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Institutional Arrangements for Land Drainage in Developing Countries

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IWMI
International Water Management Institute

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Abbreviations

AACH	Autonomous Hydrological Basin Authority (Peru)
BSWM	Bureau of Soils and Water Management (the Philippines)
CADA	Command Area Development Authority (India)
CIS	Communal Irrigation System (the Philippines)
CMA	Catchment Management Agency (South Africa)
CUA	Collector Users Association
CWC	Central Water Commission (India)
DBG	Drainage Beneficiary Groups
DGAS	General Directorate of Land and Water (Peru)
DPWH	Department of Public Works and Highways (the Philippines)
DRI	Drainage Research Institute (Egypt)
DWAF	Department of Water Affairs and Forestry (South Africa)
EPADP	Egyptian Public Authority for Drainage Projects (Egypt)
FAO	Food and Agriculture Organization of the United Nations
IA	Irrigators Associations
IBS	Irrigation Board Scheme (South Africa)
ICID	International Commission on Irrigation and Drainage
INADE	National Institute for Development (Peru)
INRENA	National Institute for Natural Resources (Peru)
MOWR	Ministry of Water Resources (India)
MWRI	Ministry of Water Resources and Irrigation (Egypt)
MARL	Ministry of Agriculture and Land Reclamation (Egypt)
NDA	National Department of Agriculture (South Africa)
NIA	National Irrigation Administration (the Philippines)
NIS	National Irrigation System (the Philippines)
NWRB	National Water Resources Board (the Philippines)
O&M	Operation and Maintenance
PDA	Provincial Department of Agriculture (South Africa)
SIS	State Irrigation Scheme (South Africa)
WRC	Water Research Commission (South Africa)
WUA	Water Users Association

1. INTRODUCTION

The worldwide expansion of irrigated agriculture has not been without social costs: Waterlogging and salinity have affected the productive capacity of irrigation systems and thus the overall target of irrigated agriculture, the increase of yields and incomes. Of the approximately 270 million hectares that are irrigated worldwide, 20 to 30 million hectares are severely affected by salinity, with another 60 to 80 million affected to some extent (FAO 1990). The World Bank/ICID (1989) assumed that in developing countries waterlogging and salinity are encountered at a significant level in about 15 million hectares of irrigated land in arid and semi-arid zones. Present data of the Drainage Working Group of the International Commission on Irrigation and Drainage (ICID) show that over 50 percent of the world's irrigated land has developed drainage problems (Abdel-Dayem 2000). In developing countries, the lack of drainage or poor drainage performance has become a critical development constraint. In addition, poorly drained fields and inadequately maintained drains favor vector-borne diseases, and create poor sanitary conditions.

Recognizing these social and environmental costs, it is all the more surprising that drainage still is the **forgotten factor** when it comes to investment in and maintenance of drainage infrastructure. Current developments suggest to focus on the realization of the full potential of already developed irrigation systems:

- The high rate of expanding irrigated agriculture came to a halt in the early 1980s due to high development costs. Land which could easily be brought under irrigation, is already developed, and the more expensive and economically less favorable areas are left;

- Population growth projections indicate that with nearly the same land and water resource base, enough food must be grown for 2 billion more people in the near future (from the present 6 billion to nearly 8 billion in 2025);

- The high emphasis on food security, so much advocated during the Second World Water Forum in 2000, suggests to realize the potential of existing capital investment in an attempt to raise cropping intensities and crop yields.

While there is considerable success in improving irrigation management performance, similar efforts concerning drainage have almost been neglected. The worldwide trend of transferring public irrigation systems to users associations is accompanied by intensive research that has revealed that user-managed irrigation systems perform better than systems managed by public agencies. The key to success is accountability to stakeholders, which forces management units to timely respond to local demands, technical requirements, natural circumstances, economic and operational conditions of farming. User-managed irrigation systems would be able to recover costs by mobilizing adequate local resources, and it is assumed that performance improves if irrigation management units depend for a substantial portion of their funding on farmers paying fees.

In most of the countries where irrigation institutions have been transformed and where management transfer has taken place, drainage institutions and management of drainage have remained, more or less, a black box. Exceptions are Pakistan and Egypt, where institutional reform includes the drainage sector. However, experience with participatory drainage approach is in an early stage. While the state has refrained from operating irrigation systems, this option is promising

less success for drainage systems. Unlike irrigation infrastructure and irrigation water which provide immediate benefits, drainage is a more difficult task for transfer and for developing institutional arrangements:

- Demand for drainage is unequally spread within the farming community; as a rule, farms in low lying areas are prone to undersupply. Effective demand for drainage varies with economic and social status (e.g. owner operators of farms, tenants etc.);

- The public goods characteristics of drainage infrastructure make exclusion of individual farmers from benefits deriving from drainage almost impossible, and enforcement of financial contributions towards cost difficult;

- If drains are used as outlets for example, industrial and communal wastewater, even poorly maintained drains may serve their purpose. In the absence of enforceable regulation, costs caused by nonagricultural users are to be borne by farmers.

However, while other goods/services with public goods characteristics or pure public goods are in effect provided by governments, provision of agricultural drainage ranges low on the agenda of politicians. Collective action for initial funding, maintenance of infrastructure and its financing is not easily forthcoming.

