. Decisions regarding both operation and maintenance are not taken on the basis of transparent and systematic procedures and there is no formal accountability to the users” (Wester et al, 1997).

The users of FCD systems are not a homogeneous group, but rather individuals with different water management interests. The FCD infrastructure or technology is often used in unforeseen ways, and additional infrastructure is shaped according to specific requirements of water users. Wester et al (1997) characterise control enacted over water according to two factors: (1) The actual use of water management infrastructure (technical control), and (2) social control over infrastructure.

An example of technical control is the cutting of embankments located on the opposite bank of a river. The people who do this think that the water levels in the river will be lowered by flooding their neighbour, thereby reducing the flood threat to themselves.

The following forms of social control over FCD technology can be distinguished (Wester et al, 1997):

- People living in the vicinity of a regulator often have control over it;
- Salt and shrimp producers monopolise the operation of minor regulators and additional infrastructure built by them in salt and shrimp areas. They are often well organised and collect funds for operation and maintenance (also from paddy farmers). Although conflicts are usually contained, there is often serious resentment among the farmers regarding the operation by the salt/shrimp producers;
- Around irrigation infrastructure (cross dams or more permanent structures), committees have often been formed. These committees sometimes go a long way back and play an important role in local water management;
- Village leaders (including Union Parishads’ chairmen) may enact control over water management by for example leasing out drainage channels or storage for fisheries, causing serious harm to other water management objectives;
- The Bangladesh Water Development Board (BWDB) is officially the most important organisation in the field of water management. Although BWDB is formally in charge of all water management infrastructure (from planning and design to operation and maintenance), in practice operation is clearly controlled by the water users.

In order to coordinate all different water management objectives in FCD systems, participation of the stakeholders in water management is regarded a prerequisite. Wester and Bron (1998) consider the recognition of participatory water management as the most important means to reach consensus on optimal water management scenarios for all parties. A way to achieve such management can be the formation of water users’ organisations.
Legal framework

In the scope of this research, the author has not had the opportunity to critically review the water sector acts in Bangladesh\(^{27}\). Therefore, this research goes from notes by other authors with respect to water sector acts. Framji et al (1981) stated the following with respect to acts on drainage:

- The Bengal Drainage Act 1880: Small drainage systems and improvement works are left to local authorities for maintenance, while drainage facilities connected with canals are to be maintained by the Irrigation Department;

- The Bengal Agriculture and Sanitary Improvement Act 1920: All outlets and water channels, natural or artificial included in a scheme under this Act and construction and maintenance of embankment and dams and works thereon, shall be subject to the laws regulating the construction and maintenance of public embankments, river channel or outlet. The law provides for sanctions on constructing weirs, etcetera, obstructing public drainage and maintenance of works, water channels, embankments and dams;

- The Bengal Cooperative Society Act 1940: Provides for the organisation of cooperative societies which are especially concerned with irrigation, drainage, flood and overflow protection;

- The Embankment and Drainage Act 1952 and its subsequent amendments: It vests the Government of Bangladesh or its respective authority with the power to take over public embankments, watercourses, etcetera, and it also provides rules for the construction of temporary dams, roads or watercourses and opening and shutting of sluices, among others.

Shamsul Hoque (1997, pp. C2-14 and 15) states the following with respect to water laws en legislation in Bangladesh:

“The current laws, regulations, policies, and administrative rules of water management in Bangladesh, … are not supportive and effective to meet the present purpose. … Many of the existing laws such as the Embankment and Drainage Act of 1952, are outdated and need revision to the present day conditions and requirements. … The Groundwater Management Ordinance 1985, framed to regulate the use of groundwater for irrigation is non-functioning. There are also multiple laws governing particular aspects of water use such as water rates levy, which need to be consolidated”.

\(^{27}\) The water sector acts in Bangladesh include: the Canals Act 1864, the Bengal Irrigation Act 1876, the Bengal Drainage Act 1880, the Limitation Act 1908, the Bengal Agriculture and Sanitary Improvement Act 1920, the Bengal Tanks Improvement Act 1939, the Bengal Cooperative Society Act 1940, the Embankment and Drainage Act 1952 and its subsequent amendments, and the Irrigation (Imposition of Water Rates) Ordinance 1963 (Framji et al, 1981).
All in all, going from the critical remarks of Shamsul Hoque as well as from personal communication with a water management specialist who supports these remarks, it is suggested to consider the existing legislation as largely insignificant with respect to daily water management practices. Today, water management often is a people’s affair, and the ‘regulation’ that does play a substantive role in water management in Bangladesh doesn’t have the status of an Act: The Guidelines for People’s Participation in Water Development Projects (GPP).

A draft People’s Participation Act has been formulated and sent to parliament in 1993. This act was never effected however, since it was decided to first gain experience with applying the Guidelines for People’s Participation in Water Development Projects, which were then being developed. In mid-1995, the Ministry of Water Resources issued the approved Guidelines for People’s Participation in Water Development Projects. The GPP resulted from initiatives undertaken in the Systems Rehabilitation Project (SRP), the Ganges Kobadak project, and some projects under the Flood Action Plan (FAP), among which the Compartmentalisation Pilot Project (CPP or FAP-20). As far as user participation is concerned, the GPP functions as a kind of legal framework (CPP, 1995). See box 3.3 for a general description of the contents of the GPP.

**Box 3.3: The Guidelines for People’s Participation in Water Development Projects**

The objective of the GPP is to help policy makers, implementing agencies and potential participants in project development with respect to formulating appropriate and adequate laws, rules and regulations for effective people’s participation, and to bring about an environment secure enough to stimulate intensive agriculture, fisheries and integrated rural and urban development. The GPP furthermore emphasises that local people should participate in the full range of programme activities, including needs assessment, project identification, pre-feasibility, feasibility, design and construction, operation and maintenance, and monitoring and evaluation (MWR, 1994).

The main features of the GPP can be described as follows:

- In an early stage of project development, a Project Council (PC) can be established. The PC will comprise representatives from the Government of Bangladesh, beneficiaries, project-affected persons (PAPs), and NGOs. If reconnaissance and preliminary consultations reveal that a pre-feasibility is worthwhile, the PC will take policy decisions, coordinate and monitor project activities (CPP, 1995, pp. 5);

- The involvement of project beneficiaries in decision making during design and construction is envisaged in the GPP. Although not made very explicit in the GPP, it seems that:
  - Once a project is deemed feasible, there must be an ongoing interaction between local people and technical planners in developing criteria and specifications for many vital project facilities or programme considerations;
  - Both formal and informal communications with local people including PAPs

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28 The particular Dutch specialist has extensive and recent experience with Bangladesh’s water sector and its institutional arrangements.
should be as open as possible. The plan itself and any modifications thereof should be explained to them and their views taken into account;

- The PC is to provide for the participation of individuals and groups directly in the activities of the project (CPP, 1995, pp. 6);

- A three-tiered organisation of water users is defined for the operation and maintenance of FCD and irrigation projects. The organisations will primarily be based on hydrologic units:
  - Water Users Groups (WUGs) are the smallest units of organisation. To speak in terms of irrigation systems, the WUGs are formed at the tertiary level;
  - Water Users Committees (WUCs) will be formed to represent two or more WUGs in a particular section of the project or system. The WUCs will also be formed on the basis of hydrologic units;
  - At the project or system level, a Water Users Association (WUA) will be formed by the representatives of all WUCs in a project or system. In case the hydrologic units or project size involves management of an area too big for one WUA to handle, a federation of associations (FWUA) can be constituted (CPP, 1995, pp. 6);

- The GPP defines a WUG as a group of farmers, people who cultivate their land, be it as owner-operator or as sharecropper. With respect to other interest groups, the GPP states that beneficiaries other than farmers shall be represented in the PC through their existing local organisation or group, as formed under the normal national outfit, to ventilate their choices and/or preferences in respect of water development projects affecting their respective interests (CPP, 1995, pp. 6-7);

- The GPP defines the composition of the WUGs, WUCs and WUAs, the way in which these will constitute their respective boards, and the tasks and duties they are to perform. The tasks and duties of the respective boards, among others, are:

  Water Users Group

  - The WUG-board is to draft rules for the WUG and submit these to the BWDB and to the general assembly of the WUG for endorsement;
  - The WUG-board is to prepare cropping schedules;
  - The WUG-board is fully responsible for installation, operation and maintenance
of water management structures like field channels, gravity turnouts, and low lift pumps;

- The WUG-board is to collect or register individual farmers’ contributions (in cash, kind or labour), and to meet the cost of development, operation and maintenance of the WUG’s unit;

- The WUG-board is to effect sanctions on farmers who violate rules or otherwise obstruct efficient and equitable water management (MWR, 1994, pp. 13-14);

*Water Users Committee*

- The WUC is to draft rules for the WUC and submit these to the BWDB and to the WUC members for endorsement;

- The WUC is to communicate to the BWDB the water users’ demands with respect to operation and maintenance;

- The WUC is to assist the BWDB in preparing plans and schedules for operation and maintenance that least interfere with water users’ agricultural plans, and report back to the members the compromises reached with the BWDB with respect to operation and maintenance plans and schedules;

- The WUC is to intervene in conflicts that WUG boards have been unable to solve;

- The WUC is to report to the BWDB information regarding operation, maintenance and related issues as appear relevant for overall decision making in these fields (MWR, 1994, pp. 15);

*Water Users Association and Federation of Water Users Associations*

- The WUA is to draft rules for the WUA and submit these to the BWDB and to the WUA members for endorsement;

- The WUA is to communicate to the BWDB the water users’ demands with respect to operation and maintenance;

- The WUA is to assist the BWDB in preparing guidelines for operation and maintenance, and plans and schedules that least interfere with water users’ agricultural plans, and report back to the WUCs the compromises reached with the BWDB with respect to operation and maintenance plans and schedules;

- The WUA is to intervene in conflicts that WUCs have been unable to solve;

- The WUA is to suggest to the BWDB how to assess and collect water fees;

- The WUA is to report to the BWDB information regarding operation, maintenance and cost recovery as appears relevant for overall decision making in these fields (MWR, 1994, pp. 16);
Although the above indicates that WUGs will actually undertake system operation and maintenance, some other texts in the GPP may suggest otherwise:

“Yearly maintenance needs for a local system should be recommended by the PC... BWDB officials will be responsible for preparing a detailed proposal including a budget in consultation with users/organisation for the maintenance of all works under the authority of the committee. ... Upon verification and adjustments as necessary, the PC will formally recommend the maintenance proposal” (MWR, 1995, pp. 19, in: CPP, 1995, pp. 7);

Funding for operation and maintenance is to be undertaken according to two categories: Small projects (< 1,000 hectares), and large projects (1,000 hectares and more). The large projects are subdivided into FCD/I and FCD projects.

In small projects, the water users organisations are ultimately to take over all operation and maintenance works, whereby the BWDB will only provide technical assistance on demand of the water users organisations.

For large FCD/I projects, the BWDB is to organise WUGs. The WUGs will be responsible for all operation and maintenance at tertiary level, while the BWDB will be responsible for operation and maintenance at secondary and system level. The WUGs will share in the costs for O & M in the form of water rate/irrigation service fees for primary and secondary level. Initially, this water fee is to cover a part of the O & M costs, but the water rate will be increased in phases to ultimately cover all O & M costs within 5 years after system rehabilitation or commissioning.

For large FCD projects BWDB will continue to provide O & M services, although the BWDB will attempt to have beneficiaries operating regulators/sluice gates, and to ultimately transfer a part of the system to WUGs, WUCs and WUAs for operation and maintenance (MWR, 1994, pp. 19).

Financing drainage

Irrigation and drainage projects, which are entirely under government control and management, are financed from revenue or public loans raised on the security of the general revenues of the state. Furthermore, loans have been obtained for the construction of large projects from the World Bank, and the Asian Development Bank, among others, and financial assistance as grants or long-term loans have been given by developed countries for particular projects (Framji et al, 1981).
The BWDB continually suffers from a Revenue Budget which is only a fraction of its needs if it is to fulfil its mandate for the O & M of the structures under its control. One of the primary goals of the SRP was to develop sustainable means for O & M of water control structures. Although there have been increases to this budget, there is need for alternative financing. These needs are linked to a principled SRP-stance that the beneficiaries of O & M should pay for the services they receive. The SRP Staff Appraisal Report (in: Soussan and Datta, 1998) proposed measures for transferring a part of the financial burden for O & M of irrigation systems to the beneficiaries through water charges, but does not suggest the same for FCD projects/systems. A pilot test with cost recovery was initiated in the Ichamati Unit of KIP (Karnaphuli Irrigation Project). The cost recovery test yielded little result. What did happen, was that farmers were paying a fee of some Tk. 700 per acre to pump managers who were the designated collectors. These pump managers, however, were not passing the collected money on to the BWDB. Although local BWDB officials and SRP staff were aware of this practice, they had few possibilities to impose sanctions. The model of cost recovery created the *de facto* privatisation of what was a public good: Irrigation water (Soussan and Datta, 1998).

**Integrated water resources management**

Through several water sector projects in Bangladesh, among which the Systems Rehabilitation Project (SRP) and the Compartmentalisation Pilot Project (CPP or FAP-20), integrated water resources management emerged as an evident requirement to meet the specific demands of agriculture, fisheries and others. Projects like SRP have consciously developed links with a number of agencies other than the BWDB, such as there are the Department of Agricultural Extension, the Bangladesh Agricultural Development Corporation, the Bangladesh Rural Development Board, the Department of Fisheries and NGOs (Soussan and Datta, 1998).

Reflecting the increasing call for a more integrated approach to water resources management, is the consideration being given to profound changes to the institutional arrangements within the Government of Bangladesh, and the search for strategies through which local people can become central actors in water resources management policies and programmes. These developments are reflected in the First Draft National Water Policy that was published in the autumn of 1997. Although merely in a draft or discussion form at the time of writing, it clearly sets out a significantly new direction for water resources management in Bangladesh, where the multiple nature of water use and its problems are recognised (Soussan and Datta, 1998).

**Impact of drainage on agriculture**

From the previous paragraphs it has become clear that without FCD, agriculture in the flood plains of Bangladesh relies on the ‘whims of mother nature’. However, it has become equally clear that construction and management of FCD systems from an agricultural perspective, produces non-benefits. Fisheries can be severely affected by a loss of breeding grounds as a result of construction of embankments. The largest problem faced by Bangladesh’s policy makers, managers and FCD users centres around the multiple uses of water (and the multiple stakeholders) and the temporal variation in water management demands.

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29 Since 1990, budgetary allocation for O & M has been enhanced each year. However, a FAP-26 report (in: Soussan and Datta, 1998) indicated that the O & M budget between 1991-1992 and 1993-1994 was only enough to meet 34% of all O & M needs (Soussan and Datta, 1998).
Institutional arrangements in drainage: Bangladesh

Institutional performance

As Wester et al (1997) remark, users’ participation in water management in Bangladesh is essential. However, the model of WUOs as envisaged in the GPP and that is commonly used in irrigation systems, has proven inappropriate in the context of FCD systems (Wester et al, 1997). Wester et al (1997) identify the following with respect to the (dis)functioning of WUOs:

- Interests with regard to water levels to be maintained are very conflictive between farmers and between farmers and other stakeholders;
- The extent of benefits strongly varies from one place to the other, depending on elevation and distance to infrastructure and differ among stakeholders from greatly benefited to disbenefit;
- The unit of management in FCD systems is usually larger than in irrigation systems. It is very difficult to organise a users’ organisation with direct participation of all or a majority of users at this level;
- FCD systems cater to diverse interests like fisheries, agriculture, transport, domestic uses, etcetera. Involving these different categories of stakeholders in one organisation is ineffective;
- In economic terms, a FCD system is partially a collective good. This means that excluding people from benefiting is difficult and that free-riding behaviour cannot be prevented.

In support of these observations, the Government of Bangladesh (GOB, 1997) remarks:

“... the adoption of an official policy on people’s participation in water development projects, had a very limited impact on the ground. ... water users’ organisations ... either exist only on paper or were hardly given the opportunity to assume any role in water management. Thus, the formation of WUOs did not contribute to close the gap between the Bangladesh Water Development Board (BWDB) and the people.”

The failure is mainly subscribed to the fact that the Guidelines for People’s Participation (GPP) do not specify the concrete function of the WUOs, as well as the fact that WUOs are not provided with any authority to enforce actions or decisions made. Furthermore, the GPP suggest criteria for the formation of WUOs that are not applicable to the context of FCD systems (GOB, 1997). The GPP seems to be based on ‘models of irrigation system management’, rather than on hands-on-experience with FCD systems. For example, costs involved in system operation and maintenance are to be covered by collected water rates or irrigation service fees. But, most systems in Bangladesh mainly involve drainage and water retention practices, rather than supply of irrigation water. Water users groups are understood to consist of farmers. Other beneficiaries are only directly represented in the Project Council, and not in the WUGs, WUC’s and WUAs. Lastly, the GPP remains rather indistinct on how to transfer responsibility for operation and
maintenance to users in large FCD systems. It implicitly almost suggests to just “do something and see where things come to an end”.