The central issue is whether drainage must be considered a public good to be financed by the general public, whether there are ways that lead to direct beneficiaries taking full responsibility, or whether other options are feasible. A **tentative approach** for designing institutions capturing drainage might be to elaborate whether drainage infrastructure and services share characteristics with public or private goods/services (see Table 1). For instance, in specific circumstances on-farm drains may be private goods if they are manageable by individual farmers, and if decisions not to maintain pipes e.g., affect individual farms only. For example, in Egypt and Pakistan, on-farm subsurface drains already connect more than one farm unit which makes exclusion difficult and requires enforceable rules for cost-sharing. If one follows the infrastructure from tertiary to main drains, an increasing number of farm units use and benefit from drainage systems, or are negatively affected by poor maintenance. With collectively used drains, once provided, exclusion from benefits and enforcement of financial contributions towards cost is difficult. In a few cases, exclusion technically may be possible from farm outlets to tertiary drains, but it is almost impossible to exclude individuals on basin level. In addition, production aspects help in defining policy options; for instance, capital with high sunk costs relies on public planning, policymaking, public financing and ownership, but private sector financing and ownership may be an option - under public regulation. Higher externalities call for state regulation or fiscal transfer to influence actors' behavior in either of the institutional arrangements.

There is no unique institutional solution but a wide range of institutional options moving along a continuum, from government department, parastatal, service contracting, management contracting, leasing, concessions, cooperative/communal arrangements to private entrepreneurship. This 'menu of institutional options'[1] needs to be applied to the varying technical facets of the drainage network, and along phases where relevant decisions are made, i.e. planning, investment, execution, financing, operation, maintenance and use.

[1]Kessides 1993. pp. 18-36.

Table 1. Characteristics of drainage infrastructure.[2]

Drainage infrastructure	Nature of goods/services		Production aspects			Externalities or social objectives involved
	Rivalry[a]	Excludability[b]	Sunk costs	Economies of scale	Coordination necessary	
On-farm						(+)
Surface drains	H	M	L	L	L	Soil productivity,
Inlets into tertiary drains	M	M	L	L	M	sanitation,
Sub-surface,[c] collector	H	M	L[e]	L[e]	L	protection of build-up
Sub-surface,[d] collector	M	L	L[e]	L[e]	M	areas, low incidences of diseases.
Tertiary and secondary drains	M	L	M	M	L to H[f]	(-) Waterlogging,
Main drains	M	L	H	M	M to H[f]	salinity, deterioration of
Regional outlets (river, sea)	L	L			H	water quality, water-related diseases.

a Rivalry, i.e. consumption by one reduces the use available to others.
b Excludability, i.e. a user can be prevented from consuming goods/services.
c On the land of only one farm unit.
d On the land of more than one farm unit.
e Higher than for surface on-farm drains.
f High if used by nonagricultural users or for flood control.
L = Low M = Moderate H = High

Designing and implementing institutional arrangements will take due consideration of **technical features,** the specific **user/beneficiary structure,** and their **ability** and **willingness** to pay: Water Users Associations (WUA) for example, in Turkey have either refused to assume responsibility or, where responsibility for off-farm drainage infrastructure has been transferred, maintenance has been omitted due to high maintenance cost involved for the aged drainage systems. Industry and municipalities use main drains for discharging wastewater, which needs both regulation (e.g. setting emission standards) and sharing in the cost. Because main drains serve an area greater than the command area of one association, WUAs may enter into contracts, form umbrella organizations and establish joint Water Boards where all users/beneficiaries are represented (Scheumann 1997).

Management models for drainage must recognize that boundaries of drainage basins (or subbasins) do not coincide with irrigation commands. However, this fact automatically does not lead to the conclusion that drainage institutions should be set up separate from irrigation institutions. Pakistan's concept of Drainage Beneficiary Groups (DBG) provides a good example (Scheumann 2001, forthcoming): DBGs comprise the most affected farmers receiving irrigation water from more than one watercourse. The number of individuals that cause drainage needs, and the number of benefiting individuals is even greater than those who are DBG members. In the absence of a mechanism that guarantees that all polluters/ beneficiaries contribute towards cost, only DBG member-farmers bear the cost of providing and maintaining the infrastructure. Such a mechanism proves effective if introduced by irrigation organizations that control the important input 'water', as DBGs have no power to force farmers outside their area of jurisdiction. A question of major concern is how to overcome the bias of irrigation organization against drainage, and

[2]Here, Kessides' concept is applied for drainage infrastructure. Kessides 1993.

whether this can be solved by giving the ‘most affected’ farmers an additional voice in the representative units.

As costs for investment and maintenance vary considerably from country to country and with the technical system (e.g. surface or subsurface drainage infrastructure), cost-sharing arrangements would respond to whether per unit costs are within the farmers’ ability to pay (net return, cost without drainage). This is a crucial point because governments and international creditors want the farmers to share the costs. Experience, for instance, in wealthy European countries suggest that tax payers finance investment and maintenance of larger drainage infrastructure. In the Netherlands, major technical efforts, e.g. construction and maintenance of dykes, clearing of river beds etc., are subsidized and not financed out of drainage charges levied by the Water Boards. The frequently cited autonomous German Water and Soil Associations receive subsidies for flood control measures and their maintenance from the European Union and the German government.

Designing and implementing institutions that are capable of effectively addressing the drainage issue are still being researched and experimented: **Functions** such as sector planning/ regulation, capital and recurrent financing, execution of investment, operation and maintenance, supervision etc. may be combined with **forms** of institutional arrangements, i.e. government department, parastatal, service contracting, management contracting, leasing, concessions, cooperative/ communal arrangements, private entrepreneurship.

2. OUTLINE OF THE CASE STUDIES

The literature review on “Institutional arrangements for land drainage in developing countries” provides an overview over irrigation and drainage development, drainage problems and, in particular, displays the institutional arrangements in selected countries (Egypt, India, Peru, the Philippines and South Africa). India, the Philippines and South Africa are countries where IWMI is interested in carrying out research on the relationship between the effectiveness of institutions and performance; Egypt has developed institutions capable of addressing drainage needs; Peru is in the process of establishing Autonomous Hydrological Basin Authorities for catchment-wide management of water resources including drainage.

Regarding agricultural drainage, the study has concentrated on surface and subsurface off-farm and on-farm drainage infrastructure, comprising the whole array of main, secondary and tertiary drains, tile drainage systems etc., if provision of these means requires collective efforts of farmers, or if they are provided and administered by public agencies. Indirect means that impact on drainage requirements, such as lining of irrigation canals, reduced water inputs induced by water charges or pricing systems, are not included because they relate more to the issue of water-use efficiency. The study also excludes vertical drainage although it is of utmost importance, for example in India. Vertical drainage usually is combined with irrigation and therefore provides incentives for construction, operation and maintenance that differ from horizontal drainage infrastructure.

The country studies are organized along the following rationale:

- Natural environment
- Development of irrigation and drainage infrastructure
- Drainage problems
- Institutional arrangement (legal framework, organizational set up, farmers participation)
- Operation and maintenance
- Financing drainage investment and recurrent cost
- Innovative approaches and constraints.

While access to documents and publications was satisfactory for Egypt and India, data were not as easily accessible for Peru, the Philippines and South Africa, because specific information is only available at the local level. In particular, data on funding investment and maintenance sometimes date back to the late 1980s, and identification of recent development and changes proved to be difficult.

3. GENERAL FINDINGS

Drainage Purposes

The countries selected have varying climatic conditions ranging from arid, semi arid (Egypt, India, South Africa) to humid with monsoon seasons (India, the Philippines) occurring cyclones (the Philippines) and the El Niño phenomena in Peru. Depending on the climate, drainage purposes are:

- to pass down surplus rainfall;
- to cater subsurface flow (allow percolation);
- to dispose surplus irrigation runoff;
- to control groundwater table depth for crop production and salinization;
- to reclaim land affected by salinity/sodicity.

It is a characteristic of all the countries that drainage of agricultural land is physically linked to irrigation although some countries, e.g. Peru, the Philippines and parts of India, are prone to floods and heavy rainfall, requiring drainage infrastructure for flood protection and for disposal of surplus precipitation (Table 2). Construction, operation and maintenance of drainage network are essentials in any of these cases.

Table 2. Drainage purposes and potential sources of impact on land.

	Climate	Drainage purposes	Waterlogging, salinity/sodicity	Induced by
Egypt	Arid to semi-arid	Land drainage Land reclamation Sewage disposal[a]	Salinity Waterlogging (Sodicity)	Irrigation[b]
India	Monsoon Ranging from arid, semi-arid to humid	Land drainage Land reclamation Flood protection	Waterlogging Salinity Sodicity	Irrigation Rainfall Marine origin of soils Irrigation with highly saline water
Peru	Ranging from arid, semi-arid to humid El Niño	Land drainage Flood protection	Salinity Waterlogging	Irrigation Seawater intrusion Rainfall River floods
The Philippines	Monsoon Typhoons	Land drainage Land reclamation Flood protection	Waterlogging	Rainfall Irrigation
South Africa	Arid to semi-arid	Land drainage Land reclamation	Salinity Waterlogging	Irrigation

[a]Sewage disposal may be a purpose either officially or informally in other countries as well.
[b]Irrigation-induced covers seepage from canals, surface runoff from excess water applications etc.

Provision of Drainage Infrastructure

Investment in surface and subsurface drainage infrastructure is significant in Egypt, but not in the other countries (Table 3), with India being in the greatest need of investment in subsurface drains. However, as main surface drainage infrastructure is lacking or in poor condition in many States of India, investment in subsurface drainage without investment first in improving the main system will not be sustainable. In the Philippines, on-farm and off-farm drainage facilities are considered to be inadequate, and system design for land drainage and flood control to be poor. The potential of salinity hazard (e.g. if soils are of marine origin) is a selection criteria for new irrigation projects only in South Africa.

With the exception of Egypt, there has been a tendency to make allocations from public resources for new irrigation projects instead of improving existing ones. However, more recently there have been attempts to address drainage needs: e.g. the Peruvian National Plan of Drainage and Land Reclamation; the Indian Water Resources and Consolidation Projects; the Egyptian Second National Drainage Program; the South East Asian Drainage Program to which the Philippines and India belong.

Table 3. Area irrigated and drained (in hectare).[3]

	Area irrigated	Area drained (surface)	Area drained (subsurface)
Egypt	3,246,000	3,024,000	2,016,000
India	90,000,000	5,800,000[a]	n.a.
Peru	1,127,000	n.a.	n.a.
The Philippines	1,530,000	1,532,000[j]	n.a.
South Africa	1,300,000	150,000[j] (total area drained)	54,000

[a]Not specified whether drained by surface or subsurface schemes.

For generating funds (see Table 4), beneficiaries contribute about 50 percent in nominal terms towards capital cost for subsurface schemes in Egypt. In the Philippines, farmers in National Irrigation Systems are required to contribute labor, material, donate land and pay 10 percent of construction cost, while in Communal Irrigation Systems they make immediate repayments of 10 percent of construction cost and pay the balance within 50 years with a 10 percent interest rate. In Peru and India, contributions towards initial cost of surface drainage infrastructure are marginal. In the South African State Irrigation Systems, the state would install a main drain into which farmers dispose drainage effluents; capital charges are assessed as a part of O&M water charges to partly recover the investment in main drains. In other schemes where more than one farmer is involved, a formula determines individual contributions as a fraction of the total cost compared to the cost involved if farmers would have installed a single system. In the many private irrigation schemes that cover about 40 percent of the irrigated area, farmers finance drainage investment and maintenance.

[3]Data available represent drainage development in different years.

If drainage infrastructure serves as outlets for industrial and domestic wastewater, the nonagricultural beneficiaries do not contribute towards capital cost, and it can be assumed that expenses are paid by the general public. If drainage infrastructure serves for flood control, the same may apply.