Drainage, flood control, and water retention affects the livelihoods of the large majority of the people in the project area. Water management related problems cannot be solved individually. This, together with its generally high individual priority, may enhance peoples’ and their leaders’ participation. However, it may be questioned whether it is necessary to create new water management institutions at the local level, while in Bangladesh there already are democratic institutions at the local level, such as Union Parishads, where water management is discussed (Duyne, 1998). Moreover, despite the absence of informal or formal organisations moulded according to general western standards, in Bangladesh water use related practices are being managed by groups of people that have developed institutions. Duyne (1998) describes a large number of such institutional arrangements that prove quite effective.
**Drainage Development in Egypt**

**Introduction**

The arid climate of Egypt requires irrigation in order to produce crops. Irrigation, however, has not only facilitated and enhanced agricultural production, but it also brought problems of waterlogging and soil salinity. Phenomena that have a negative effect on agricultural production. Drainage is one strategy to deal with waterlogging and salinity. Until today, a large part of Egypt’s irrigated lands have been equipped with some form of drainage. To implement and coordinate drainage development, the Egyptian Public Authority for Drainage Projects (EPADP) has been established. This organisation has been relatively successful in achieving its objectives. However, requirements put on EPADP have somewhat changed over time: Drainage is no longer a matter of only disposing of excess water, but also of re-using effluent due to ever increasing water scarcity. Water management is what is needed, rather than drainage management. Furthermore, many systems constructed several decades ago by EPADP, are now reaching their technical lifetime and need increasing maintenance or even replacement. The question is, whether the current institutional arrangement in Egypt’s drainage sector is up to these tasks.

**Irrigation and drainage development**

86% of Egypt is classified as extremely arid and 14% as arid. Country wide, the average annual rainfall is approximately 10 millimetres. However, local variations in rainfall are considerable and range approximately between 2 and 200 millimetres. To produce crops in Egypt’s arid climate, irrigation is a necessity.

Already from the days of the pharaohs, irrigation has been practised. The Nile flooded the area every August and September. After the water had receded, a crop was grown. During the 19th century, the Nile Barrages and a network of irrigation and drainage canals were constructed. To make more water available for irrigation, in 1902 the old Aswan Dam was constructed. The Aswan High Dam, which was constructed between 1960 and 1968, finally eliminated the Nile’s seasonal floods and allowed for all agricultural land to be brought under perennial irrigation (Amer, 1996).

**Current status of irrigation**

Today, the total (potential) area under irrigation in Egypt covers around 3.15 million hectares (Abdel-Dayem, 2000). In the ‘old lands’, an area of approximately 2.3 million hectares in the Nile Valley, irrigation water is provided for by force of gravity through systems of main, secondary and tertiary canals. The water is pumped from the tertiaries and applied to the fields. The main and secondary canals supply a continuous water flow, while the tertiaries receive water according to specific schedules. In the ‘new lands’, reclaimed land covering an area of approximately 0.85 million hectares in the Nile Valley, irrigation water is provided for by force of gravity through systems of main, secondary and tertiary canals. The water is pumped from the tertiaries and applied to the fields. The main and secondary canals supply a continuous water flow, while the tertiaries receive water according to specific schedules. In the ‘new lands’, reclaimed land covering an area of approximately 0.85 million hectares, a succession of pumping stations lift the water from the main canals to the fields. Here, instead of surface irrigation techniques, sprinkler or drip technologies are to be employed. Sprinkler and drip systems are used to water areas of approximately 312,000 and 104,000 hectares, respectively (Amer, 1996). These 416,000 hectares irrigated with drip and sprinkler techniques cover less than half of the total area of the reclaimed lands. The discrepancy can be considered an indication of the difference between potential and actual irrigated area in the new lands.
Main and secondary irrigation canals up to and including the tertiary canal off-takes are public property. So far, these have been operated and maintained exclusively by the Irrigation Department. Tertiary and field canals on the other hand, are considered private property and are under full farmers’ control (Verstappen et al, 1997).

Most lands in Egypt are irrigated using water from the River Nile. In the provinces of Matrouh, Sinai and New Valley however, some 146,000 hectares are irrigated using groundwater. Irrigation induced problems in Egypt include limited water control, inadequate system operation, and seepage from the extensive canal network that causes a water table rise and soil salinity problems (Amer, 1996).

**The need for drainage**

Agricultural drainage in Egypt is irrigation induced. With control over the Nile River flow after the construction of the Aswan High Dam, crop intensities rose to 200%. Natural drainage that had sustained permanent agriculture for millennia could no longer cope with the increased seepage from irrigation. As a result, large areas became waterlogged and salinised (Amer, 1996). Today, around 600,000 hectares (some 19% of the irrigated area) of agricultural land are waterlogged, while 1,000,000 hectares (around 32% of the irrigated area) are affected by salinity (Abdel-Dayem, 2000). The original objective of drainage in the Nile Valley is to control and prevent this waterlogging and salinisation, while in the Nile Delta drainage is required to reclaim lands (Amer, 1996). With increasing intensities of water utilisation, drainage systems are furthermore developed to recover excessive irrigation water for reuse (Snellen et al, 1996, and Saad, 1999).

**Drainage technology**

**Main drainage**

By 1952, 800,000 hectares of irrigated land were somehow served by a network of open drains. This network was extended, and by 1995 served around 2,700,000 hectares of irrigated land. The water table in open drains is generally maintained at 2.5 metres below ground surface. The open drain system incorporates about 18,000 kilometres drain length, with bed widths varying from 1 to more than 15 metres. The water flow in the open drains is operated through force of gravity. However, pumping stations pump the drainage water from the main drains into the principal drains; River Nile, lakes, and the Mediterranean Sea (Amer, 1996).

**Field drainage**

Open field drains proved problematic because of its space/land consumption, the split of area into small plots, and the complication of agricultural operations. Maintenance (cleaning of drains) proved laborious and drains could become a favourable environment for weeds. In 1942, experiments with tile drainage started. Mainly after 1968 (completion Aswan High Dam), tile drainage took off. By 1973, the Egyptian Public Authority for Drainage Projects (EPADP) was established to organise and execute five (World Bank supported) projects to provide tile drainage to an area of 1,100,000 hectares. To support EPADP, in 1975 the Drainage Research Institute (DRI) was founded. The Egyptian drainage policy was revised in 1978 in order to, in the long run, provide subsurface drainage to all cultivated lands. Today, some 1.7 million hectares are equipped with subsurface drains (Amer, 1996).

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Moreover, horizontal subsurface drainage in Egypt is a more appropriate technology than vertical subsurface drainage because of soils. Most agricultural lands in Egypt consist of alluvial deposits (clay, clay loam, and sandy clay). The clay content generally ranges between 30% and 80%, the soils have a low to medium hydraulic conductivity and low permeability. Especially in the east and middle Nile Delta, the soils require a narrow drain spacing (Amer, 1996).
The field drainage system consists of a network of laterals and collector drains. The laterals (corrugated PVC pipes laid at a minimum slope of 0.1m/100m, 72 mm inside diameter, in the past plain concrete pipes of 50 cm length) are about 200 metres long and discharge into collectors (generally plain concrete pipes with inside diameters of 150 to 400 mm at varying slopes) which evacuate the drainage water into the main and branch open drains (Euroconsult, 1995).

Disposal and reuse of excess water

In 1991/1992, 13 billion cubic metres of drainage effluent were disposed of into the Mediterranean Sea, while 4.12 billion cubic metres were reused for irrigation. The quantity of drainage water that is reused is to be increased over time. Drainage water is generally mixed with fresh (canal) water before it is reused for irrigation (Amer, 1996).

Institutional framework

Traditionally, the Ministry of Irrigation has been primarily responsible for agricultural drainage. In 1987, this ministry was renamed the Ministry of Public Works and Water Resources (MPWWR). The MPWWR was again renamed early 2000, and today carries the name Ministry of Water Resources and Irrigation (MWRI). This ministry has overall responsibility for capturing, distributing, and regulating water supply and drainage in Egypt. Most of its large number of professional staff are civil engineers. The ministry has many functions, which is reflected in the large number of different types of management units within the ministry: Headquarters, survey authority, EPADP, coast protection authority, and the irrigation department, among others. The ministry can be characterised as a multifunctional but single-disciplinary organisation which is institutionally fragmented (Merrey, 1998).

The Egyptian Public Authority for Drainage Projects (EPADP) is an autonomous organisation within MWRI (created under law by Presidential Decree No. 158 of 1973). EPADP is now vested with all the necessary power over financial, administrative and technical aspects of drainage systems: Design, implementation, operation and maintenance, and development of public drainage systems at the national level. The pumping stations (pumping drainage effluent into the principal drains) are operated and maintained by the Mechanical and Electrical Department of EPADP. The Drainage Research Institute (DRI) mainly conducts research and development work on subsurface drainage (design and technology), economic evaluation of drainage projects, water management in rice fields, and reuse of drainage water for irrigation. The Land Improvement Authority of the Ministry of Agriculture and Land Reclamation is responsible for installation of open field drainage in newly reclaimed areas through its own public companies or private sector contractors (Amer, 1996). See figure 4.1 for a diagram of government organisations dealing with agricultural drainage in Egypt.

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31 See Merrey (1998) for an overview of the then MPWWR’s staff.
**Operation and maintenance of drainage facilities**

EPADP consists of 162 drainage maintenance centres that each cover an area of around 16,800 hectares (40,000 feddan) and 450 drainage sub-centres covering around 2,100 hectares (5,000 feddan) each. These centres are divided over 29 general directorates of drainage in 5 drainage sectors/departments. Together, these bodies are responsible for regular and specialised maintenance of drainage systems (Saad, 1999). See figure 4.2 for a diagram of this part of EPADP’s organisational structure.

**Open drains**
Open main drains are considered public property and their construction, remodelling and maintenance are consequently done and paid by EPADP. Maintenance (weed harvesting, earthmoving) is performed mechanically by private contractors awarded by EPADP for larger and main drains. In small drains and upstream of critical structures, cleaning is done manually by EPADP labourers. Under irrigation law, maintenance of open field drains (considered private property) is legally done and paid for by farmers (Saad, 1999).

**Subsurface drains**

Subsurface drains are maintained by EPADP staff. The manholes are supposed to be inspected, cleaned and repaired six times per year, and the lateral and collector drains inspected, cleaned and flushed two times annually. EPADP also undertakes rehabilitation of old subsurface drains. Maintenance of subsurface drains is financed by EPADP (Saad, 1999). Flushing equipment consists of flushing machines, a tractor, a water tank, and a mobile water pump for every 30,000 feddan.
**DAS-units**

The general directorate of Sectors Affairs and Drainage Advisory Services (SADAS) at EPADP’s headquarters plans drainage advisory services, while the DAS-units at every Drainage Sector/Department implement drainage advisory services. The DAS-units have an engineer and assistant engineer at each general directorate of drainage maintenance. Their tasks are:

- Before implementation of subsurface drainage: DAS-staff explain the benefits of the system to farmers and persuade them to allow entry of pipe laying machines to their fields;

- During implementation of subsurface drainage: DAS-staff instructs farmers how to facilitate implementation (for example to stop irrigation when pipe laying machines are on the fields);

- After implementation of subsurface drainage: DAS-staff formulate Collector User Associations (CUAs), organise elections for leaders and members, lecture, organise workshops and meetings, and demonstrate (on-site) how farmers can perform simple maintenance and how farmers have to communicate with EPADP’s maintenance directorates for specialised maintenance;
Institutional arrangements in drainage: Egypt

• With respect to surface (open) drainage: DAS-staff launches public awareness campaigns to keep drains clean and uncontaminated with disposals, etcetera (Saad, 1999).

Farmers’ participation in drainage development

Farmers and EPADP are formally related through general drainage project directorates, drainage maintenance directorates, units of drainage advisory services (DAS-units), and the general directorate of SADAS at EPADP headquarters (Saad, 1999).

Engineers of the DAS-units provide farmers with extension services required to delegate responsibility of simple maintenance of subsurface drainage to farmers through five stages: Selection of collector drains, explanation, formulation of Collector User Associations, handing over of responsibilities, and monitoring and evaluation (Saad, 1999).

However, actual farmers’ participation in drainage development and operation and maintenance has remained rather restricted. Generally, farmers are informed that a drainage system will be installed in their area, but they are not involved in planning, design and construction. Especially in subsurface drainage, EPADP has traditionally been involved in the execution and design of the systems, while their maintenance has been given low priority from the start. Little attention has been paid to the establishment of an effective interface between farmers and officials (Verstappen et al., 1997).

Verstappen et al. (1997) observe a low level of efficiency and effectiveness in maintenance of subsurface drainage. In the Fayoum for example, the first installed (concrete) subsurface drainage systems are now reaching the end of their technical lifetime, which may have been reduced because of inadequate maintenance. Checking collector outlets for obstructions and keeping manhole covers in place, among other tasks, can hardly be performed by EPADP having a limited number of staff. Moreover, EPADP generally relies and acts on complaints from farmers. Organising farmers would streamline this process of (individual) complaint and response. Furthermore, Verstappen et al. (1997) conclude that because the subsurface drainage systems are owned by EPADP, there is a general disinterest among the users to take proper care of the facilities. Whether this last conclusion is valid remains to be seen, since farmers do have to share in the investments for tile drainage (see section 4.5).

Advisory Panel on Land Drainage and Water Management

Established in 1975, the Advisory Panel on Land Drainage is a result of EPADP’s request for technical assistance from the Netherlands. Originally, the panel was composed of experts in land drainage, land reclamation, project coordination, project planning, and agricultural water management. The experts came from both Egypt and the Netherlands (Amer, 1996).

Through initiation of a large number of projects, involving tens of millions of US Dollars over the years, the panel has had substantial influence in Egypt's agricultural water sector, and especially in land drainage. The Advisory Panel contributed towards the water sector in Egypt by achieving better and
cheaper subsurface drainage installation, upgrading of design procedures, development of O & M and rehabilitation criteria for drainage systems, soil and water management studies (Nile delta, Upper Egypt and the Fayoum), establishment of water quality monitoring programmes, development of a re-use of drainage water strategy, institutional support to the MWRI (previously the MPWWR), and recommendations towards improved policy and management of water resources (ILRI, personal communication).

Throughout the years, the Advisory Panel widened its scope from drainage specific issues to water management issues, and gradually changed from a technology oriented to a policy oriented panel. Today, the main objective of the panel is to assist, in its advisory capacity, the Ministry of Water Resources and Irrigation (MWRI) in carrying out its responsibilities with regard to managing Egypt's water resources more efficiently and effectively. Six Egyptian and five Dutch members take seat in the panel, which is chaired by Egypt's Minister of Water Resources and Irrigation (ILRI, personal communication).

Legal framework

Acts and regulation

Little has come to the fore with respect to contents of drainage acts and laws in Egypt. Framji et al (1981) present a reflection on the content of one law in Egypt: Law number 68 of 1953, which relates to irrigation and drainage. The law vests absolute power and entire supervision of the irrigation and drainage related public domain in the Ministry of Works, the predecessor of the Ministry of Irrigation, which again was the predecessor of today's Ministry of Water Resources and Irrigation. The law specifies responsibilities for maintenance and clearance of private watercourses and drains, and it contains a number of articles relating to water distribution. The absolute power of the Irrigation Department (ID) stands out from the Act: “Article 31, … the ID has absolute authority over the distribution of irrigation water to the various kinds of public channels as well as the distribution of water of every public channel to private intakes fed therefrom. The said department is empowered to introduce whatever change or modification to the irrigation and drainage system, and to clear whatever public canals and drains as and when it considers necessary. Article 32, … no claim for compensation may be laid against the Government for any damage that may arise from practising the power authorised to the ID by article 31…” (Framji et al, 1981, pp. 351).

Users’ participation in water resources management

Law 32/1964 on private non-governmental organisations, allows for the establishment of water user associations whereby membership of Collector Users Associations is voluntary and decisions apply to members only. Law 213/1994 and its bylaws contain modifications to Law 12/1984 and provide a legal basis for farmers’ participation in water management at ‘mesqa’ (tertiary) level, including operation and maintenance of the mesqa and organising a system for cost recovery. Creating private associations on the level of the branch canal or higher is possible in accordance with Law 32/1964, and provided these do not violate the authority of the ministry (Snellen et al, 1996).
Financing drainage

Installation and construction

Since 1970, the World Bank has continued to finance the agricultural drainage programme in Egypt. By the year 2012, EPADP aims to have around 6.4 million feddan\(^\text{32}\) (approximately 2.7 million hectares) of agricultural land equipped with subsurface drains. Currently, installation of subsurface drains is carried out at a rate of 230,000 feddan (approximately 100,000 hectares) per year. To produce plastic pipes for subsurface drains, seven manufacturing plants have been established in the Nile Valley and Delta with the help of World Bank loans. The seven plants are government owned, and managed and operated by EPADP. The production of the pipes, including purchase of raw material, forms some 20% of the overall costs to install subsurface drainage in Egypt. These costs are partly recovered from farmers through interest free loans. At the moment, the Government of Egypt is considering the possibility to privatise the production of drainage pipes, in order for government agencies to concentrate on their core (public) duties (Arab Republic of Egypt, 1999).

Contractors transport and install the products of the seven manufacturing plants in the field. For installation of subsurface drainage, special machinery is required. Initially, EPADP, using loans and grants, purchased drainage machinery. After purchase, the drainage machinery was put at disposal of state contractors. When privatisation started and private contractors started to compete with state contractors, the situation changed. These private contractors had only limited financial means. EPADP developed a method in which it continued to purchase the machinery through international tenders. The drainage machines were then made available to contractors who had been awarded drainage installation contracts on a hire-purchase basis. The contractors could finance the hire-purchase price from the proceeds of the contract. Local (private) contractors could thus build up experience in drainage installation. Contracts are generally given out for areas of some 4,000 to 5,000 hectares (Croon, 1997).