Maintenance of Drainage Infrastructure

It is a common feature that maintenance of drainage infrastructure is at least inadequate but in many cases totally neglected, which raises the need for re-modeling or rehabilitation. In India, for instance, surface drainage infrastructure is heavily silted up and infested by weed, and in Peru as well as in the Philippines maintenance is very poor. In Egypt, maintenance of the main system is contracted to maintenance companies according to a plan which requires that each open drain, or the main system has to be de-weeded or de-silted every 2 years. Insufficient budget allocations extend the cleaning period to every 3-4 years[4] which is inadequate due to enhanced growth rate of weed caused by relatively low salty water, agricultural and municipal nutrients and warm weather. For subsurface horizontal drainage, EPADP experiences that Collector Users Groups carry out simple maintenance work on small-scale pilot schemes.

Inadequate financial allocations for drainage maintenance are prevalent in all countries. However, in the countries where maintenance responsibility comes under state or parastatal irrigation management units, O&M is done either by separate drainage wings (India) or irrigation operation divisions (the Philippines). A common feature is that the major share of O&M budgets is spent on personnel (up to 80 percent), leaving little for the physical works component, e.g. fuel, spare parts.

Whether beneficiaries are charged for the supply of drainage services could not be identified for all countries. If they are, then collection is a widespread problem which causes notorious deficits in the operating budget of e.g. the Peruvian Water Users Associations and the Technical Administrators. However, if charges, or taxes, are to be paid to national treasuries, budget allocations are dissociated (except in the Philippines). In any of the cases mentioned, internal decision-making on budget allocations for O&M of drainage infrastructure remains a black box. Equally, poor maintenance performance is rarely satisfactorily explained by inadequate funds or lack of (qualified) staff. It would be useful to evaluate e.g. labor productivity, the equipment available (see Egypt). Of particular importance is whether and how drainage works improve if contracted out, the procedures for quality control, monitoring, supervision of private contractors and for restricting rent-seeking.

Data on the Impact of Drainage

Due to a lack of measuring systems and regular monitoring, the data base on ultimate positive and negative impacts deriving from drainage is not satisfactory and sometimes confusing, with Egypt being an exception (Ali et al. 2001). Negative effects usually are quantified as the extent of area affected by waterlogging and salinity, including the area that went out of production. Clear figures can rarely be given if classification criteria for saline land vary (e.g. across the States of India) and are not standardized. Low cropping intensity, limited crop diversity and yield depressions

[4]The same applies to maintenance of surface drainage infrastructure in Turkish public irrigation systems, see Scheumann 1997.

are mentioned but rarely quantified, probably because they are influenced not only by drainage but by many other factors (e.g. use of fertilizer and pesticide). Income losses and reduced employment opportunities are sometimes mentioned.

Roughly estimated overall national figures are of limited value in evaluating whether farmers are better off with or without drainage, and with regard to net return from drainage investment. Compilation of data (on country bases) on the relationship between major crop yield, salinity and water table depth seems necessary. Research in cost caused by a lack of proper drainage compared to the cost of drainage would provide strong arguments for both public and private investment.[5] In addition, it would be useful to evaluate cost of measurement systems and data processing, for example, in Egypt which seems to be in an advanced stage.

Research institutes exist in Egypt (Drainage Research Institute, Soil and Water Research Institute), India (Central Water Commission, Central Soil Salinity Research Institute, Central Arid Zone Research Institute), Peru (SUDRET) and South Africa (Agricultural Research Council, Water Research Commission). However, there is little evidence whether they influence planning, financing and management institutions, Egypt being an exception: There, research in pilot areas helped making substantial improvement, particularly in technology of materials, machinery and quality control of construction. Success could be achieved because research and implementation institutions worked together.

Management Units

Organizations responsible for operation and maintenance (O&M) of drainage infrastructure are diverse with respect to their relation to the state on the one side including e.g. regulatory and supervisory functions of the state, and the beneficiaries on the other hand (Table 4). The countries experiment participation with agricultural and nonagricultural beneficiaries in drainage affairs to a varying degree:

- Egypt has a financially dependent drainage agency (EPADP) with Drainage Centers and Drainage Subcenters, and the Maintenance Directorates that monitor and supervise private contractors. In pilot schemes, Egypt experiments whether Collector Users Groups are able to manage subsurface drainage schemes. It is intended to establish Water Boards – with representatives from agricultural and nonagricultural users—that are assumed to operate irrigation systems at secondary level and also take over responsibility for subsurface drainage schemes.

- India has financially dependent state irrigation departments, in some states with separate drainage wings in their technical departments. If they have Water Users Associations, it is for irrigation purposes only.

- Autonomous Water Users Associations, Irrigators Commissions and Irrigators Committees in Peru manage O&M of drainage infrastructure under the supervision of Technical Administrators (Ministry of Agriculture), but construction, rehabilitation and reclamation is the responsibility of state departments (INADE and INRENA).

[5]In South Africa, investment for, e.g. table grapes is R 125,000/ha while drainage cost would be R 10,000/ha; for low value crops the investment could be as low as R 15,000/ha and drainage R 7,000/ha.

- The National Irrigation Agency of the Philippines is semi-autonomous and its Operation Divisions share responsibility to varying degrees with Irrigators Associations in National Irrigation Systems. Communal Irrigation Systems are managed by either Irrigators Associations or local governments.

- Institutions in South Africa are in transition, e.g. from State Irrigation Boards, Users Irrigation Boards and from management agencies appointed by the homelands to Water Users Associations that are assumed to also deal with drainage affairs.

Identifying O&M responsibilities for the respective sections of surface drainage infrastructure, i.e. main, secondary and tertiary drains, and for subsurface schemes, access to information has been difficult, and a clear distinction is not always mentioned in the documents.

Egypt and Pakistan are on the way of implementing innovative approaches both for management and financing of drainage infrastructure, e.g. cost-sharing arrangements and participation of collector users' or beneficiary groups, respectively. An evaluation of their experience in establishing these kind of groups for surface and subsurface schemes, their linkages to irrigation commands and irrigators' groups, their legal status, assigned responsibilities, representative systems, internal decision-making structures, financing practices etc. would support developing new strategies.

The operative units and supervisory agencies are under the Ministries of Agriculture in Peru, the Philippines, and under the Ministries of Water Resources and Irrigation/Forestry in Egypt, India and South Africa; in Peru e.g. users associations are supervised by officials appointed by the Ministry of Agriculture. For further research, it would be necessary to consider that operating units are embedded in an institutional hierarchy where multiparties at multiple levels simultaneously hold decision-making power concerning sectoral/project planning, investment, operation, maintenance and financing. The way and quality in which they perform is – among other factors - shaped by these institutional hierarchies, and an analysis might help in identifying at which level gaps and deficits occur and whether one is confronted with a lack of political programs and targets or with deficient institutional incentives. From data and documents available there is no way of identifying relevant institutional variables that foster good drainage performance.

Table 4. Management units for land drainage, farmers participation and funding.

	Status	Farmers participation	Financing investment	Financing O&M
Egypt	Drainage Agency EPADP Ministry of Water Resources and Irrigation	Collector Users Groups Water Boards	Subsurface drains >50% subsidies; farmers (20 years, 5 years grace, interest-free)	Inadequate budget allocations Subsurface drains Labor contribution for maintenance; adjustment of land tax to account for O&M surface drains 35% through land tax
India	Irrigation Dept with drainage wing Command Area Development Authorities	Water Users Associations Service Organizations (pilot area)	Public investment in surface drains, small contributions from farmers	Inadequate budget for maintenance, partly recovered by water charges; low collection rate
Peru	Govt. Dept INADE (construction) and DGAS (O&M) Technical Administrator (Ministry of Agriculture)	Water Users Associations (Irrigation District) Irrigators Commissions (Irrigation Sector) Irrigators Committees (Irrigation Subsector)	Public investment, small contributions from farmers (1 to 3%)	Water charges for WUA + operating budget of Technical Administrator Low water charges, 5 to 10% collection rate, special water levies
The Philippines	Semi-autonomous National Irrigation Administration	Water Users Associations (National Irrigation Systems, NIS) Water Users Associations (Communal Irrigation Systems, CIS)	(NIS) Farmers contribute labor, material, land, 10% of construction costs (CIS) 10% repayment of construction costs, 10% interest, balance within 50 years	(NIS) Irrigation fee to recover costs (CIS) cost recovery
South Africa	Provincial Dept of Agriculture (Irrigation Board Schemes, IBS) Dept of Water Affairs and Forestry (State Irrigation Schemes, SIS)	Water Users Associations (after transfer)	(IBS) 1/3 subsidized (SIS) 100% subsidized (private) 100% farmers	(IBS) cost recovery (planned) (SIS) substantial subsidies, land taxes (planned) (private) 100% farmers

Fragmented Responsibilities

State responsibilities for varying aspects of drainage are fragmented as follows (Table 5):

- Constructing drainage infrastructure is separated from its operation and maintenance in e.g. Peru;

- Drainage for reclamation of saline and waterlogged land and regular drainage comes under different agencies in Egypt;

- Responsibility for off-farm drainage is assigned to line agencies (Irrigation Departments) and to non-line agencies (Command Area Development Authorities) in India;

- Drainage is the joint responsibility of farmers organizations and public agencies (the Philippines, Peru, foreseen in South Africa, experienced in Egypt);

- Drainage maintenance is separated from irrigation management within a State irrigation agency (drainage wings in India). It is separated at the implementation level in Egypt, but planning and management is coordinated at the Ministry and Central Governorate Irrigation Departments[6] levels;

- Drainage for flood control is separated from land drainage (Peru, the Philippines).

In all cases, the literature rarely deals with the impact of fragmented responsibilities on drainage performance; whether and how coordination is institutionalized and the procedures therein. The only exception is South Africa where District Councils – a new third level of government - are responsible for development and implementation of infrastructure projects in local communities including e.g. irrigation and drainage, which effectively means that District Councils set development tasks and coordinate funding.

Table 5. State responsibilities for land drainage, reclamation and flood control.

	Land drainage	Land reclamation	Flood control	Multifunctional
Egypt	EPADP	Land Improvement Authority		Ministry of Water Resources and Irrigation
India	Irrigation Department Drainage Wing	Irrigation Department	National Flood Commission	
Peru	INADE DGAS in INRENA	INRENA	INRENA	Autonomous Hydrological Basin Authorities
The Philippines	National Irrigation Administration		Dept Public Works and Highways	
South Africa	Provincial Dept of Agriculture (IBS); Dept of Water Affairs and Forestry (SIS); District Councils	National and Provincial Department of Agriculture	Dept of Water Affairs and Forestry; National and Provincial Dept of Agriculture	Catchment Management Agencies

As a special issue, drainage water is reused for irrigation in Egypt, and responsibility for land drainage and reuse of drainage water is fragmented between EPADP and the Ministry of Water Resources and Irrigation (MWRI). The Ministry's Drainage Research Institute is supposed to monitor water quality. However, if water quality standards are violated, EPADP will give notice to the police, and violations are subject to the judicial system (KfW 2000). However, enforcement is poor, and cases are pending.

[6]These are departments for coordinating the decentralized regional operation and liaison the ministry's mandate with the local governments and legislators.

Funding Maintenance of Drainage Infrastructure

In the countries examined, the common feature is under-provision in maintaining main and secondary surface drainage infrastructure. Budget allocations seem to be inadequate; the major share is spent for own personnel cost, leaving little for maintenance work components, i.e. spare parts, fuel, hiring of seasonal laborers etc., and for contracting out maintenance services. However, the literature reviewed rarely reveals how and if recurrent expenditure is funded, the Egyptian case being an exception where farmers contribute towards maintenance costs for surface schemes through land taxes and labor for maintaining collector pipe schemes. In India, Peru and the Philippines O&M budget allocations, water charges and their collection are mentioned for irrigation service provision, but are not specified for drainage. In the State Irrigation Schemes in South Africa, maintenance cost is intended to be recovered as a part of O&M charges, while recurrent cost for on-farm drains would be borne by farmers.