According to article 32 of Law 12 of 1984, landholders have to repay the construction costs of subsurface field drains on 20 year interest-free annual instalments starting from the beginning of the first year after execution (Euroconsult, 1995). Installation of subsurface drainage in Egypt is estimated to cost around US$ 750 per hectare (Croon, 1997) or some EGP 2,620. EPADP compensates farmers for land expropriation and crops damaged during construction of open and subsurface drains (Euroconsult, 1995).

Operation and maintenance

Open main drains are considered public property and their construction, remodelling and maintenance are consequently paid by EPADP. Field drains are considered private property, and their maintenance is paid

\(^{32}\) 1 feddan = 0.42 hectare (Amer, 1996)
by farmers (Saad, 1999). Annual costs for maintaining the public open drain system amount to approximately EGP$^{33} 36,000,000^{34}$. Annual costs for maintaining the subsurface field drains amount to approximately EGP 22,000,000$^{35}$ (Euroconsult, 1995).

Land taxes are the only revenue for funding government drainage services like maintenance (Saad, 1999). The currently modest recovery of operation and maintenance expenditures used to be more appropriate when farmers were heavily taxed through government’s price-fixing of agricultural produce. A need to raise the recovery of O & M costs is the result. Raising the rate of recovery could involve privatisation of O & M activities, or developing a repayment mechanism (Euroconsult, 1995).

**Integrated water resources management**

Apart from the MWRI, a number of other agencies are concerned with water resource management in Egypt. The major ones include the Ministry of Agriculture and Land Reclamation (MALR), the Egyptian Environmental Affairs Agency (EEAA), and the Ministries of Health, Industry, and Housing.

Through the Land Improvement Authority, the MALR is responsible for installation of open field drains in newly reclaimed areas. The EEAA has a coordinating role in environmental protection including water resources, and the Ministries of Health, Industry and Housing include the agencies responsible for municipal water supply and wastewater disposal. Coordination of the large number of diverse and sometimes conflicting stakeholders for integrated water resources planning and management is a serious problem (Merrey, 1998).

Increasing water shortages due to an ongoing increase of the irrigated area in Egypt, has resulted in a strong call for more efficient use of water in the upper and middle parts of the Nile valley. It has been reasoned that the ‘saved’ water can be used elsewhere in Egypt. This reasoning has led to a general support for a horizontal increase of the irrigated area. However, water lost from the fields in upper and middle Egypt returns to the river Nile and is already (re)used elsewhere. The savings appear to only be ‘paper’ savings. Continued horizontal expansion of irrigation in Egypt can thus lead to water shortages in the Nile Valley (Merrey, 1998).

For the MWRI and other ministries to respond to this ‘creeping crisis’ (as Merrey, 1998, refers to it), is at best difficult. First, the ‘greening of the Sinai’ is a strong political imperative, and since Arab donors are prepared to fund this expansion of irrigated area, it is financially painless. Furthermore, while engineers within the MWRI recognise the technical dimensions of the problem, understanding and responding to the institutional issues faced by the ministry is more difficult (Merrey, 1998). To address the problem of increasing water scarcity, Merrey (1998) argues for the integration of water delivery, distribution, drainage and groundwater management at the local level, and for a reorganisation of the ministry. The reorganisation would entail the separation of policy-making, planning and regulatory functions from the construction and operational functions.

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$^{33}$ An EGP is an Egyptian Pound. At 17$^{th}$ August 2000, US$ 1 equalled approximately EGP 3.49

$^{34}$ This amount is estimated as the average expenses for weed harvesting and earthmoving to maintain the open drain network. It can be presented per unit area served by open drains as approximately EGP 5 per feddan (Euroconsult, 1995).

$^{35}$ This amount is estimated as the average expenses for periodic flushing and maintenance of lateral pipes and collectors, maintenance of manholes, and temporary works on subsurface drainage. It can be presented per unit area served by tile drainage as approximately EGP 5 per feddan (Euroconsult, 1995).
Impact of drainage on agriculture

Without irrigation, agriculture in Egypt would largely be impossible. Drainage is again required to sustain irrigated agriculture. Without drainage, many agricultural fields in Egypt can become waterlogged and/or salinised. Both surface and subsurface drainage can improve agricultural production. Box 4.1 presents an example that indicates the potential benefit of subsurface drainage on crop yields.

Box 4.1: Impact of subsurface drainage on crop yield: An example from Dakahlia

Rashed et al (2000) set out to acquire information on the impact of subsurface drainage through means of an evaluation study in the 30,000 hectares Integrated Soil and Water Improvement Project in Dakahlia in the Nile Delta. Initial surveys showed that the top 1.5 metres of the soil in more than 62% of the project area had Electrical Conductivity (EC) values higher than 4 (dS/m), and higher than 8 (dS/m) in more than 25% of the project area (ISAWIP, 1994, in: Rashed et al, 2000).

Between 1989 and 1998, field tests were conducted for five different crops in an area of 210 hectares within the project area. As soil salinity and sodicity significantly affect crop yield, the performance evaluation of the subsurface drainage was based on the development of the crop yield as a function of both soil salinity (expressed as extract-soil-EC in dS/m) and sodicity (expressed in soil exchangeable sodium percentage, ESP%).

At the beginning of each season, the cropping pattern was determined. Crop yields were measured during harvest of each different crop. As berseem is harvested 4 to 5 times, the yield was measured every cut and the results accumulated to produce the total crop yield. Furthermore, the salinity and sodicity of the (top) soil were determined. The reference year (before installation of subsurface drainage) is 1989.

Rashed et al (2000) generally concluded that crop yield increases with improved soil conditions (salinity and sodicity) as a result of the installation of a subsurface drainage system. They made use of the crop-yield-ratio\(^{36}\) (CYR) as a quantitative indicator for crop yields. The CYR for cotton increased from 127% to 247%, the CYR for beans increased from 124% to 226%, the CYR for berseem (Egyptian clover) increased from 125% to 152%, while the CYR for wheat decreased from 100% to 83% (as a result of

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\(^{36}\)Crop-yield-ratio = Crop yield after installation of subsurface drainage (= crop yield in a given year after installation) divided by Crop yield before installation of subsurface drainage (= crop yield in 1989)
Institutional performance

The drainage sector in Egypt faces the following challenges: Increasing the low rate of cost recovery for O&M, increasing the low efficiency and effectiveness of tile drainage maintenance, and making more optimal use of available surface water resources. The intended vehicle for addressing the problems and accepting the challenges seems to be participatory drainage management. As mentioned before, farmers’ participation in drainage operation and maintenance is considered useful, as well as a more integrated approach (irrigation-drainage) is considered useful.

It is often assumed that the same organisational principles developed for users’ participation in irrigation can be employed in facilitating users’ participation in drainage. Verstappen et al (1997) identify certain differences, however, which may call for a distinct approach.

Irrigation has been performed since ancient times, and farmers have developed routines and rules structuring their irrigation practices. Especially subsurface drainage, however, is a relatively new practice and users have no formal or informal framework to serve as a reference. Subsurface drains are mostly invisible and inaccessible, limiting farmers’ insight with respect to the functioning of the system. For example, a farmer who closes drains to retain water in his fields may cause a problem for upstream farmers. In fact, the ‘head-end’ farmers in an irrigation system, are the ‘tail-end’ farmers in a drainage system.

Furthermore, subsurface drainage differs from irrigation in the operational sense. At field and tertiary level, drainage hardly requires operation. This results in a ‘lack’ of frequent attention, which may hamper adequate maintenance. Moreover, if performance of drainage facilities is insufficient, effects (for example due to increasing salinity) will only be noticed in the relatively longer run. On the contrary, if an irrigation system performs below its required level, the negative effects on crop yield are of a more immediate character (Verstappen et al, 1997).

Lastly, earthmoving for drainage and irrigation facilities have similar technical requirements, and weed growth in drains may be heavier than weed growth in canals, but both require similar measures for removal. However, maintenance standards and procedures for subsurface (field) drainage totally differ from farm water delivery in irrigation (Euroconsult, 1995).

In Egypt, several experiments have been undertaken with respect to the aim of increasing farmers’ participation in operation and maintenance of drainage. In the Fayoum, three approaches were being tested:

1. Organise drainage user groups after installation and proven functioning of the subsurface drainage system;

2. Organise drainage user groups before and during installation of the subsurface drainage system;
Institutional arrangements in drainage: Egypt

3. Organise irrigation user groups first, and then install the subsurface drainage system. The maintenance and operation requirements of the drainage system are included in the tasks/responsibilities of the irrigation organisation.

Verstappen *et al* (1997) conclude that the first approach seems least successful, while the third seems to be the most promising approach. They argue that especially in cases of water scarcity, which today is an ever more occurring phenomenon in Egyptian irrigated agriculture, prevention of salinisation requires a rather subtle interplay between the provision of irrigation water for leaching and the effective functioning of the drainage system. Setting up of separate organisations for irrigation and drainage would thus seem rather superfluous, and may put an unnecessary strain on the still relatively scarce organisational skills available with the farmers. Instead, Verstappen *et al* (1997) argue for involving farmers in drainage management through irrigation-based organisations as opposed to single-purpose farmers organisations for drainage. Their argument is supported by Snellen *et al* (1996), who state that the interdependence of the functioning drainage and irrigation systems does not seem to call for separate farmers’ organisations for the two functions, and by Merrey (1998) who calls for integration of water delivery, distribution, drainage and groundwater management.
Drainage Development In India

Introduction

India has a large variety of agro-ecological and socio-economical settings. As a result, most types of agricultural land drainage can be found in India: Flood control in the Indo-Gangetic plain, land reclamation in the State of Kerala, and land drainage in irrigated agriculture in a number of (semi-arid and arid) states. See appendix A for a general overview of the climatic and physiographic variation within in India, as well as for an overview of drainage related problems in irrigated agriculture.

To review drainage institutions in India in general could do injustice to regional efforts in drainage development. Moreover, a general review would provide little insight in the sector's functioning and the problems it experiences. To handle this variety of settings, the author has decided to specifically deal with land drainage in irrigated agriculture in two large canal irrigation projects in the (semi) arid State of Rajasthan (the IGNP and Chambal projects) and with land reclamation in the more humid State of Kerala. The choice for reviewing drainage institutions in (parts of) these both states has several reasons:

- It illustrates the large differences in agro-ecological settings within India;
- It illustrates the occurrence of more than one type of drainage, although drainage in irrigated canal commands is the most dominant drainage type in India when considered from and area perspective;
- There is relatively ample literature available on drainage in both states, and especially on drainage in Rajasthan. Furthermore, an Indian drainage expert from Rajasthan could be consulted because he was based in the Netherlands at the time of this desk-study.

Drainage development

Land drainage in irrigated agriculture

Irrigation in India dates back many centuries, and some old structures still exist in different parts of the country. Modern irrigation development, however, started in the 19th century during British colonial rule, with the construction of large-scale canal systems in the semi-arid areas according to the concept of 'protective' irrigation (CWC, 1997). This term emerged as an element of British colonial irrigation policy in the 19th century. In protective irrigation systems water is scarce by design (see also the chapter on Pakistan). Protective irrigation undertook to supply limited quantities of water to subsistence-oriented peasants growing traditional food crops. In the occasion of drought, crops and livelihoods would be safeguarded, famine and social instability prevented, and colonial rule secured. After Independence, protective irrigation became part of the new government’s policy for agricultural development, emphasising both growth and equity objectives: Production and productivity increase, and the spread of the benefits of development over different sections of the population and over different regions. At
Independence in 1947, 13.6 million hectares of canal irrigation had been created in India, of which productive irrigation covered some 11.4 million hectares and protective irrigation covered around 2.17 million hectares\(^{37}\) (Mollinga, 1998). Today, approximately 50.1 million out of some 142.5 million hectares of cultivated land in India are irrigated. Most of the water is supplied through surface irrigation techniques, although around 771,000 hectares are irrigated using sprinkler or micro irrigation. Groundwater is essential to today’s irrigation in India, with tubewells and open wells supplying more than half (53\%) of the irrigation water (FAO, 1999). Groundwater can either be used conjunctively with surface water, or it can be the sole source of irrigation water\(^{38}\).

Irrigation did not only bring about blessings. With the increasing development of irrigation in India, waterlogging and salinity have increasingly become problematic by negatively affecting agricultural production. Waterlogging in irrigated fields was first observed around 1850 in the Punjab and by 1855 in the State of Haryana. During the early stages of irrigation development, rising groundwater tables could still be controlled relatively effectively by lining canals and improvement of drainage systems, but today the vastness of the irrigation systems, high cropping intensities, production of high water consuming crops, and problematic water management\(^{39}\) have complicated drainage development and as such have proven to be obstacles to improved drainage performance. Moreover, similar as to many irrigated areas in Pakistan, the construction of infrastructural works like roads, railways and canals, and the growth of villages, towns, and cities have substantially added to the problem by cutting across or obstructing natural drainage lines (CWC, 1997). With a general focus on irrigation development rather than drainage development, large-scale problems have occurred as a consequence of poor performance of drainage systems. An assessment by the Central Ministry of Water Resources in 1991 indicated that some 2.46 million hectares of land under canal irrigation commands (around 5\% of the total irrigated area) are waterlogged due to rising groundwater tables. Here, ‘waterlogged land’ is defined as land with a groundwater table within 2 metres of ground surface. The Ministry further estimated that around 3.3 million hectares (some 6.5\% of the total irrigated area) have excessive salt concentrations\(^{40}\) (CWC, 1997).

**Land drainage in irrigated agriculture in Rajasthan**

Even within the State of Rajasthan, considerable variation exists in agro-ecological settings. This report reviews drainage development within two different regions of this state: The Thar Desert in the west where the irrigation project 'Indira Gandhi Nahar Pariyojna' (IGNP) is located, and the southeast where the 'Chambal Command Area' irrigation project is located. Both canal irrigation systems face problems of waterlogging and soil salinity within their respective command areas. Drainage measures are planned and implemented to control waterlogging and salinity. Apart from the IGNP and the Chambal Command Area, virtually nothing has been done elsewhere in the State of Rajasthan to control waterlogging and soil salinity (Rakesh Hooja, 2000 b).

**The IGNP**

\(^{37}\) For an explanation of the terms ‘productive’ and ‘protective’ irrigation in India, see Mollinga (1998, pp. 35 - 62).

\(^{38}\) Many areas in India that are largely irrigated with groundwater, suffer from groundwater depletion rather than from a groundwater table rise. Apart from field drainage, in these areas main drainage infrastructure is generally not required.

\(^{39}\) See Mollinga (1998) for a comprehensive account of water distribution in a South Indian canal system.

\(^{40}\) Problems of waterlogging and salinity (and alkalinity) are closely related and interlinked. Over time, different estimations have been made with respect to the area of agricultural land in India that has been negatively affected by either one or both of the phenomena. Different estimations furthermore occur due to the use of different criteria/norms in labelling land as waterlogged or saline (CWC, 1997). See CWC (1997, pp. C5-8) for an overview of the criteria used in classifying soils as saline, saline-alkali, or non-saline or alkali.
The average annual rainfall in the IGNP command area is around 200 to 300 millimetres. The soils are predominately sandy and have a relatively low moisture retention capacity, as well as a low natural fertility. The soils are fairly susceptible to wind erosion. The IGNP is underlain by quaternary marine alluvial and aeolian deposits lying on tertiary deposits of sandstones and limestones. These form a kind of hydrological barrier at a relatively shallow depth. This gives the area the character of a 'large bowl of sand'. The groundwater in most of the area is saline (Diwan, 2000, and Rakesh Hooja et al, 2000 a).

The IGNP was conceived around 1948, construction started in 1951, and water started to flow through (parts of) the system in 1961. The main canal is 445 kilometres long and some 8,200 kilometres of distributaries have been built, are under construction or are planned for (Dr. Avdhesh Chandra, personal communication). The project consists of two phases: Stage-I and Stage-II. Stage-I is near to completion creating a potential of some 550,000 hectares of culturable command area (CCA). Stage-II is to create an additional irrigation potential of around 760,000 hectares of CCA (Diwan, 2000, and Rakesh Hooja et al, 2000 a). Largely as a consequence of the IGNP, problems of waterlogging and soil salinity have come up. From the actual irrigated area, some 150,000 hectares are affected by waterlogging or salinity (Dr. Avdhesh Chandra, personal communication). Diwan (2000), Rakesh Hooja et al (2000 a) and Chandra (personal communication) have distinguished a number of responsible factors:

- Absence of an adequate drainage network;
- Absence of a major outfall structure to facilitate the functioning of a drainage system;
- Excessive inflow and application of irrigation water into the area due to an underdeveloped CCA (Canals need to be operated at full supply levels to feed offtakes);
- Seepage from inadequately lined canals;
- Wild flooding to assist land levelling (which is frequently required due to strong wind erosion);
- A hydrological barrier at a relatively shallow depth;
- Flat topography with no natural drainage (as a consequence of low rainfall in the area).

To solve the increasing burden on agricultural and rural development as a result of waterlogging and salinity, a number of measures have been taken:

- Through On Farm Development (OFD) projects: Lining of canals in some tertiary units, and improving water application at field level by training of farmers;
- Reducing the systems' water allocations per unit of land;
• Experiments with vertical drainage;
• Pilot subsurface drainage projects;
• Mixing of drainage effluent with canal water;
• Bio-drainage;
• Discharge of drainage effluent into evaporation ponds (Rakesh Hooja, 2000 b).