In the countries where responsibility for drainage comes under irrigation management units, internal decision-making on allocations for O&M of drainage infrastructure is not specified. Water charges, or irrigation service fees, which are either set to fully or partly recover O&M expenditure are not sufficient to fund O&M requirements, and collection rates, however, are low (e.g. Peru). Whether water charges do include a separate drainage portion without indicating it, could not be solved. In general, it seems that funding maintenance is highly subsidized.

In addition, if drainage infrastructure serves as outlets for industrial and domestic wastewater, nonagricultural beneficiaries do not contribute towards recurrent costs, and it can be assumed that expenses are paid by the general public. The same applies if drainage infrastructure provides flood control.

4. FURTHER RESEARCH

Starting from the literature review, **key research issues** are:

- How does fragmentation of responsibilities impact on performance,[7] for example, land drainage and drainage for flood control, land drainage and irrigation, drainage and land reclamation either within one or among public agencies? Does amalgamation of functions towards integrated water management provide advantages: what are 'appropriate levels' for decentralization of varying drainage tasks?

- What are the costs and benefits of having institutional arrangements for investing in and managing drainage, e.g. comparison of cost deriving from a lack of adequate drainage compared with cost of providing drainage? How does investment cost compare for major crops? If drainage impacts on the quality of the end product (mentioned for South Africa), how does this influence market prices and net return?

- What institutional arrangements and financial mechanisms are most effective and acceptable in terms of improved service provision and financial viability taking due consideration to farmers ability to pay and contributions from nonagricultural users? Analyses would include the whole array of institutional options; the organizational structure of operating units and how they are embedded within an institutional hierarchy concerning planning, investment, operation and maintenance; approaches for financing investment and recurrent expenditure (e.g. charges, collection), and internal decision-making for budget allocations for O&M of drainage infrastructure.

- Of particular concern are experiences with participatory approaches for investment and management including agricultural and nonagricultural beneficiaries. This includes legal status, representative system, assigned responsibilities of the user groups, as well as their financing and relation to irrigation organizations and coordination with government departments.

- How can decision-making on investment and management be improved through, e.g. structuring the relation between research, policy and management or the development of low-cost measurement systems and data processing.

- An issue of particular concern is the relation between and effects of drainage on natural areas and habitat (wetlands), not only in an ecological but an institutional sense (institutions dealing with land drainage and protecting environmental quality and bio-diversity both within and outside irrigation systems).

[7]For most of the items mentioned here, performance indicators are needed to allow cross-country comparison.

This might include strategies for minimizing risks and development of enforceable regulation for disposing drainage effluents into rivers/irrigation canals though affecting water quality for downstream water use, or the officially sanctioned or informal use of drainage water.

For deciding which countries can serve as **case studies,** relevant criteria are:

- whether salinity/waterlogging is widespread;
- whether the whole array of land drainage means (horizontal and vertical) is applied;
- whether institutional change has occurred;
- whether and how the newly created institutional arrangements focus on drainage;
- the kind of users' participation in drainage affairs, and, finally,
- whether literature is available and accessible.

Table 6. Countries reviewed and recommended.

Country	Salinity/ waterlogging	Institutional change	Users participation	Literature
Egypt	Widespread	On-going	Yes	Available
India	Widespread	On-going	Limited	Accessible
Pakistan	Widespread	On-going	Yes	Available,[a] needs updating
Peru	Prevalent	On-going	Yes	Partly
The Philippines	Partly	Yes	Yes	Accessible
South Africa	Prevalent	On-going	Yes	Accessible
Turkey	Partly	On-going	Yes	Available,[b] needs updating

[a]Ul-Hassan (1999), Scheumann (2001).
[b]Scheumann (1997), Scheumann (1999), Ul-Hassan; Scheumann (2001).

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5. EGYPT

5.1 Natural Environment

Egypt is an arid country that covers an area of about 1 million square kilometers. About 99 percent of the 62 million inhabitants live in the Nile Valley and the Delta Region which equals about 4 percent of the country's territory. Geographically the country may be divided into three main regions: the Delta, the Nile Valley and the Deserts. About 86 percent of Egypt's land is classified as extremely arid. Precipitation ranges from 200 mm near the Mediterranean Coast to practically zero in the south of Cairo.

Egyptian water resources are limited to the flow of the River Nile, deep groundwater aquifers in the deserts and a small amount of rainfall at the northern coast and in the Sinai. The River Nile is the lifeline of the country and provides irrigation water which is regulated by the Aswan High Dam.

5.2 Irrigation and Drainage Development

Almost all agriculture in Egypt is irrigated agriculture. Agriculture is the largest water user, exceeding 80 percent of the total water demand of the country. The total area irrigated amounts to 3.25 million hectares, 90 percent of which is situated in the Nile Valley and the Delta. The total potential for irrigation development is estimated as 4.4 million hectares, and it was planned to reclaim 1.2 million hectares before the year 2000 (FAO 1997). Crop yields in Egypt are among the highest in the world. Cotton, maize, rice, sugarcane, oranges, tomato, potato and wheat are the important agricultural crops.

Basin irrigation had been practiced in Egypt until the nineteenth century. During the Nile floods, from August to September, the water was stored for about 40 days in nearby basins, where crops were planted after the water had receded. Only one crop per year was grown. This ancient irrigation technique allowed the accumulated salts in the basins to be evacuated so that the land did not salinize.

The use of open drainage systems started in 1898, when open drains and pumping systems were constructed. With the installation of the Nile barrages and later the Aswan High Dam in the 1950s, a profound change in the hydrology of the Nile Delta and the Valley was introduced. When a huge network of open drains and pumping stations was established in 1938, it was recognized that the network of **surface drains and pumping stations** would not be effective without a network of field drainage. The problem of salinization and soil deterioration continued. The construction of field drains that was left to the initiative of individuals showed little progress due to lack of financial capacity and because open field drains consumed 10 percent of the land, which small farm holdings could not afford. Agricultural operations became complicated because the area was fragmented into small plots, and maintenance of field drainage was difficult because of the increased infestation of weeds in open drains.

Construction of **subsurface drainage schemes** started in 1942, after field studies were carried out all over the country. In 1949, Law No. 35 decreed that the State would undertake the implementation of tile drainage projects on all agricultural lands, and that farmers would be charged for the costs incurred. After a period of 10 years, it proved that tile drainage improved crop productivity and was most effective in lowering the salinity hazard (Amer 1996).

A comprehensive nationwide Drainage Program was initiated and credited by the World Bank in 1970, with the aim of controlling waterlogging and salinity. The program included the construction of new main surface drains, remodeling, deepening and widening of existing main open drains and the construction of additional pumping stations for improving drainage conditions in low-lying areas. The aim of this government policy was, in particular, to provide all irrigated lands with tile drainage. It is planned, in addition, that by 2005 most of the cultivated lands will be equipped with subsurface drainage.

The recently completed National Drainage Program 1 (1994-2000), co-financed by the World Bank, the German Bank for Reconstruction (KfW) and the Government of the Netherlands with a total investment of US$1,000 million, equipped almost 2 million hectares with subsurface drainage and constituent works, such as construction of open drains and pumping stations. Part of the National Drainage Program 1 was the establishment of five regional Monitoring and Evaluation Units at the Egyptian Public Authority for Drainage Projects (EPADP) by the German Bank for Reconstruction.

The National Drainage Program 2 (2001-2007) foresees the improvement of the drainage systems in an area of about 336,000 hectares. The program[8] includes the rehabilitation of the subsurface drainage system; provision of new subsurface drainage, and deepening and remodeling of existing surface drains. Other issues, i.e. poverty eradication, capacity building, environmental aspects, cost recovery and sustainability, are also addressed. The program includes participation of beneficiaries in O&M in subsurface drainage systems by establishing Collector Users Associations (CUA) on pilot scale, in coordination with Water Users Associations which are already established at the tertiary level (World Bank 2000).

In 2000, the total area provided with open surface drains was about 3 million hectares (i.e. 90 percent of the total irrigated area), and about 2 million hectares are provided with subsurface drainage (i.e. 57 percent). The majority of the open drains are second through fourth-order drains. Regional outlets are the River Nile, coastal lakes and the Mediterranean Sea which receive drainage water from the main drains generally by lift and sometimes by gravity. Water flows from branch drains to main drains, and from collector drains to branch drains through gravity.

The **reuse of drainage** water is a major resource to meet increasing irrigation water demand. In the late seventies the Drainage Research Institute initiated the establishment of a network of measuring stations on key points of main drains in the Nile Delta and Fayoum. In 1995/96, the total amount of drainage water reused was estimated at 4.3 billion cubic meters per year. Drainage flows are generated by tail-end and seepage losses, surface runoff and deep percolation from irrigated lands (partly required for salt leaching). Return flows from irrigated fields amount to 25 or 30 percent. In the southern part of Egypt, drainage flows and agricultural effluents from fields discharge directly into the River Nile, where they dilute with river water. Downstream, river water with higher salt content is used for irrigation purposes and may cause soil sodicity.

[8]Credits are provided by the World Bank, the European Investment Bank, the German Bank for Reconstruction and the Netherlands.

5.3 Drainage Problems

Agricultural land in Egypt struggles with waterlogging and salinity due to irregular use and over-use of irrigation water, low soil hydraulic conductivity, over-irrigation on newly reclaimed lands and intrusion of saline groundwater from the high lying lands to the old lands of the Nile Delta and Valley (El Guindy 1993).

After completion of the Aswan High Dam, all agricultural land could be kept under perennial irrigation, raising crop intensities to 200 percent. As long as the land was being basin-irrigated, no drainage problems occurred. Any excess water was soon removed by natural drainage during the fallow season. Salts that may have been accumulated over the year, were leached during the next flooding for basin irrigation. After completion of the Aswan High Dam in 1965 the risk of salinization and waterlogging increased extremely. With the installation of perennial irrigation, waterlogging and salinity emerged due to increased deep percolation from irrigated fields and seepage from irrigation canals. In 1970, 7 percent of the total irrigated area was affected by salinity; 60 percent of all cultivated lands was classified as moderately to severely affected by waterlogging and salinity (Croon 1997). Ghassemi et al. (1995) mention that salinity would have been a problem since 1938 due to inadequate drainage. In 1977, an area of 0.8 million hectares was estimated to be affected by soil salinity and poor drainage to varying degrees. This led to a loss in crop production in these areas which was estimated at 30 percent of the potential production. Recent estimates from the ICID Drainage Group (in Abdel-Dayem 2000) suggest that out of an irrigated area of 3,150,000 hectares, 1 million hectares would be affected by salinity and 600,000 hectares would be waterlogged.

5.4 Institutional Arrangement for Land Drainage

5.4.1 Legal Regulations

Law No. 35 (1949) obliged the State to implement tile drainage projects on all agricultural lands. The farmers would be charged for investment cost incurred. Later on in 1953, Law No. 68 was enacted which relates to irrigation and drainage. Articles 5 to 9 vested the power to the Ministry of Public Works.[9] The law also specifies and assigns responsibility for maintenance and clearance of private watercourses and drains. The Irrigation Department that has authority over the distribution of irrigation water (Article 31) was 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.