All in all, these (experimental) measures are implemented on a small scale and as such have resorted marginal effect from a system level point of view. The underlying problem with most of these drainage measures is that they 'only' relocate the problems within the command area. Overall, too much water is coming into the area where only a part of it is used and the excess has no way to go.

A possibility that may offer more tangible relieve at system level is the construction of a 600 kilometres long outfall drain to the Arabian Sea, through which the drainage effluent has to be lifted some 120 to 200 metres. This is an enormous undertaking both in terms of construction and operation, and in terms of required capital investments. An undertaking that has so far be deemed impossible (Chandra, personal communication). Another option is to supply water that exactly meets the requirements and is thus fully used. This may prove just as impossible as the construction and operation of the large outfall drain, however.

**The Chambal Command Area**

The Chambal Command Area irrigation project is located in the southeast of Rajasthan, where it receives more rainfall (on average some 740 millimetres annually) than the IGNP, and where natural drainage (slopes and gullies or 'nallas') provides better outfall opportunities than is the case in the IGNP. The soils in the Chambal project generally consist of clay-loam and have better soil moisture retention capacities and higher fertility than the soils in the IGNP (Rakesh Hooja, 2000 b).

The project's command area covers some 385,000 hectares of which 229,000 hectares are located in the State of Rajasthan and some 156,000 in the State of Madhya Pradesh. The project has been developed since the 1960s. Today, some 167,000 hectares of culturable command are served by a network of open main and submain drains, and around 72,000 hectares have carrier and field open drains that are constructed under the On Farm Development project\(^{41}\). Approximately 15,000 hectares of command area are equipped with horizontal subsurface drains under the RAJAD\(^{42}\) project (Srivastava *et al*, 2000). Despite the presence of a drainage system in a considerable area of the command, today many hectares of land are affected by waterlogging and soil salinity. By 1990, around 161,000 hectares of the command area showed evidence of waterlogging and around 25,000 hectares were affected by soil salinity (Kaushal *et al*, 2000).

\(^{41}\) The Government of India, the United Nations Development Programme (UNDP), and the Agriculture and Food Organisation of the United Nations (FAO) in 1967 started this project, in order to prevent lands from becoming waterlogging and affected by soil salinity and to reclaim already affected lands. After 1970, the project was supported by the World Bank (Barla *et al*, 2000).

\(^{42}\) RAJAD = Rajasthan Agricultural Drainage Research Project, a joint project of the Governments of India, Rajasthan, and Canada. This project intended to contribute to the control of waterlogging and soil salinity by introducing subsurface drainage to the Chambal Command Area. The project combined engineering, agriculture, socio-economic dimensions, environmental considerations, institutional strengthening, and human resources development (Mundra *et al*, 2000).
Land reclamation in Kayal lands, Kuttanad, Kerala

(source: Joseph, 2000)

Kuttanad, in the State of Kerala, is the name of a coastal area covering around 110,000 hectares. The area contributes some 25% to Kerala’s total rice production.

In Kuttanad, the previous shallow sea was transformed into an area of lagoons and lakes through an upheaval of the laterite formations. Today, more than 30,000 hectares are located at an elevation of 1.0 metre above mean sea level or higher, while some 50,000 hectares are located between 0.6 and 2.2 metres below mean sea level. Four rivers discharge water into this area of dry lands, wet lands and open water.

Joseph (2000) has studied a particular area within Kuttanad known as the ‘Kayal lands’. Kayal covers a land area of some 9,464 hectares, which are entirely reclaimed from Vembanad Lake. The Kayal lands are situated at some 2 metres below mean sea level. In order to prevent ingress of saline water from the adjoining sea, Vembanad Lake is ‘separated’ from the sea through the Thanneermukkum barrier, constructed in 1975. The Kayal agricultural fields, used to cultivate paddy, are protected from the lake by permanent embankments. Despite these embankments, the fields are flooded annually during the southwest monsoon. The fields are grouped in polders (‘padasekharas’) that vary in size from 2 to 1,000 hectares.

The main season of paddy cultivation is Punja, which covers the period from December to March. Before the start of the growing season, after the annual floods, the embankments and bunds require repair. After strengthening and repairing the embankments and bunds, dewatering starts in order to lower the water levels to desirable levels for paddy transplantation. This initial drainage has to be taken up simultaneously, and then continued throughout the growing season to compensate for seepage water entering the polders.

Control of water levels has to be conducted meticulously, since the soil is acidic below the topsoil. Frequent letting in of water and application of lime are necessary to sustain the rice crops. Furthermore in Kuttanad, rice is cultivated in higher cropping intensities, and with more use of High Yielding Varieties (HYVs) than in other parts of Kerala.

Institutional framework

In India, planning, execution, operation and maintenance of water resources projects (irrigation and drainage) are the direct responsibilities of the respective State Governments, while the Central Government is concerned with overall policy planning, financial allocation and coordination. At the central level the Ministry of Water Resources and the Ministry of Agriculture both are concerned with drainage related matters. At state level, the Departments of Irrigation (or Water Resources) and
Agriculture are the main ministerial organisations concerned with drainage. Some states have separate drainage wings under the technical departments that again resort under the respective ministries (CWC, 1997).

Several organisations in India have been involved in development of basic data on soil, land use, land degradation and groundwater table levels through surveys and monitoring networks. The same organisations have also formulated policies and plans on utilisation of land resources, on remedial measures regarding waterlogging and salinity, and have engaged in research on crops and salinity. However, nation-wide and large-scale development of physical and institutional drainage structures have not been undertaken (GOI, 1991).

Generally in India, there is no specific organisational set up developed for the sole purpose of looking after and tackling the two problems of waterlogging and soil salinity/alkalinity. Agriculture and Irrigation Departments at the level of State Government have been undertaking some works on drainage, however adequate institutional arrangements are lacking in most states (GOI, 1991).

The organisations in India that can most directly be regarded as responsible for the implementation and O & M of drainage facilities within irrigation commands, are the Command Area Development Authorities (CADAs). The CAD Programme was launched during the period 1974 to 1975, as a centrally sponsored programme that was to bring about improved water use efficiencies and reduced chances of producing excess water (percolation) in the process of irrigation, as to control waterlogging and soil salinity. CADAs were established at project or system level. Conceptually, CADAs were also to coordinate correction of irrigation system 'deficiencies' by providing drainage facilities within the projects. However, CADAs proved incapable of monitoring waterlogging and salinity, let alone of responding to these problems (GOI, 1991).

**Rajasthan**

Whereas in the IGNP no structural drainage development is undertaken as yet, an extensive drainage system has been constructed in the Chambal Command Area. The construction of the open drains has been a government initiative supported by foreign donor organisations and the World Bank. Also, the subsurface drains were installed at government initiative and with foreign (Canadian) technical and financial assistance.

Pipes for the subsurface drainage system in the Chambal Command Area have been locally manufactured by a private company that was set up as a part of the RAJAD project. The required equipment for the production of PVC pipes was provided by Canada (Mundra *et al*, 2000). The installation of pipe drains in the Chambal Command Area was done on a service contract basis by private contractors under the authority of the RAJAD project. The project issued tenders to Canadian owned firms or joint ventures. These contractors were required to work with an Indian contractor to promote training of its staff and to facilitate technology transfer. Canadian and Dutch machines were used for the installation of the drains (Miller *et al*, 2000).

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43 Among others, these organisations are: The All India Soil and Land Use Survey Organisation (AISLUS), the National Land Use and Conservation Board (NLCB), the National Bureau of Soil Survey and Land Utilisation (NBSSLU), the Central Soil Salinity Research Institute (CSSRI in Karnal), the Central Arid Zone Research Institute (CAZRI in Jodhpur), the Central Ground Water Board (CGWB), and universities.
Farmers' participation

Under the OFD project in the Chambal Command Area, farmers’ committees were formed to enable their participation in planning and implementing a system of (subsurface) field and carrier drains. The committees played an active role during the execution of the OFD works. Also prior to and during the installation of the subsurface drainage have farmers been involved, although this involvement was merely confined to awareness campaigns, village level meetings, demonstration days, and visits to research sites. As a result, farmers have been said to allow for the installation of tile drains without requesting for crop compensation. The farmer committees were not established under any legislation, and their participation in operation and drainage seems rather limited.

At the tertiary level of the irrigation system, 30 Water Users Associations (WUAs) were formed in 1995 - 1996 that successfully managed, maintained and distributed water in their respective commands. Today, there are 81 WUAs in the Chambal Command Area (Srivastava et al, 2000). Whether they also engage in O & M of the drains in their commands is not clear.

Kayal lands, Kuttanad, Kerala

To organise farmers to collectively and simultaneously take up the initial dewatering and subsequent drainage, farmers in each polder organise in Farmers’ Committees (FCs). In the Kayal areas, there are some 123 FCs, which each cover an average area of around 83 hectares. All farmers in a polder are members of the general board, from which the Executive Committee and its Governor are nominated and elected. Apart from drainage, the FCs can also be involved in other agriculture related activities (Joseph, 2000).

Coordination between FCs, and thus between the different polders in the Kayal lands, is taken up by an officer of the Revenue Department. This officer, the Punja Special Officer (PSO), forms a ‘bridge of communication’ between the FCs. FCs forward their requests for (the start of) dewatering to the PSO, who then decides upon a specific time when private contractors should install the required pumps and execute pumping at the start of the growing season and during its subsequent days. The hired contractors are generally the lowest bidders. Contractors are paid through the PSO. FCs supervise pumping and drainage and if contractors do not perform their duties adequately, the FCs can inform the PSO who can take action accordingly (Joseph, 2000).

Accountability of the contractor is thus directed more towards the PSO and less to the farmers. It remains unclear whether this has particular effects on the functioning of the contractors. The accountability of the PSO towards the farmers is limited. Most of the contractors’ expenses and charges are paid for by the PSO as a subsidy to the farmers. The remaining required finances are provided for by the farmers.
Legal framework

India is a union of states. The constitutional provisions in respect of allocation of responsibilities between the state and the central government fall into three categories:

1. The Union List under which the Indian Parliament can formulate laws;
2. The State List under which states can legislate;
3. The Concurrent List under which both state and central government can legislate, although state law must not be in opposition to any existing central regulation.

In the Constitution, water is a matter included in Entry 17 of List-II, the State List. This entry is subject to the provision of Entry 56 of List-I, the Union List. Entry 17 of List-II provides that “Water, that is to say water supplies, irrigation and canals, drainage and embankments, water storage and water power, are subject to the provisions of Entry 56 of List-I”. Entry 56 of List-I provides that “Regulation and development of inter-State rivers and river valleys, to the extent to which such regulation and development under the control of the Union are declared by Parliament by law, are to be expedient in the public interest”.

The various aspects of drainage have not been given much attention in framing laws in India. Most of the states in North India still follow the Northern India Canal and Drainage Act of 1893. Rules similar to this act govern the drainage aspects in eastern states. The rules in the acts do not cover the rights, privileges and duties of the upstream and downstream farmers, and the manner in which the drainage water should be disposed off from upstream to downstream fields. The Northern India Canal and Drainage Act (1893) and other existing Acts only define the powers of the State Governments to order removal of obstructions from drainage channels, plan drainage works, and levy drainage cess. The Acts and Rules do not cover farmers involvement in construction, operation and maintenance of drainage facilities (CWC, 1997).

Financing drainage

Financing drainage in irrigated agriculture in Rajasthan

Both networks of open drains and subsurface drains have been constructed with technical and financial support of foreign donor organisations and the World Bank. The costs involved in the production of drain pipes and their installation in farmers’ fields in the Chambal Command Area are estimated at an average of 34,250 Indian Rupees. Especially small farmers may not be able to finance such investments in subsurface field drainage. To facilitate further development of subsurface drainage subsidies are required (Barla et al, 2000).

Farmers generally don’t contribute to the costs involved in drainage development outside of their fields. The Irrigation Department on the other hand faces limited financial means to engage in drainage development. The budget is largely employed in relation with canal construction and O & M in irrigation facilities. To solve this lack of money, special efforts were made by the State Government to get funds for pilot projects under the World Bank funded Agriculture Development Project (ADP). The project was sanctioned in the 1990s. However, both the Departments of Agriculture and Irrigation expressed their inability to prepare and carry out the projects (Rakesh Hooja, 2000 b). This has been identified by Rakesh Hooja (2000 b) as one of the main reasons for slow progress in drainage development and continuing problems with waterlogging and salinity.
Financing drainage in Kayal lands, Kuttanad, Kerala

The initial and subsequent drainage of the polders is taken up by private contractors, who are paid through the Punja Special Officer (PSO). Some 85% of the expenses and charges of the contractors are paid through general revenue, while the remaining 15% is paid for by the farmers. Although the 85% is paid directly by the PSO to the contractors, it should be regarded as a subsidy to the farmers. The subsidy more or less covers electricity costs, hire of motors and equipment, motor installation, wages of the pump operators, transport, and the cost of the land where the motors and pumps are installed. Each FC decides on how the individual members are to share the collective 15%-costs contribution.

Integrated water resources management

In the arid and semi arid regions of India, a large number of Watershed Development Projects can be observed. These projects combine soil and water conservation measures at 'catchment' level. Within canal irrigation systems the concept of integrated water management has not yet developed.

The Andhra Pradesh Farmers Management of Irrigation Systems Act (issued in 1997) is an example of how new legislation on irrigation and drainage system management lacks attention for and a conception of drainage construction and management within canal irrigation systems. It illustrates the generally non-integrated irrigation and drainage system management. The Act facilitates farmers’ management of irrigation systems: Establishment of water users’ associations (WUAs) at tertiary level, a distributary committee at the secondary level, and a project committee at the project or system level. Although it is not made very explicit in the rules of the Act, it seems that an ‘irrigation system’ is understood as to include a ‘drainage system’. The Act thus automatically refers to farmers’ involvement in the management of drainage facilities. From reading the rules of the Act, it becomes apparent that drainage was hardly considered when the Act was made. Emphasis of the rules are on farmer participation with respect to operation and maintenance of the irrigation system (water allocation and distribution, and collection of charges to cover for costs). See appendix B for a brief description of the irrigation management reform in Andhra Pradesh and the content of the Act.

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44 The rules of the Act explicitly mention drainage in section 5, 6, 16 and 18, among others, as being part of the scope of the Act.
Impact of drainage on agriculture

Impact of drainage on irrigated agriculture in Rajasthan

The IGNP

In the IGNP, little progress has been made on the implementation of drainage measures on a larger scale. Both problems of waterlogging and soil salinity in the IGNP prove to be an extremely hard nut to crack when it comes to achieving effective disposal of excess water and salts. The system's users and managers face a lack of financial means and drainage outfall, and continue to struggle with local measures that may resort some local or temporary relief. In the mean time, the sandy 'bowl' that forms the IGNP is 'filled' with water that is supplied in excess.

The Chambal Command Area

The potential positive impact of subsurface drainage on soil salinity has already been proven many times and in many places of the world. In the Chambal Command Area, a general study has been conducted on a research farm in order to evaluate the performance of pipe drains in reducing soil salinity. Reference soil salinity values were determined before installation of pipe drains, after which a study was conducted between 1995 and 1998 on the effect of the pipe drains on local soil salinity. Drains were installed in two 'blocks', one with a drain spacing of 35 metres and one with a spacing of 60 metres. The average depth of the drains was 1.2 metres. The research showed that soil salinity in both blocks was reduced considerably over the three-year period, be it that the positive effect of drains on soil salinity was much more prominent in the block with narrower drain spacing. The study also showed however, that nutrient losses from the soil were higher with the narrower drain spacing (Rana et al., 2000).

Considering (a) the before-mentioned potential benefits of subsurface drainage, (b) the natural outfall facilities of the area, and (c) that an extensive area within the command is served by a network of open drains and a smaller area by horizontal subsurface drains, one may expect drainage in Chambal to be effective. However, vast tracts of land within the command area are still affected by waterlogging and salinity. Rakesh Hooja (2000 b) has identified three factors that hamper effective mitigation and reclamation of waterlogged and saline lands within the Chambal Command Area: (1) lack of funds for O & M and capital investments, (2) a lack of identified 'problem areas', a lack of data to identify these areas, and a lack of equipment to collect data, and (3) lack of technical knowledge to plan, design, and implement location specific drainage related interventions. Underlying problem seems to be the insufficient attention for drainage of policy makers and system managers.

Impact of drainage on Kayal lands, Kuttanad, Kerala

Without drainage in the Kayal lands in Kerala, cultivation of crops would be a hazardous or even impossible affair. As such the impact of drainage on agriculture is obvious and tangible. However, the local land reclamation and drainage activities also produce non-benefits, especially for non-farmers inhabiting the same and surrounding lands.
With the construction of Thanneermukkum barrier, a stop was put to limit the ingress of saline water into Lake Vembanad and into the paddy fields, but also problems occurred. The barrier is closed from mid-November to February. Drainage is a core farming activity during this period.

The drainage effluent contains (high) concentrations of fertilisers, insecticides, and herbicides, among others. Because the barrier is closed, water movement is strongly restricted and as a consequence, the pollution in the lake ‘accumulates’. The concentration of pollutants further increases due to water use and evaporation, which result in lower water levels. The increase of the concentration of pollutants in the surface waters causes health problems.

After the construction of the Thanneermukkum Barrier, there is increased conflict between fishermen and farmers. The populations of fish and prawns suffer from the pollution, from the acidification of surface waters as a result of drainage of acid-sulphate soils, and from lower salt contents of the water in the lake (Joseph, 2000). These consequences of the barrier, drainage and other agricultural practices, are not addressed in the management of agricultural operations, i.e. other water management demands appear not to be considered in drainage operations.

**Institutional performance**

The farmers in Kerala do contribute to operation and maintenance of their polder drainage system, which seems to be functioning much more effective and efficient as the systems in Rajasthan. However, comparing both types and specific cases of drainage may not be justified. In Kerala, drainage produces much more direct and tangible benefits to the farmers than is the case in Rajasthan, where irrigation produces the direct and tangible benefits. Moreover, effective drainage in Rajasthan requires action on a considerably larger scale than does drainage in Kerala's polders.

Despite the large problems of waterlogging and soil salinity in canal irrigation systems in Rajasthan, efforts to control the problems (by further developing and adequately managing the existing drainage) seem to have been undertaken only at a modest scale or seem to be rather ineffective. Two main factors underlying this phenomenon can be identified: (1) The absence of an institutional framework that is targeted towards drainage development, and organisations that have clearly defined responsibilities and tasks, and (2) limited possibilities for drainage outfall. In Rajasthan, both government and farmers have restricted financial means to invest and to operate and maintain a drainage system. Clear relations of accountability and a system of cost recovery for operation and maintenance of drainage works are absent. At the same time, the technical and agro-ecological dimensions of waterlogging and salinity should not be overlooked. Would an effective drainage management be able to solve the problem of outfall in the IGNP?

\[45\] Next to the benefits for the farmers, the drainage systems result in negative effects on fisheries.
Drainage Development In Japan

Introduction

Japan is located in a temperate zone in the Asian monsoon area. The average annual precipitation in Japan’s capital of Tokyo, which is located almost in the centre of the country, totals around 1,405 millimetres. The topography is generally steep, although in the valleys and coastal areas also marshes and swamps are cultivated. Due to the climate, Japan has only one growing season, which is the summer period from May/June to September/October. The summer and the rainy season synchronise, and farming is a sometimes hazardous affair because of heavy rains causing inundation of fields or severe floods. In this context, drainage and flood control have been essential for agricultural development in Japan (Okamoto, 1997).

Already for centuries have farmers in Japan collectively taken up drainage and irrigation development through the ‘mura’ (traditional farmer organisations). This kind of farmers initiative appears to be partly provoked by force of the respective rulers. Be that as it may, the mura have provided the basis for today’s Land Improvement Districts (LIDs): Farmers’ bodies that largely manage irrigation and drainage facilities. What can be observed in Japan is a trend of scale enlargement with respect to the LIDs. This trend seems incited by the need to address the increasing gap between LIDs’ income and expenditure, and make operation and maintenance activities of LIDs more cost effective.

Drainage and irrigation development

Current status of irrigation

Japan has a cultivated area of around 4,776,000 hectares. Of this agricultural acreage, 3,128,079 hectares are irrigated, either with surface irrigation techniques (90%), sprinkler irrigation (8%) or micro irrigation (2%). Most of the irrigation water is drawn from surface water resources, although around 16% of the quantity of irrigation water is extracted from groundwater resources. Groundwater is generally used to supplement surface irrigation (FAO, 1999). Paddy is the staple food of the Japanese people, and it is this crop that covers the largest part of the agricultural area (Okamoto, 1997).

Institutional development

During the Edo era in the 17th and 18th centuries, ‘mura’ were established. Mura are traditional villages, and form the basis for the constitution of water users groups. The Edo era is characterised by a strong population growth, which again induced an expansion of the area of farmlands. Farmlands were developed by converting marshlands on the alluvial plains and by reclaiming land by draining sea and lakes. Mining and castle building technology was employed to control flows in larger rivers, reclaim land, and irrigate land. Simultaneously with this development, new villages and communities sprang throughout the country. The Edo government and feudal lords forced people to increase the production of rice to control the mura, and strengthened the control over the mura in order to produce more rice. They imposed a kind of land tax on rice crops. This tax was imposed on villages (mura) rather than on individuals. People comprising a mura were thus forced to work together in other to produce rice for paying the land taxes. In time, farmers in the mura constructed dams and irrigation canals. Later on,
several mura representatives organised and developed into a form of mura-federation representing several villages (Mizutani, 1991).

The Meiji era was founded in 1868 and the institutional basis of water management remained with the mura. From the start, a new administrative set up was introduced, which can be characterised by ‘scale enlargement’, i.e. the Meiji rulers organised new administrative towns and villages. By 1874, there were 80,372 villages. By 1888, the government had reduced this number to 13,347 villages. The expanded administrative areas undermined the nature and make up of the mura. Eventually, the mura based water users’ groups were separated from the administrative units of villages and towns. In 1890, the government decreed a Water Users’ Association Act, and in 1908 promulgated an Irrigation Association Act, which defined the role of water users’ associations (WUAs). The membership of these WUAs was limited to landowners and not to tenant farmers (Mizutani, 1991).

During the same period of time, the Meiji rulers continued to promote an increase in rice production. In 1899, the Arable Land Readjustment Act, and in 1902 the Hokkaido Reclamation Act (restricted to the Hokkaido area) were proclaimed. Both acts stipulated that farmers have to organise themselves into groups for the purpose of arable land readjustments, drainage, irrigation, repair of irrigation ponds, and more. The government was to provide for technical and financial assistance. Again, association members were landowners only. The associations managed the irrigation facilities after construction had been completed by the national government. All that time, landowners represented the mura and were supported by the mura which thus kept on playing the role of the irrigation water users community (Mizutani, 1991).

In 1949, the government proclaimed the Land Improvement Act. That same year, Land Improvement Districts (LIDs) were instituted. LIDs are farmer bodies largely responsible for operation and maintenance of irrigation and drainage infrastructure. Since the 1960s, the mura somewhat lost its importance in irrigation management due to the rapid spread of the commodity economy, the advent of part-time farmers, and the proliferation of non-agricultural workers in villages (Mizutani, 1991).

**Drainage technology**

In the steeper areas, run off caused by heavy rainfall generally flows down from catchment areas through main rivers and their tributaries to the sea, sometimes flooding valleys and plains. In these cases, flood control in river valleys and surface drainage in inundated areas are required. For cultivating paddy on marsh or swamplands, surface (open) drainage is also required. Similarly, paddy fields that are reclaimed from sea or lakes have a lower elevation than sea level and require surface drainage. In these cases, surface drainage is powered through pumping instead of gravity. Horizontal subsurface drainage is a common phenomenon in polders or for the prevention of soil salinisation. It is sometimes even used for paddy cultivation, because pipe drains improve the aeration of the root zone which again activates the function of the paddy roots and results in higher yields (Okamoto, 1997).

**Institutional framework**

**Central institutions for drainage**

Three ministries of the central government of Japan are involved in drainage development:

1. The Ministry of Construction:
   a) The River Bureau of the Ministry of Construction is responsible for the management of large scale, basin wide, flood control. This bureau manages flood control of rivers and issues water rights to irrigation associations, hydropower, domestic water supply, and industries on the basis of the River Law. Planning, construction, operation and maintenance of basin wide flood control related facilities
are all conducted and financed by the River Bureau or by prefectural governments. No farmer beneficiaries contribute in cash or kind;

b) Another bureau of the Ministry of Construction is responsible for the management of sewerage projects. On the basis of the Sewerage Law, this bureau supervises the planning, construction, operation and maintenance of sewerage facilities by city, town and village offices. The treatment of sewage is paid by the beneficiaries, while other costs are covered from general state revenue;

2. The Agency for Home Affairs: Small rivers or ditches that are not managed by central or prefectural governments are under the control of city, town or village offices. All costs are covered by general city revenue, with financial support from the Agency for Home Affairs;

3. The Ministry of Agriculture, Forestry and Fisheries: The Agricultural Structure Improvement Bureau of the MAFF is responsible for the construction and/or rehabilitation of main irrigation and drainage canals and structures. After completion of construction or rehabilitation, the responsibility for operation and maintenance of the entire infrastructural facilities (including pumps, gates, etcetera) is transferred to the respective LIDs (Okamoto, 1997).

**Construction**

The construction of land improvement projects in Japan can be classified into three types depending on the host organisation:

1. National Government construction;
2. Prefectural Government construction;
3. Corporation (municipal government or LID) construction (Mizutani, 1991).

Construction projects start with the application of the LID. The national, prefectural or municipal engineers often prepare the project plan and then notify the respective farmers (Mizutani, 1991).

**Operation and maintenance**

In Japan, the operation and maintenance of Land Improvement facilities are under the management of LIDs, prefectures, the Water Resources Development Public Corporation (WRDPC), the Ministry of Agriculture, Forestry and Fisheries (MAFF), administrative associations, and water users’ groups. Most of the basic facilities (involving areas of 20 to 200 hectares) are placed under the management of the respective LIDs. Irrigation facilities relating to more than two prefectures or two divisions of water users are put under the management of prefectures (involving areas of around 200 to 3,000 hectares), the
MAFF, and the WRDPC (generally when areas of more than 3,000 hectares are involved). LIDs can employ their own full-time or part-time staff (Mizutani, 1991).

Current status of LIDs – User participation

LIDs are comprised of farmer beneficiaries, and are principally concerned with operation and maintenance of irrigation facilities (86% of the LIDs take charge in these activities), and with the operation and maintenance of drainage facilities (68% of the LIDs take charge in these activities). By March 1990 there were 8,224 LIDs, having a total of 4.704 million members, which covered an area of approximately 3.288 million hectares. The LIDs vary in size from less than 100 hectares to more than 10,000 hectares. Both a trend of a reducing number of LIDs and a trend of an increasing average area covered per LID can be observed until 1990. Approximately 30% of the total number of LIDs overlap in coverage with each other. It is possible for small sized LIDs to function within larger LIDs. In such cases a division of tasks can generally be observed, and although one LID may not engage in construction of works, another LID covering that same area may take up construction.

Today’s LIDs experience several problems. First, the expenses for operation and maintenance have increased, while the level of fees could not keep up with this growth. The operation and maintenance expenses have increased for a number of reasons:

- The area for paddy has been restricted. This restriction has caused a reduction in the area of paddy, which again resulted in a reduction in the systems' water storage capacity. A higher rate of run off and more flood damage is the consequence;

- More (expensive) facilities with highly developed functions and technology have been constructed. Such facilities require more money to pay for specialised engineers, higher electricity charges, and higher repair and inspection charges;

- Labour costs have increased because of a shortage of free labour that full-time beneficiary farmers used to provide. More and more farmers turn to part-time farming and have less time available for operation and maintenance activities;

- There is an increasing number of facilities and structures to maintain, and there is an increase in urban spill. Both result in increased costs for maintenance. More facilities require more time for maintenance, while the urban spill (household and factory drainage effluent) flows to the farmlands. This water requires additional cleaning, and because of higher concentrations of nitrogen in the water due to the spill, the growth of algae and waterweeds is encouraged (further increasing maintenance requirements).

The level of collected revenue could not keep up with the increase in expenses for operation and maintenance because of:

- A restriction in the area with paddy production (reducing the income from taxes);

- A reduction in the official price of rice.

Secondly, small sized LIDs have lower engineering capacity, while the small number of staff is poorly paid. It seems that the size of these LIDs restricts their mode of operation, for which they seem destined to only engage in operation and maintenance and not in construction of land improvement works.
Furthermore, the Land Improvement Act needs to be re-examined to render it more responsive to today’s needs in integrated water management (Mizutani, 1991).

**Legal framework**

After the Second World War, the occupation-forces introduced a land reform. In this land reform, the government forcibly bought arable lands from large landowners and sold the same at low prices to tenants and small landholders. Landholdings were generally limited to an area of 3 hectares. In support of the land reform, the Land Improvement Act abolished the pre-war Irrigation Association, the Arable Land Readjustment, and the Hokkaido Reclamation Association and placed instead the LID, with only farmer members.

After having undergone several modifications, the Land Improvement Act of 1949 is still the main law in Japan dealing with drainage. One of its dominant features is that it enables the constitution of LIDs.

A LID can be formed anywhere and at any time upon petition of at least fifteen farmers. Once approved by the governor, the LID is a public corporation treated as any other autonomous body:

- A LID is granted the right of collection of members’ fees;
- The election of LID officers or representatives is subject to the supervision of the municipal Election Administration;
- Erring LID officers are punishable as though they are civil servants;
- Revenues and assets of LIDs are exempted from national and local taxes (Mizutani, 1991).

The LIDs are legal farmer bodies, which are organised according to the provisions of the Act. All farmers can be extended membership. The major concern of a LID are the operation, maintenance, and management of irrigation and drainage facilities, as well as the construction of irrigation and drainage projects, farm readjustment and reclamation (Mizutani, 1991).

**Financing drainage**

In the recent past, between 50 and 80% of all expenses involved in land improvement construction projects were born by the national and prefectural governments. The balance used to be born by the farmer beneficiaries. Expenditures for the operation and maintenance of irrigation, drainage and other facilities were without subsidies from either the national or prefectural governments. These expenses were to be entirely covered by the ordinary annual fees collected from the farmer beneficiaries. These fees were generally determined in proportion to the areas of land of the respective members. A few LIDs determined the fees based on the quantity of water used (Mizutani, 1991).
Today, the costs involved in operation and maintenance of irrigation facilities are still largely born by the beneficiary farmers as a ‘water charge’. But, drainage facilities have been recognised to serve not only private interests, but also serve public safety and welfare. Consequently, today the central and/or prefectural governments bear all costs involved in construction, operation and maintenance of drainage facilities. These expenses are covered from general state revenue (Okamoto, 1997).
Drainage Development In Pakistan

Introduction

Vast tracts of Pakistan’s agricultural land are irrigated through water which is supplied by systems of canals. These systems are experiencing increasing problems: Large-scale occurrence of waterlogging and salinity, inequitable water distribution, low efficiency in water delivery and use, and insufficient cost recovery. To enhance agricultural production in Pakistan and to make farming more sustainable, major irrigation sector reforms have been proposed and are initiated. The adopted strategy for the reforms is Participatory Irrigation Management. Irrigation water is to be commercialised (and later on to be privatised), and irrigation management is to become decentralised wherein farmer organisations will be principally responsible for system operation and maintenance, and act in a financially autonomous way.

Drainage development has so far been inadequate. The protective irrigation systems of Pakistan have initially been developed without provision for drainage. This subsequently resulted in rising groundwater tables and problems of waterlogging and salinity. The problem of inadequate drainage has been aggravated by the construction of numerous canals, roads and other infrastructure obstructing lines of natural drainage. Starting already in the 19th century, measures have been taken to lower or control water table levels. The most important action taken to control groundwater levels, was the initiation of SCARP (Salinity Control and Land Reclamation Project) deep public tubewells to provide for vertical subsurface drainage. The measures, however, have yielded only local or temporary relief.

Will the irrigation sector reforms enhance the performance of drainage in the irrigation systems? Thus far, it appears that farmers have basically learned to cope with their particular situations and have developed strategies to deal with variations in water supply and inadequate drainage to the best of their abilities. The reforms have just taken off and have scarcely progressed beyond the establishment of Provincial Irrigation and Drainage Authorities and the enforcement of legislation that somewhat facilitates farmer participation in system management. Drainage performance doesn’t seem to have improved as a consequence. Furthermore, the question arises whether irrigation sector reforms based on productive irrigation can be applied to protective irrigation?

Irrigation and drainage development

The climate of Pakistan is semi-arid to arid, and irrigation is considered essential to maintain levels of adequate agricultural production (Croon, 1997). Figures presented by the Food and Agriculture Organisation of the United Nations, indicate that Pakistan has a cultivated area of around 16.56 million hectares, of which some 15.73 million hectares are irrigated. Almost 1.5 million hectares are irrigated through spate irrigation (FAO, 1997), while most of the irrigated area is supplied with water through surface canal systems. Pakistan has the distinction of having the largest contiguous gravity flow irrigation system in the world; the Indus Basin Irrigation Systems or IBIS (Asrar-ul-Haq et al, 1999). The IBIS covers a gross area of 16.8 million hectares, of which some 14.2 million hectares are culturable (Tarar, 1995). Not surprisingly, surface water resources are utilised to irrigate most of the area, although groundwater resources are also essential for they supply water to irrigate some 34% of the irrigated area (FAO, 1997).
**Protective irrigation**

The initial development of the canal irrigation systems took place under the auspices of British colonial administrators and engineers. Since the Indus tributary rivers were easier to control than the Indus itself and because the extensive areas between the tributaries are generally flat (slopes of approximately one foot per mile\(^{46}\)), the areas in Punjab were the first to be developed for large-scale canal irrigation (Lieftinck et al., 1968). The canals in the Indus Basin are designed to minimise both scouring as a result of steep gradients and sedimentation as a result of insignificant slopes. Irrigation in Pakistan is generally based on the concept of ‘protective irrigation’, i.e. irrigation is designed to prevent crop failure by spreading water over a large area and thus optimising crop production per unit of water, rather than optimising crop production per unit of land. Average crop yields per unit of water in Pakistan are among the highest in the world (Bhatti et al., 1991, in: Wolters and Bhutta, 1997).

The embedded element of water scarcity is a crucial factor in the determination of the nature of the irrigation service that can be provided by the system. Water is delivered through a conveyance network, maintaining levels of full flow in the main canal infrastructure. In times of water scarcity, however, a rotational supply is employed. During the development of the systems in the 19\(^{th}\) and 20\(^{th}\) centuries, this system of rotational water distribution was applied more and more, since more and more tertiary units were connected to the canal infrastructure. Farmers could connect to canals by application and construction of minor conveyance canals and temporary embankment cuts or outlets. Moreover, tertiary units were developed or enlarged and the cuts were enlarged consequently. There were no tight controls on the size of the outlets or cuts. Timing and duration of water supply is largely left to the discretion of canal officers (Halsema, forthcoming). In general, it can be observed that water in large-scale canal systems in Pakistan is not distributed in an equitable way. For the rotational supply of water in Indus Basin systems to be equitable, two elements are crucial: (1) The flow of water in a watercourse should be at a constant rate, and (2) a uniform flow rate among the different watercourses is necessary. Bandaragoda (1998) observes that these both criteria, however, are at stake.

**Need for drainage**

In order to economise on construction costs and because pre-irrigation groundwater tables were very low, the systems of irrigation canals in Pakistan were initially developed without provision for drainage. Persistent seepage from unlined canals and percolation from irrigated fields over the years caused the groundwater tables to rise dramatically. Waterlogging and soil salinisation were the consequences of this rise, and today there is a large need for drainage to prevent further salinisation and waterlogging (Tarar, 1995). Asrar-ul-Haq et al. (1999) report that approximately 6% of the gross canal command in Pakistan is severely affected by salinity, about 8% is moderately affected, while around 30% of the gross canal command suffers from waterlogging and that some 14% of the gross canal command area can be considered as highly waterlogged. Unfortunately, due to the construction of infrastructural facilities (such as roads, railways, flood embankments and irrigation systems) and due to the flat topography of the Indus Plains, both surface and subsurface natural drainage has been restricted (Tarar, 1995).

By 1993, the artificially drained area in Pakistan covered some 6 million hectares. As from 1993, another 2.2 million hectares have been considered for or supplied with drainage facilities through ongoing projects (Tarar, 1995).

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\(^{46}\) A slope of 1.0 foot per mile approximately equals 0.2 metres per kilometre.
Institutional arrangements in drainage: Pakistan

**Executing drainage**

Traditionally, salinity has been associated with irrigated agriculture in the Indus Basin. Often salinity was considered to be linked to waterlogging and the rise of the groundwater table, which occurred as a result of large-scale perennial irrigation. However, the causes of salinity are more diverse. Three main causes have been identified: (1) Genetic salinity due to weathering of parent material, (2) rising groundwater tables displace salts and bring them into the rootzone through capillary rise, and (3) salinisation occurs through the use of poor quality groundwater, which is extracted with private and public tubewells. In order to control salinity, measures taken by the Government of Pakistan have largely focussed on controlling groundwater table levels with the idea to contain the salinisation process. These measures included the prevention of seepage through canal lining (from 1895 onwards), tree plantations, surface and interceptor drains (from 1930 onwards), irrigation management (lowering of full supply levels in canals and temporary canal closures from 1930 onwards), and vertical drainage through tubewells from 1940 onwards (Ahmed and Chaudry, 1988, in: Kuper, 1997). However, none of these measures provided more than local or temporary relief (Asrar-ul-Haq *et al*., 1999). All in all, vertical drainage was considered to be the most effective measure.

**Drainage technology**

Agricultural drainage in Pakistan is irrigation induced. It is carried out using either vertical drainage (tubewells), surface drains or pipe drains (subsurface drains). Tubewell technology and surface drains are by far the most adopted means of drainage. Subsurface drains cover ‘only’ some 220,000 hectares (NESPAK *et al*., 1995, in: Asrar-ul-Haq, 1999).

Horizontal pipe drainage is a relatively recent phenomenon in Pakistan. The first pipe drainage project started in 1977 in East Khairpur. Since then, a number of horizontal pipe drainage projects have been undertaken, among which the Mardan, Faisalabad, Chashma, Mawab Shah, and Khushab projects. The standard layout for these projects is a system of laterals that discharge into collectors, through which the drainage effluent is transported to sumps. From the sumps, water is pumped into shallow open surface drains. Sometimes, gravity outlets instead of pumps are used. Soil and geohydrological conditions can be such that horizontal pipe drainage is the only feasible means of lowering the groundwater table and controlling waterlogging and salinisation. The groundwater can be too saline to be used as a supplementary source of irrigation water. However, pipe drain depth and unstable soils make high demands on machinery and operators (Achthoven and Mirza, 1992).

The drainage of agricultural lands by means of tubewells is a twentieth century development and, hence, a recent one in relation to the long history of irrigation. Pumping of water for any purpose from depths greater than those to which open wells can be dug, has paralleled the development of centrifugal and turbine pumps. Tubewells offer an attractive facility for dewatering large areas of land, wherever the geologic and hydraulic characteristics of the aquifer are favourable. In Pakistan soils are generally medium textured, well permeable and underlain by permeable aquifers which often contain good quality water. These conditions favour vertical drainage (Wahab F. Sheikh, 1992).
Tubewells are used to extract groundwater and control the groundwater table levels. In areas with fresh groundwater, the extracted water can be used for irrigation, while in areas with saline groundwater the drainage effluent is discharged into water bodies. Presently, the country’s drainage infrastructure comprises 14,500 kilometres of surface (open) drains, around 12,700 public tubewells in fresh and 2,500 public tubewells in saline groundwater areas, 560 kilometres of interceptor drains, and tile drainage serving an area of approximately 220,000 hectares. There are over 400,000 private tubewells operating in fresh groundwater areas (Asrar-ul-Haq et al., 1999).

Disposal and reuse of excess water

Apart from the Left Bank Outfall Drainage Project, all drainage effluent is reused or recycled, in one form or another, within the canal irrigation systems. It has been estimated that 28,000,000 tons of salt are being added to the system every year (Mohtadullah, 1997, in: Asrar-ul-Haq et al., 1999). The total annual saline drainage effluent is anticipated to be 13.2 billion cubic metres (BCM). It is proposed to dispose off 1.7 BCM into canals, 2.9 BCM into rivers, 1.4 BCM into ponds, and about 7.2 BCM into the sea (Asrar-ul-Haq et al., 1999).

Institutional development

(main source: Van der Velde and Tirmizi, 1999)

Emergence and development of WAPDA as pre-eminent water sector agency

The first post-Independence crisis in West Pakistan had its base in the need to replace water supplied by the Eastern Punjab rivers Sutlej and Ravi, which were now controlled by India. An engineering solution was sought by constructing large trans-basin canals to transfer water from Indus tributaries in Western Punjab and so to replace the lost flows. Enormous capital was required for this undertaking and the World Bank, itself seeking a major development finance capital undertaking to confirm its reputation, became the primary lender. During the same period of time (1950s and 1960s and into the 1970s), the Water and Power Development Authority (WAPDA) was established (1958) as the agency responsible for coordination of design, construction and initial operation of the planned engineering works. WAPDA subsequently emerged as the pre-eminent national agency for the execution of all new water sector projects in Pakistan. No longer was the West Pakistan Irrigation Department the prime irrigation institution in the country. Many of Pakistan’s most promising and ambitious bureaucrats, civil engineers and other professionals were attracted to WAPDA for their careers. This resulted in a slow decline in quality and professionalism of the officer cadre comprising the West Pakistan Irrigation Department and the Provincial Irrigation Departments (PIDs).

Tackling waterlogging and salinity through SCARPs

Although not at all new phenomena to farmers and administrators, only by the early 1960s the extent and serious consequences of widespread waterlogging and salinity in the IBIS were beginning to be recognised and viewed as primary threats to the massive financial investments. Once more, a technological engineering solution and the required capital for its implementation, was sought (Van der Velde and Tirmizi, 1999). One of the tasks of WAPDA was and is to reverse the trend of increasing waterlogging and salinity. In the period 1960 to 1966, the WAPDA launched some 51 SCARPs (salinity control and land reclamation projects), involving the provision of vertical drainage to large areas (Croon, 1997). The World Bank provided the loans for the initiation of the first SCARP. The Bank remained the principal lender to Pakistan for the subsequent SCARPs. WAPDA was responsible for the design, construction, initial operation and monitoring of the deep tubewell projects, but the PIDs were responsible...
for the continuing operation and maintenance of the SCARPs. This had several unforeseen institutional consequences over the next two decades:

- Next to the cadre of civil engineers, traditionally comprising the Provincial Irrigation Departments, a new cadre of mechanical engineers came into being. While the civil engineers remained dominant in the canal related works as well as in the bureaucratic ranks of the departments, the mechanical engineers formed a minority that operated from separate administrative field units. As a result, canal and tubewell operations were rarely if ever coordinated for effective conjunctive use of water;

- Within SCARP areas, PID officers and non-professional field staff now had visible and active roles at the tertiary level, because this is where the tubewells were pumping water to supplement the canal water supplies. Before the SCARPs, these people had largely been confined to works above the (secondary) canal outlets;

- The financial consequences of operation and maintenance of the SCARP tubewells, had the most serious impact on the PIDs, particularly in the Province of Punjab. The annual costs involved in operation and maintenance of the large number of deep tubewells were enormous, not least because tubewell life expectancies proved to be less than half as estimated in the first SCARPs. By the early 1980s, the rising annual costs for operation and maintenance exceeded one-half the budget of the Punjab Irrigation Department and put a strain on the operation and maintenance of canal systems. The financial burden of operating and maintaining public tubewells became unsupportable.

**Diminishing control of the PIDs**

From the mid-1960s to the mid-1970s, research was carried out in central Punjab canal commands. The studies revealed that dilapidated and poorly maintained water distribution infrastructure at tertiary level (below watercourse outlet) was responsible for a significant portion of overall system water losses. This was especially the case in general canal commands where SCARP tubewells were established without provision for watercourse remodelling. The water losses contributed to the growing problems of waterlogging and salinity, and were a primary cause for shortages in tail-end water supplies. In 1976 a USAID-assisted pilot On-Farm Water Management Project (OFWMP) was implemented to demonstrate the effect of improved watercourses and farm water management (through agricultural extension). However, the PIDs, notably the Punjab ID, rejected to implement the pilot project. On Farm Water Management Directorates were established under the Provincial Agriculture Departments (PADs). As became more evident over time, this would erode the PIDs’ influence and control over water distribution at the secondary/tertiary irrigation systems interface. A nation-wide series of OFWMPs were funded by the World Bank, the Asian Development Bank, and bilateral assistance programmes. While the PIDs’ budgets for operation and maintenance were increasingly strapped through the 1980s and into the 1990s, vigorous and well funded OFWM Directorates emerged in the provinces. Again, the PIDs primacy in irrigation matters was challenged. Farmers were to participate in the physical works and were to remain as the primary contact point for continuing agricultural extension activities. To achieve this, WUAs were formed, and they were provided a legal basis through adoption of legislation in all four provinces.
Although the work of the WUAs was largely sustained as long as necessary to complete watercourse improvements, their appearance and encouragement marked a significant shift in irrigation policy.

The onset of today’s irrigation and drainage sector reforms in Pakistan

In order to address the problems of waterlogging and salinity, low efficiency in water delivery and use, inequitable water distribution, and insufficient cost recovery, the World Bank argued for irrigation water to be commercialised and later to be privatised instead of treating irrigation water as a public good. The Bank outlined a strategy for the phased implementation of such changes in irrigation policy, which included:

- Enabling legislation on water rights, quality and markets;
- Pilot projects at canal command level and setting up public utilities;
- Promotion and development of Farmer Organisations (FOs);
- Organising and strengthening provincial water authorities, and strengthening federal water agencies.

These policy changes were outlined in the World Bank document: “Pakistan Irrigation and Drainage: Issues and Options” (1993). This document is generally understood to be at the basis of the current irrigation reform in Pakistan, although hindsight suggests that the trend in this direction was already fairly well established by the early 1990s. In this, the SCARP Transition Project (phasing out of the deep public tubewells, see box 7.1) was important. The intended vehicle for transforming irrigation and drainage policy in Pakistan is the National Drainage Programme (NDP). See box 7.2 for a brief description of the NDP.

A feasibility study was carried out and it proposed major remodelling of the physical irrigation and drainage system of the Lower Bari Doab Canal (LBDC) system in the context of institutional changes. Those changes included a greatly enhanced role for organised farmer participation at all levels of the system’s operation and maintenance, as well as cost recovery to sustain system requirements. Key elements in this institutional strategy included granting land-owning farmers specific rights to water, farmer participation in hydraulic unit remodelling, transparency in water distribution within the hydraulic unit, and granting the union of watercourse associations (WUAs) a long term concession to operate, maintain, and develop its irrigation and drainage infrastructure. The changes proposed by the LBDC study finally emerged in 1995, along with news of a draft enabling legislation of the Government of Pakistan that involved a strategy for decentralising and transferring management of the IB irrigation and drainage systems. The legislation envisaged a transformation of the PIDs into autonomous Provincial Irrigation and Drainage Authorities (PIDAs), system level management to be decentralised from PIDAs to newly created Area Water Boards (AWBs), while at farmer level water users would be encouraged to engage in an increased management role through water users or farmer organisations (FOs).

The details of the feasibility study and the news of a draft legislation resulted in a firestorm of criticism, which centred around the issues of privatising canal systems and separating land from water so that the latter could be sold or traded as a commodity. The Punjab Irrigation Department rejected the LBDC feasibility study, and it was joined by the other PIDs in its opposition to the institutional reforms. A long and chaotic discussion unfolded. Among the donors the issues of cost recovery and new participatory institutions apparently were more important than any others, while on the Pakistani side any appearance of ‘privatisation’ was an anathema and there was a pragmatic appreciation for the amount of foreign exchange at stake in the proposed US$ 750 million financing for the NDP. Under pressure of multi-lateral donors (the two major donors being the World Bank and Asian Development Bank) the Government of
Pakistan, which at this point in time was an interim government, secured the provincial agreements and PIDA Ordinances were notified in early 1997, subsequently replaced by formal PIDA Acts that were passed by the provincial assemblies and notified by mid-1997\textsuperscript{47}.

**Box 7.1: SCARP deep public tubewells in Punjab**

The SCARP (Salinity Control and Land Reclamation Projects) programme installed 9,800 public deep tubewells in the Punjab during three decades, of which 8,000 were in areas with fresh groundwater. The tubewells were generally installed at the head of tertiary irrigation canals. The development of public deep tubewells was soon followed by private investment in (individually owned) shallow tubewells, especially after locally manufactured inexpensive high speed diesel powered pump-engines became available. In fact, by the early 1990s, an estimated 34\% of the total water supplies (groundwater and surface water) in the Punjab was contributed by private shallow tubewells and another 8\% by public SCARP tubewells (Steenbergen, …).

However, the performance of the SCARP deep tubewells deteriorated and by 1995, an estimated 80\% of the deep tubewells were either out of order or operating at 50\% of their original discharge (Steenbergen, …). This high rate of tubewell performance deterioration was partly due to deficiencies in design and construction, and partly due to a lack of maintenance. Coupled with the uneven performance of the SCARP tubewells, is the financial burden (Wahab F. Sheikh, 1992). The costs for operating the deep tubewells became prohibitive. Furthermore, there were doubts with respect to how wise it is to extract relatively saline deep groundwater, when shallow groundwater is usually less saline (Steenbergen, …).

The failing performance of the deep tubewells, their heavy burden on the budget of the Provincial Irrigation Department, and the questioned practice of pumping relatively saline deep groundwater to the surface, prompted the Government of Punjab to start phasing out the public tubewells in 1986. Closure of the deep tubewells was promoted, since there was virtually zero interest among the farmers to take over the public deep tubewells: The turbine pumps were difficult to repair and electricity was not the preferred source of energy because of the low diesel price and the considerable ‘hassle factor’ (Steenbergen, …).

To compensate for the loss of drainage capacity and irrigation supplies, farmers were

\textsuperscript{47} See Van der Velde and Tirmizi (1999) for an extensive account of the policy reforms in Pakistan’s water sector. See section 7.8 for an explanation of the troublesome implementation of the policy reform and its limited success to date.
enabled to develop shallow tubewells in the areas where SCARP tubewells were closed down. Until 1994, the policy was to support development of individually owned shallow tubewells. Then it was recognised, however, that this was disproportionately benefitting medium and large scale farmers. Since these farmers were considered able to ‘help themselves’ in developing tubewells, individual tubewell development was abandoned and the focus shifted towards developing community tubewells (Steenbergen, …).

Development of community tubewells is done in the Second SCARP Transition Project and the Punjab Private Groundwater Development Project, where farmer groups managing shallow community tubewells are created. These new tubewells were supposed to discharge in the water course, as was the case with the deep SCARP tubewells. Farmers, who selected their own groups, established the community shallow tubewells. Construction costs were subsidised (50 – 70%). All costs for operation and maintenance are for the farmers (Van Steenbergen, …).

**Box 7.2: The National Drainage Programme: Pakistan’s water sector policy reforms**

As a follow up of the Drainage Sector Environmental Assessment (1991) study, the GOP planned to launch a major drainage programme: the NDP. It aims to restore the sustainability of environmentally sound irrigated agriculture by minimising the drainage surplus and its eventual evacuation to the sea (Asrar-ul-Haq *et al.*, 1999). In the NDP, the key institutional changes and irrigation reforms were to be initiated first. Only then would the major funding for additional engineering works be forthcoming to repair the severely decayed physical fabric of the irrigation system and to create new drainage infrastructure to make it more sustainable (Van der Velde and Tirmizi, 1999). The programme is multi-phased. The first phase (NDP-I) has been conceived and planned, and is to be implemented in the period 1998 to 2004. The estimated costs of 785 million US$ are financed with assistance of the WB, ADB and OECF of Japan. The investment component under NDP-I is to finance new drainage schemes, rehabilitation and modernisation of off-farm and on-farm drainage, modernisation of canal commands, and O & M of drainage projects through performance contracts. So far, the start of the project experienced one year’s delay and the pace of implementation in the first year has been quite slow (Asrar-ul-Haq *et al.*, 1999).

**Institutional framework**

*Provincial Irrigation and Drainage Authorities*

From the PIDA Act of Balochistan (1997), it becomes clear that PIDAs are overall responsible for planning, design, construction, rehabilitation, maintenance and operation (including disposal of drainage
Institutional arrangements in drainage: Pakistan

effluent) of irrigation, storage reservoirs, drainage and flood control facilities. In conjunction with the Provincial Government, PIDAs are to determine drainage cess or other entities for the conveyance and disposal of drainage effluent, payable by Area Water Boards (AWBs). The PIDA Act of Balochistan is used here to illustrate the general character and content of the four PIDA Acts. However, Van Steenbergen (…)notes that in comparison to the acts of Sindh, NWFP and Balochistan, the PIDA Act of Punjab is less far reaching and more conservative. The Punjab-IDA Act does not describe the functions of FOs in system management and revenue collection, and merely mentions that the Government may establish such FOs.

The PIDA in Balochistan is to facilitate and promote formation and development of AWBs and Farmer Organisations (FOs), and to ensure orderly and systematic induction of the AWB and FO activities into the operations of the PIDA. PIDA’s funds consist of revenue collected (water charges, drainage cess, sale proceeds, etc.), Government grants, Government loans, Local Bodies grants, sale proceeds of bonds or any other debt instrument, foreign assistance and loans, etcetera.

Within a period of 7 to 10 years (thus, before the year 2003 to 2006), the PIDA, the AWBs and the FOs have to become financially self sustaining (autonomous) entities, with respect to O & M costs involved in irrigation and drainage. PIDA’s, AWBs’ and FOs’ income to cover the O & M costs, is to be provided through levying water charges (irrigation) and drainage cess. For irrigation canals and secondary drains the full 100% of O & M costs is to be covered. The operation and maintenance of flood protection and public sector fresh groundwater tubewells will be excluded from ‘abiana’. If the PIDA feels it is required, PIDA is allowed to recover from farmers 5% of the O & M cost of main drains or public tubewells in saline groundwater areas.

The PIDA Act of Balochistan enables the establishment of Area Water Boards, be it first on a pilot project scale, with the intention to later on transfer this institutional measure to all major canal commands in the province. The government forms the AWBs. An AWB in Balochistan is composed of the following people: Four farmer representatives from FOs, one PIDA representative, one director agriculture ex-officio, two technocrats, one director of the AWB ex-officio, and one Government representative ex-officio. The AWB shall: (a) Formulate and implement policies for the effective, economical and efficient utilisation of irrigation water at its disposal, (b) ensure its financial autonomy within a period of 7 to 10 years, (c) plan, design, construct, operate and maintain the irrigation, drainage and flood control infrastructure located within its territorial jurisdiction, (d) adopt and implement policies aimed at promoting formation, growth and development of Farmer Organisations.

The PIDA Act of Balochistan also enables the establishment of Farmer Organisations, be it first on a pilot project scale, with the intention to later on transfer this institutional measure to all minors/distributaries. In conjunction with the PIDA, the AWBs are to form the FOs. PIDA and the AWB concerned are to enable a FO to become financially self supporting and self sufficient within a maximum of seven years. The FO shall: (a) operate, manage and improve the irrigation and drainage infrastructure comprising minors, distributaries and drains within the area relevant to the FO concerned, (b) obtain irrigation water from the PIDA or AWB concerned at the head of the distributary and to supply the same to the FO-
members and other water users, (c) receive drainage effluent from their water users and to convey the same through field and collector drains to the designated points, (d) collect the agreed water charges and other dues (if any) from the water users, and pay PIDA or an AWB for the supplied irrigation water and conveyance/disposal of drainage effluent, (e) hire consultants or employees as may be deemed necessary.

Farmers’ participation in drainage development

Apart from the three farmer organisations (FOs) within the FESS pilot programme (see following section) no FOs, or Area Water Boards (AWBs) for that matter, have actually been set up and are operating and maintaining drainage within the scope of the PIDA Acts. However, some other pilot FOs have been set up. For example, some pilots are initiated in the Punjab and Sindh with the assistance of the International Water Management Institute (IWMI). Within the National Drainage Programme, plans exist for financing and constructing subsurface drainage systems with farmers’ cooperation. It is assumed that the reason for the rather slow take off of the constitution of FOs and AWBs is related to the fact that the PIDA Acts have been passed in a relatively high speed. Previous institutional arrangements do therefore still function next to the new institutional arrangements. Civil servants still use the old rules to organise their work, i.e. WAPDA is still largely responsible for construction, and for operation and maintenance of drainage systems until some two years after construction, while Provincial Irrigation and Drainage Authorities are responsible for operation and maintenance after the two years. Today’s period of time can thus be characterised as a ‘period of transition’.

Box 7.3: Experiences with farmers’ participation: FESS

The FESS Project

The Fordwah Eastern Sadiqia South (FESS) Irrigation and Drainage Project started in 1994. The project involves irrigation and drainage development in an area of some 120,000 hectares in the south-east of the Province of Punjab. This particular agricultural area has been subject to the effects of decades of (over)-irrigation and seepage of water from irrigation canals. In some areas, the groundwater table has risen to almost ground surface resulting in waterlogging and increased groundwater salinity. The FESS Project aims to implement measures to more effectively use available irrigation water, avoid waterlosses, and bring down the level of the groundwater table. The measures include the construction of open drains, interceptor drain trial sites, subsurface drain trial sites, construction of interceptor drains, and the preparation of phase II including subsurface drainage (FESS, 1997, and FESS, 2000).

In the scope of the FESS Project, a pilot programme for farmer-managed interceptor-cum-subsurface drainage systems (ICSDs) has been implemented between 1st April 1998 and 30th June 2000. The pilot is financed by the World Bank. In April 2000, three ICSDs were handed over to farmer organisations (FOs), which have been set up as a part of the pilot. The three sites cover an area of around 580 hectares:

- Farmers select the beneficiaries, i.e. compose the FOs;
- Prior to construction, farmers were to pay 15% of the costs of constructing the ICSDs. They contributed Rs. 2,250 per acre (= 0.4 hectare) and after calculation of the actual costs for construction, it turned out the farmers had paid just over 10% of these actual costs;
The government hired a contractor to construct the system. Throughout the period of construction, the project engineers, the social unit of the project and the contractor responded to farmers’ questions and requests. As such the farmers had a say in the final system lay-out, and received practical training in operation and maintenance;

The ICSDs are handed over to the FOs after approval of all involved parties;

After handing over the ICSDs, their operation and maintenance is the full responsibility of the farmers;

The FOs install/appoint their own officials;

FOs calculate the annual expenses for operation and maintenance and charge each member, collect revenue, pay for the operator, purchase necessary tools and diesel, and determine the number of hours of pumping per day or per season. By the end of the pilot project, the FOs planned to charge some Rs. 300 per acre per year for operation and maintenance;

Through monitoring groundwater levels in several piezometers, which were installed in the scope of the pilot programme, it has been observed that groundwater levels at the three sites decreased by 2.3 to 3.25 feet (FESS, 2000).

These FOs function adequately so far, although farmers appear not to be very eager to cooperate with government agencies, since these are regarded not to operate to the farmers’ benefit. Furthermore, farmers are not particularly interested to officially register the ownership of the ICSDs, because this is not expected to yield any benefit such as improved services, advise, or assistance in major maintenance works.

The ‘success’ of the FESS Pilot Programme with establishing FOs for drainage development, although very young, is based on several distinct features:

- The ICSDs cover relatively small areas and have well defined and clear boundaries;
- In their functioning, the FOs are not dependant on any other FO, the government, or an inadequately functioning drainage network;
- The PIDA has agreed on a direct access to an irrigation canal in order to dispose of drainage effluent;
- The farmers have selected their own beneficiaries, i.e. FO members;
• Farmers have recognised the importance of good functioning drainage. This recognition can be characterised as the ‘engine of collective action’;

• During a period of months, farmers have been able to see to the construction and functioning of the ICSDs.

As for increasing farmers’ involvement in construction, operation and maintenance of drainage systems, the following general ‘hindrances’ can be distinguished:

• Lack or unreliability of irrigation water supply is often experienced by farmers as more prominent;

• Pumping drainage water (to dispose of it or in vertical drainage) is costly, for example as a result of the use of diesel;

• The link between drainage and its benefits are not exclusive. Farmers wonder why they should maintain a drain that (also) benefits farmers upstream, or they wonder about the consequences of other farmers not contributing to maintenance of drains. This seems to be a classical problem of ‘free-riding’: Whenever one person cannot be excluded from the benefits that others provide, each person can be motivated not to contribute to the joint effort, but to free-ride on the efforts of others.

Coping with circumstances

Farmers in the IBIS in Pakistan have thus far had to deal with poor delivery and distribution of irrigation water, and limited opportunities for disposal of excess water. And they do cope in many different ways. This section presents an example of how farmers manage excess water and use it to their benefit, and an example of how farmers manage problems with salinity and sodicity.

Managing excess water: Farmers’ strategies in Sheikh Yousaf Minor

Overall water supply in the command area of Sheikh Yousaf Minor (Lower Swat Canal in North Western Frontier Province, Pakistan) is generous to abundant. The system of *warabandi*\(^{48}\) has been modified by the farmers to handle the excess water supplies (Halsema, 1997).

The Lower Swat Canal (LSC) system is one of the first irrigation systems in Pakistan for which an extensive drainage network has been constructed. With the completion of the Mardan-SCARP project in 1992, the LSC became a good example of a system where irrigation and drainage are fully integrated. The drainage network comprises both surface and subsurface drainage; every branch, distributary and minor

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\(^{48}\) *Warabandi* can briefly be described as a proportional time allocation in canal water supply, i.e. water is supposed to be supplied in a fixed flow rate (canal water level) for a certain period of time, at a certain time, and is proportional to the area served. This rotational system of water distribution is employed in the large-scale protective canal irrigation systems in Pakistan. Protective irrigation is characterised by an embedded water scarcity, i.e. less water is supplied than required for optimising crop production per unit of land, rather, crop production is optimised per unit of water.
canal is complemented by an open secondary drain (some 4 to 5 metres deep). At the tertiary level, around 29,000 hectares of culturable command area were provided with a subsurface drainage network of quaternary laterals and tertiary collectors (Harza-Nespak, 1985, in: Halsema, 1997). These collectors discharge directly into the open secondary drains. In addition to the subsurface drains, every tertiary unit possesses ample facilities for diverting excess water into open secondary drains through the surface drainage system. It is not always clear which channels are used for water distribution and which are used for drainage. Every tertiary unit possesses a dense network of surface channels that can be used either for irrigation or drainage purposes, and at various points in the network water can be readily disposed into the secondary drainage network outside of the tertiary unit (Halsema, 1997).

In general, the farmers of Sheikh Yousaf Minor command appear to be managing excess water throughout most of the year very effectively. They make full use of all available means, adapting their strategies to meet the excess water conditions they encounter. Halsema (1997) observes that the variability of excess water throughout the irrigation season, in conjunction with opportunities for drainage leads to three basic modes of water management:

1. During the hot summer water is still not perceived as being in excess, although supply significantly exceeds requirements. All excess water is drained passively, and perhaps unconsciously by percolation from over-irrigated crops into and through the subsurface drainage system;

2. During times of perceived excess, water is actively managed through the surface drainage system. This is primarily based on ‘classifying’ irrigation water as excess and diverting that portion of its flow into a surface drain. Since surface drainage facilities are available throughout each tertiary unit, this activity does not require group operation and can be characterised as ‘individualised action’. Farmers have established effective rules concerning the use of surface drainage water within a tertiary unit. This use of ‘extra’ water enhances the irrigation management options for individual farmers, resulting in a more flexible water distribution among farmers for much of the year. Night irrigation can be abandoned completely during the start of rabi season;

3. At times of heavy rainfall when excess water becomes an acute threat to crops and during times of low crop water requirements, the amount of excess water is reduced by manipulating the rate of canal water supply at the outlet. Managing excess water by closing watercourse outlets requires the possibility for water from the tail of the canal to be directly diverted into a drain. If such a facility does not exist, water levels at the tail will rise dangerously, threatening farms and settlements located there.

In addition to the above, it is important to recognise that the context of drainage in irrigation projects in NWFP differs considerably from the Provinces of Punjab and Sindh, where water supplies are generally
far less abundant\(^{49}\) and lack of slopes and many man-made obstructions seriously inhibit the drainage of excess water.

*Managing salinity and sodicity: Farmers’ strategies in watercourse 14-R on the Fordwah distributary*

Kielen (1996) describes how farmers have a good set of physical and crop appearance indicators to recognise and classify soil salinity and sodicity, as well as classifying the types of irrigation water. However, farmers do not necessarily use this knowledge to form a strategy to reduce the salinity and sodicity levels in their entire farms. This strategy depends on the global farming objectives, possibilities and constraints set by the farming system.

**Legal framework**

Pakistan consists of four provinces: Balochistan, Sindh, North Western Frontier Province (NWFP), and Punjab. For all four provinces, Provincial Irrigation and Drainage Authority Acts were issued in 1997. These Acts winded up the Provincial Irrigation Departments and replaced these with Provincial Irrigation and Drainage Authorities (PIDAs). These new authorities have the task to become financially autonomous within ten years, for which they will have to initiate a number of cost-reducing and revenue-increasing measures. The closure of public deep tubewells is one of these measures. More important, the Acts create the possibility of transferring irrigation and drainage system management at distributary and minor level to farmer organisations (Van Steenbergen, …).

**Financing drainage**

*Construction of subsurface (pipe) drainage*

The installation of subsurface drainage has mainly been financed by the Government of Pakistan through loans provided for by the World Bank and the Asian Development Bank, and through bilateral assistance by the governments of the Netherlands, United Kingdom and Canada. Associations of foreign and local consultants have carried out the design of and supervision on the construction of the subsurface drainage projects. Initially, foreign contractors constructed the pipe drainage projects, varying in size from around 10,000 to 20,000 hectares and more. Contracts for these activities were tendered by WAPDA. In 1987, the first contract was awarded to a local contractor. The long period of some twenty years, the large size of the contracts, and the relatively difficult installation conditions resulted in the concentration of knowledge in only one private local contractor. Only recently has a second local, be it government owned, contractor started to build up experience (Croon, 1997).

*Operation and maintenance of drainage facilities*

Expenses involved in operation and maintenance of irrigation and drainage systems are grouped in the provincial irrigation and drainage budgets. All together, the budget has proven insufficient for effective

\(^{49}\) Halsema et al (1997), indicate a Relative Water Supply (RWS) ratio of 1.0 - 1.4 or more for the Sheikh Yousaf Minor command area, Lower Swat Canal, NWFP. Whereas the RWS ratio in the IBIS in Punjab and Sindh is generally below 1.0 (Halsema, 2000, personal communication). The RWS ratio is defined as:

\[
\text{Amount of canal water supply and Rainfall / Net crop water requirements}
\]
operation and maintenance of both irrigation and drainage facilities. As a result, these facilities have been deteriorating (Tarar, 1995).

By 1995, an estimated 80% of the deep SCARP tubewells in the Province of Punjab were either out of order or operating at less than 50% of their original discharge. The costs for operating the deep tubewells became prohibitive, with the average annual cost estimated at more than US$ 4,000 per tubewell. Often these costs were inflated, as WAPDA booked a lot of electricity units on the tubewells. As a result of this practice, the operation and maintenance of the SCARP tubewells continued to account for nearly half of the budget of the Punjab Irrigation Department, in spite of an ever more failing performance of the tubewells. Even though a double water tax was levied in the SCARP areas, the proceeding of this tax was grossly insufficient to pay for the costs (Steenbergen, n.d.).

Present revenue receipts from water charges and drainage cess are only about half of the expenses involved in operation and maintenance. The recovery from canal water charges is around 70% of the operation and maintenance expenses, whereas receipts from drainage cess cover only some 20% of the actual expenses (Tarar, 1995).

It has been estimated that the current O & M allocations for drainage projects cover only 10% to 15% of the needs (NESPAK and MMI, 1995, in: Asrar-ul-Haq et al, 1999).

In 1995/96, the total cropped area in Sindh Province that was assessed by the Irrigation and Power Department (IPD) for water charges (abiana, drainage cess) covered more than 3 million hectares. The anticipated annual revenue was assessed by the Board of Revenue at Rs. 477 million. The same board stated that some Rs. 472 million were recovered. However, the cropped area appears under-estimated as a result of too low assumed cropping intensities. Consultants have estimated the actual average cropping intensity for Sindh Province at 91.5%, instead of the assumed 61%. On the basis of this higher cropping intensity, the direct Provincial Revenue should be at least Rs. 713 million as compared to the anticipated 477 million. The present annual O & M expenditure for irrigation, drainage and flood control infrastructure in Sindh is around Rs. 3 billion. An average expenditure of around Rs. 264 per acre. Especially the establishment costs (irrigation/SCARP) with 32% and the allocation for electricity charges with 47%, comprise the total expenditures. There has been a general call for handing over the O & M of lift schemes and fresh groundwater tubewells to users, in order to considerably reduce the costs and bring about balance between expenditures and receipts (Government of Sindh, 1998).

Impact of drainage on agriculture: Technical performance of drainage

Every year Pakistan looses many acres of culturable land as a result of waterlogging and salinity. For example during the 1960’s, some 40,000 hectares per year were lost due to waterlogging. On the other hand, drainage facilities enable recovery of many acres of previously waterlogged land. In the 1970’s some 50,000 hectares were recovered per year. The area where the groundwater table was within five feet (approximately 1.5 metres) of the ground surface during the months of April to June has varied over the
years. In 1979, the groundwater table was within five feet in some 15% of the agricultural lands. This percentage has gradually decreased to approximately 9% in 1988. However, after 1988, the percentage of the agricultural area with a groundwater table within five feet of the ground surface has increased to approximately 18% in 1992 (Tarar, 1995, table 9, pp. 15). The impact of drainage so far can thus best be characterised as ‘mitigating’. However, there is still substantial scope for improvement.

**Surface (open) drains**

The system of surface or open drains in Pakistan serves to evacuate excess rain (or storm) water within a 3 to 5 days period, and it serves to evacuate seepage. The capacities of these drains are designed with rule-of-thumb criteria of 1 to 4 cusecs per square mile of catchment area. Particularly during periods of severe rainfall, it has become apparent that the design capacities are too low. The inadequate capacities have been further aggravated by man-made obstructions (ill-planned construction of roads, embankments, link canals, blockage of natural drainage lines, and lack of adequate cross drainage works), and inadequate maintenance (due to a lack of O & M funds) has led to clogging with sediments and weeds (Asrar-ul-Haq *et al*, 1999).

**Major drainage projects**

Asrar-ul-Haq *et al* (1999) discuss the implementation and performance of three major drainage projects in Pakistan: Drainage IV Faisalabad (Pipe drainage), Left Bank Outfall Drainage Project (LBOD), and the Fordwah Sadiqia (Remaining) Project. Major conclusions reveal that these projects experienced substantial cost and time over-runs, experienced technical, managerial and operational problems, and suffered from inadequate O & M funding, environmental degradation during the construction phase, and deterioration of the constructed facilities. The consequence is a significant under-performance of the projects compared with the anticipated effects.

**Performance evaluation of tile drainage in Mardan-SCARP (NWFP)**

Unlike the Salinity Control and Reclamation Projects (SCARPs) in Pakistan, the problem of waterlogging in Mardan was tackled by installing tile drains in the period 1987 to 1991. The technology of tile drains was preferred over deep tubewells because of the low hydraulic conductivities in the area. Jamal Khan *et al* (1997) report of a study that has been carried out in the period 1993 to 1997. The study was undertaken to assess the benefits of tile drainage and to determine if the tile drainage system was still functioning effectively.

Two sample drainage plans were selected for a detailed study of changes in groundwater levels, collector discharges and drainage coefficients. One of the plans covered the lower part of the Sheikh Yousaf Minor command (see section 7.3.3). It was generally concluded that the Mardan-SCARP has been very effective in lowering the groundwater table throughout the project area. The depth of the groundwater level dropped from a pre-project level of 0.3 – 1.2 metres below ground surface to 1.2 – 2.5 metres after installation of the tile drains (Jamal Khan *et al*, 1997).
Institutional performance

The process of the irrigation and drainage policy reforms

(source: Van der Velde and Tirmizi, 1999)

Three principal stakeholder groups can broadly be distinguished with respect to the reform of Pakistan’s irrigation and drainage sector: (1) The Government of Pakistan, specifically the Provincial Irrigation Department’s, (2) multi-lateral donor organisations, with the World Bank in the leading role, and (3) the farmers, who can roughly be differentiated along the large group of (powerless) small farmers and the small group of influential large landowners. Each group of stakeholders claims to support the key component of the reforms, which is Participatory Irrigation Management (PIM). PIM is based on a substantive role for farmers in the operation and maintenance of canal systems and their responsibility for mobilising the required resources for it. But, why then have the reforms scarcely progressed beyond establishment of the PIDAs?

Farmers

Farmers did not initiate the policy reforms and have been farming within the IBIS systems for several generations. They may thus not have any clear plan for assuming control of secondary canals, or how the Irrigation Department should be restructured. They have, however, long been aware of many causes and consequences of inadequate, unreliable and inequitable water deliveries. They have developed their own strategies for dealing with those conditions.

Furthermore, farmers have not been systematically consulted in the process of the irrigation policy reforms. Instead, the ‘average’ Pakistani farmer has been particularly susceptible to and bombarded by unsubstantiated rumour and purposeful misinformation about the reform. This contributed enormously to the environment of widespread farmer opposition to the initial reform proposals (which were perceived as delinking water rights from land ownership and privatisation of whole systems for the benefit of multinational corporations).

Multi-lateral donors

Current reform proposals emerged at the initiative of two major multi-lateral donors: The World Bank and the Asian Development Bank. They were concerned that the trend of rising operation and
maintenance costs for Pakistan’s irrigation and drainage systems, and the capital requirements for new and improved systems infrastructure was not sustainable, especially when measured against overall system performance.

A paradigm shift has taken place within the multi-lateral donors, i.e. instead of the previous ‘hardware’ solutions (technological and/or engineering solutions), interventions in the ‘software’ of Pakistan’s irrigation and drainage sector have now been proposed. The key institutional issues to be addressed were the dominance of irrigation by inefficient and administratively focused public sector agencies, weak or non-existent farmer organisations and the consequent lack of farmer participation in system operation and maintenance, and the absence of formal water markets. This paradigm shift was not welcomed by the irrigation establishment nor those who were disproportionately benefiting from the existing status quo, specifically the large landowners and feudals as well as the engineering profession. The donors had no coherent response to this opposition apart from the implicit or explicit threat to reduce or terminate financial support to Pakistan’s irrigation and drainage sector.

The donors accepted an acknowledged weak legal framework for irrigation reform implementation. The Canal and Drainage Act of 1873 vested virtually all meaningful control of the irrigation and drainage systems in government institutions, specifically the PIDs. The reform opposition was successful in weakening the legal framework. This became evident in the PIDA Ordinances, and subsequently in the PIDA Acts. Faced with the prospect of either working within the new law, or further delaying the NDP while again trying to negotiate the adoption of stronger reform legislation, the multi-lateral donors opted for the first course of action.

Irrigation agencies and Government

The reforms openly threatened the job security of thousands of non-professional staff for whose skills the floundering Pakistan economy offers few if any employment alternatives, let alone more attractive ones. PID-officers were equally quick to recognise that, for many, their own professional futures were similarly limited. Meanwhile, no longer would the PIDs be the exclusive preserve of the engineering fraternity.

The reforms and PIM were certain to greatly reduce, if not completely eliminate, the manifold and lucrative opportunities to extract rents, as well as the power and influence exercised by irrigation staff through the existing institutional structure of irrigation.

Performance of drainage in Pakistan: Some conclusions and considerations

The overall performance of past drainage interventions in Pakistan has been quite uneven and mixed. The brighter side of the picture includes partial control of waterlogging and salinity, reclamation of some of the affected areas, and development of conjunctive (ground)water use. The major concerns include the disposal of drainage effluent, declining or low performance of existing drainage facilities, and the lack of financial viability and sustainability of drainage projects (Asrar-ul-Haq et al., 1999).

It can be questioned whether employing the technology of (private or community) tubewells within canal commands, to supplement canal supplies and to extract groundwater (i.e. conjunctive water use), by itself will bring about groundwater table control. First, adopting vertical drainage to control groundwater table levels diverts attention away from the problematic water allocation and distribution in especially Punjab and Sindh. Second, canal water generally contains less dissolved salts than groundwater, and it contains silt that may increase soil fertility. Third, canal water comes at lower costs for farmers than groundwater, which is pumped using diesel or electric pumps. Farmers are thus likely to continue using canal water as much as possible.
Lastly, the IBIS was designed and later on developed with water scarcity as an embedded element, i.e. the Indus Basin Irrigation systems are designed as protective irrigation systems. Crop production is to be optimised per unit of water, rather than per unit of land and the systems infrastructure is supposed to do just that. The proposed and ongoing reforms of Pakistan’s water sector are based on commercialising (or even privatising) protective irrigation. Isn’t that a *contradictio in terminis*?
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Appendix 1. Physiography and climate in India: A general overview

India’s present-day relief features have been superimposed on three basic structural units: The Himalayas in the north, the Deccan Plateau (or Decan) in the south, and the Indo-Gangetic Plain between the two. Being the loftiest mountain system in the world, the Himalayas form the northern limit of India’s territory. The Indo-Gangetic Plain is a former seabed, now filled with river-borne alluvium to depths up to some 1,800 metres. The Deccan Plateau or peninsular India mainly lies between 300 and 800 metres above sea level. It is a topographically variegated region composed of ‘hard rock’; gneiss, granite-gneiss, schists, granites and more recent basaltic lava flows. Generally, the Deccan slope is descending towards the east (Encyclopaedia Britannica, 2000).

More than 70% of India’s territory drains into the Bay of Bengal via the Ganges-Brahmaputra river system and a number of large and small peninsular rivers (the Mahanadi, Godavari, Krishna and Kaveri rivers). Another 20% of India’s territory, located in the Indus-basin, drains into the Arabian Sea. The remaining areas either lie in regions of interior drainage, or drain into the Andaman Sea via tributaries of the Irrawaddy (Encyclopaedia Britannica, 2000).

Although considerable regional differences occur, overall India has a monsoon climate. The southwest monsoon or wet season occurs from about mid-June to October, when three-fourths of the country’s annual precipitation falls. The driest months are from November through February. Average annual rainfall in India varies strongly from region to region (Encyclopaedia Britannica, 2000). Average annual rainfall is very high in the Himalayas, where it ranges between 1,500 and 10,000 millimetres. Rainfall varies from very low (some 100 millimetres) to moderate (some 1,500 millimetres) in the Indo-Gangetic Plain. On the peninsular, the average annual rainfall ranges between low (some 400 millimetres) and high with around 5,000 millimetres (Majumdar and Tanwar, 2000).

Drainage related problems in irrigated agriculture in India: A regional overview

Drainage related problems in irrigated agriculture in India can roughly be divided over five geographical zones:

1. **North West India**, including the States of Punjab, Haryana, (NorthWestern) Rajasthan and (Western) Uttar Pradesh. Here problems with both waterlogging and salinity exist. The region largely lacks natural (outfall) drainage, and excess water cannot effectively be evacuated;

2. **Central Peninsular India**, including the States of Madhya Pradesh, Maharashtra, Karnataka and (Western) Andhra Pradesh. These hard rock areas generally have relatively shallow soils and undulating topography. Drainage problems tend to be local and are caused by seepage and percolation from canals and irrigated fields. Waterlogging is the main problem in this zone, although salinity can be a problem in areas with mineral rich soils;

3. **Eastern plains and deltas**, including the States of (Eastern) Uttar Pradesh, Bihar and West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. Here, waterlogging induced by high monsoon rainfall is the main problem. Persistent high water levels in the main drains flood-lock outfall of drainage effluent. With irrigation, problems of waterlogging have been aggravated. As a positive consequence of the high (seasonal) rainfall, soil salinity is almost non-existent;
4. *Coastal area of Western India*, including the State of Gujarat. Large tracts of coastal lands are affected by excess salinity, which is primarily of marine origin. The problem is aggravated by irrigation. Low rainfall is inadequate to leach salts, which is further rendered ineffective due to poor soil drainability and rising groundwater tables;

5. *Sodic land of Western Gangetic plains*, including parts of the States of Haryana, Punjab, Uttar Pradesh and Bihar. Lands in these states, and more specifically lands in depressions, have a high sodicity in the upper soil layers due to prolonged ponding of excess surface water. At places, irrigation by groundwater containing carbonates has also caused soil sodicity (CWC, 1997).
Appendix 2. Water Users Associations in Andhra Pradesh, India


Introduction

In the State of Andhra Pradesh (AP), India, the gross irrigated area has increased from 3.1 million hectares in 1955-1956 to 5.5 million hectares in 1989-1990. However, there is a large gap between irrigation potential created and the actual area that is irrigated under surface irrigation systems. According to the World Bank (1997, in: Venkateswarlu, 1999, pp. 4-5), in Andhra Pradesh the gap between the potential created and utilised is 20 to 25%, which indicates significant inefficiency in the surface irrigation systems. A number of factors have been attributed as responsible for the inefficiency of public surface irrigation systems in AP. The most critical being (a) Lack of sufficient funds allocated to operation and maintenance, (b) poor water management and unequal distribution of water between head and tail-end farmers, (c) lack of users’ participation in maintenance and management of irrigation systems, (d) inadequate cost recovery, and (e) low priority to minor irrigation and the disappearance of local institutions and resources for the maintenance of thousands of irrigation tanks. It was this context in which the rapid establishment of more than 10,000 Water Users’ Associations (WUAs) has been justified (Venkateswarlu, 1999). Driving forces behind the reform of the irrigation sector have been the World Bank and the Telugu Desam Party government, headed by Chief Minister N. Chandrababu Naidu50 (Narasimha Reddy, 1999). To facilitate the establishment of the WUAs by providing a legal basis for water users’ participation in the operation and maintenance of surface irrigation systems, the Andhra Pradesh Farmers Management of Irrigation Systems Act was passed and notified in 1997.

The Act

Venkateswarlu (1999) describes the main features of the Act as follows:

- It enables the formation of WUAs in all surface irrigation projects of the State, except those under Panchayat Raj institutions and all minor bodies in the scheduled areas of AP;

- Every irrigation system was to be divided into convenient units of operation: Projects, distributaries (Distributary Committees) and tertiaries (WUAs). The jurisdiction of a WUA was to be delineated on a hydraulic basis. Depending on the type of the irrigation system, there may be single or two or three tier associations/committees. The command area under a WUA would be divided into territorial constituencies depending upon hydraulic units. Each constituency shall elect a member of the managing committee of the WUA and shall directly elect the president of the WUA;

- All farmers within the command area of a project, including titleholders as well as tenants, are compulsory made members with voting rights of a WUA. All other water users from non-command areas or users for non-agricultural purposes will be members without voting rights;

50 For a critical account of the process of formation of WUAs, see Venkateswarlu (1999) and Narasimha Reddy (1999).
The WUA members elect the president and other office bearers. The presidents of the WUAs will automatically be member of the Distributary Committee (DC), and as such directly elect their DC-president and managing committee members. All the DC-presidents will be the members of the Project Committee (PC) and they will in turn elect the PC-president and the members of the PC managing committee;

The WUA’s responsibilities include (a) maintenance of the irrigation and drainage system within its command area, (b) water allocation and distribution, (c) preparation of operational plans at the beginning of the crop season, (d) ensuring equitable distribution of water and resolving conflicts among members, (e) maintaining the records, accounts and list of members, and (f) conducting social audits, mobilising resources, etcetera;

The WUAs have been given the power (or rights) to (a) levy fees for system maintenance, and any other fee or service charge to meet management costs and other expenses, (b) raise loans from the banks, and (c) get income from sources (trees, government buildings) attached to the irrigation system;

The Irrigation Department (ID) officials are made accountable to the WUAs as the competent authority, requiring ID staff to implement the decisions of the WUAs;

Another significant feature of the Act is its provision to recall elected members of the WUAs. No other elected body (Panchayat Raj, state legislatures and state as well as country parliament) has this kind of provision to recall elected members.

The ‘big-bang’ approach to the constitution of more than 10,000 WUAs in Andhra Pradesh, and the character of this irrigation management reform, have provoked the following criticism:

Water users have had little time and opportunity to become aware of the ongoing reforms, because the elections for the WUAs were already announced two months after the enactment of the law. This short time often helped the ruling party cadre, local civil contractors and people who are connected to the Irrigation Department, who all had greater access to information, to take advantage and secure positions in WUAs (Venkateswarlu, 1999, pp. 18);

The basis for the constitution of WUAs is hydraulic rather than social. This basis seems to be provided for by (the World Bank) giving preference to efficiency over equity. The main question seems to be how to extract the costs for operation and maintenance of irrigation systems, and not who should pay for the costs (Narasimha Reddy, 1999, pp. 17). As both papers from Venkateswarlu (1999, pp. 19-22) and Narasimha Reddy (1999, pp. 18-19) show, the process of composition of the WUAs appears to have favoured higher castes, richer people, or those affiliated to the then ruling Telugu Desam Party;

The conditions under which irrigation systems are to be managed may vary from project to project, although mechanisms of operation, regulation, and arrangements for distribution are likely to be more or less similar under all major and medium irrigation projects. However, minor systems like tank irrigation systems, are spread all over AP and are likely to have extensive differences based on their historical and spatial specificities. A uniform command approach may thus not be appropriate. This needs significant attention, considering that almost 80% of all WUAs are under minor irrigation works like tanks (Narasimha Reddy, 1999, pp. 19);
The creation of WUAs and with it the new rules, commands and flow of funds\(^{51}\), may undermine the community orientation through depersonalised bureaucratic procedures (Narasimha Reddy, 1999, pp. 20);

There has been suppressed displeasure among several (lower) level government (Irrigation Department) officials, who now have to be ‘accountable’ to the WUAs and who are perceiving a loss of control and power (Narasimha Reddy, 1999, pp. 21, and Venkateswarlu, 1999, pp. 27).

\(^{51}\) Each WUA is given 30,000 Indian Rupees, and in case of unanimous election of office bearers 50,000 Indian Rupees towards administrative and other expenses. Furthermore, since 1998 all WUAs have been receiving funds at the rate of 100 Indian Rupees per acre for operation and maintenance activities (Venkateswarlu, 1999, pp. 23).