The water-related responsibilities of the Ministry of Water Resources and Irrigation (MWRI) are laid down in the Irrigation and Drainage Law (Law No. 74, 1971; replaced in 1984 by Law No. 12), and gives the overall responsibility to the MWRI for appropriating and distributing irrigation water and for managing drainage water and groundwater. It regulates that subsurface drainage costs are to be recovered by the farmers. In 1994, an amendment to Law No. 12 legalized the establishment of Water Users Associations at mesqa level,[10] and regulates the recovery of

[9]The Ministry of Public Works was renamed into Ministry of Irrigation, then into Ministry of Public Works and Water Resources and only recently (2000) renamed into Ministry of Water Resources and Irrigation.

[10]A mesqa is the communally owned tertiary delivery channel which is operated by the farmers.

capital cost for Irrigation Improvement Projects (IIP); modernization or irrigation and construction drainage infrastructure) at mesqa level.

Drainage of liquid waste into sewer systems is subject to Law No. 93 (1962) and specifies standards for liquid waste disposal into sewers and for use in irrigation. The responsible agency is the Ministry of Housing and Utilities. Law No. 48 (1982) classifies types of waterways and regulates the protection of the Nile, fresh water and brackish water against pollution. The Environmental Law of 1992 sets the standards for wastewater disposal from industrial and municipal facilities.

5.4.2 Organizational Set Up

Egypt is one of the few countries worldwide that has developed institutions with capacities to address drainage needs.

The Ministry of Water Resources and Irrigation (MWRI) is in charge of water resource development and distribution, and plans and implements water resources development projects including the River Nile, surface water, groundwater and drainage water. It undertakes construction, operation and maintenance of irrigation and drainage network, and is responsible for the basic infrastructure and pumping stations in new agricultural lands. The ministry is responsible for studies and research through the National Water Resources Center.

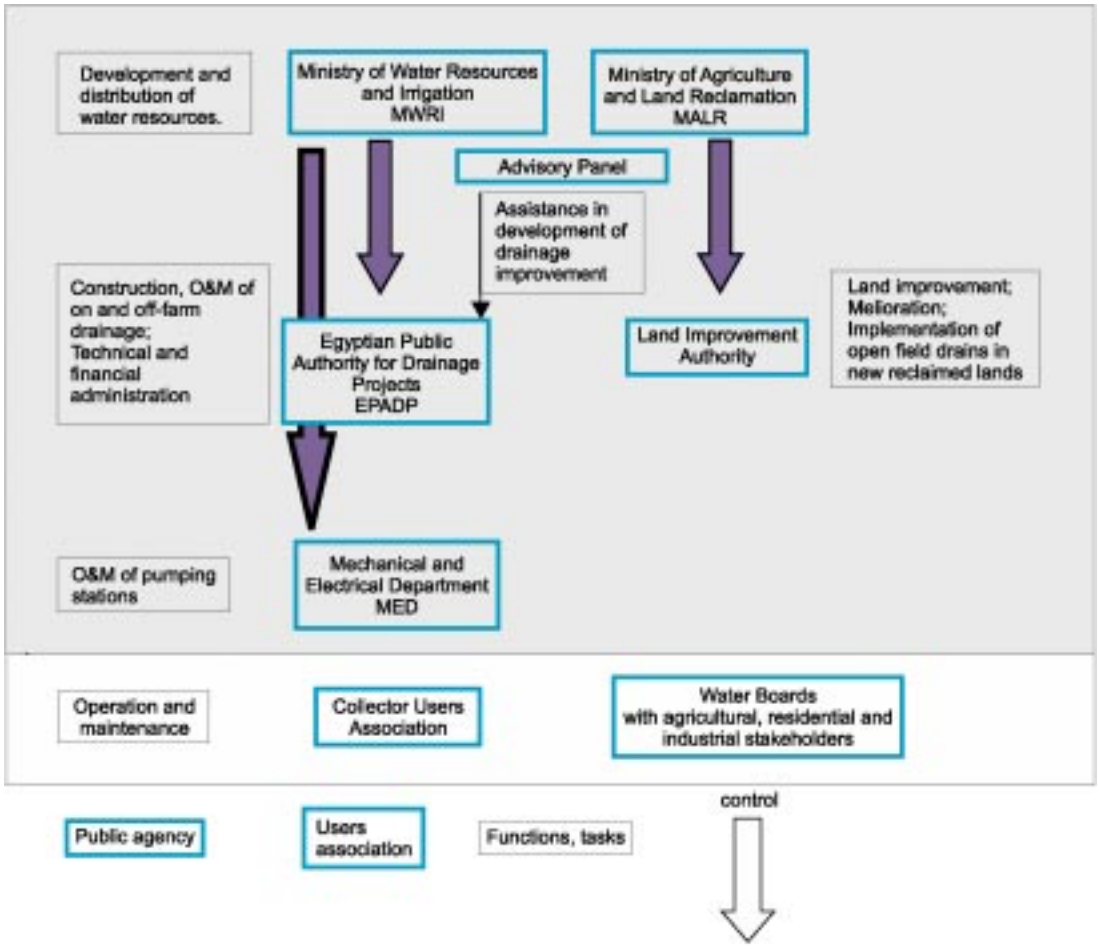
The main public entity for drainage issues is the Egyptian Public Authority for Drainage Projects (EPADP). EPADP is a public authority under the MWRI, established in 1973 by Presidential Decree No. 158. It is vested with power over the financial, technical and administrative aspects of implementation, operation and maintenance of drainage systems. Its activities involve field investigation, planning, designing and procurement of equipment for civil works, budgeting and operating budget accounts. The main features of EPADP's activities are surface and subsurface drainage projects, their maintenance and rehabilitation (MPWWR 1996a).

EPADP is headed by a chairman, followed by one deputy chairman. There are seven Central Departments headed by undersecretaries; one of them being in charge of field investigation and a second undersecretary is responsible for financial and administrative affairs. The remaining five undersecretaries are in charge of managing five Regional Drainage Sectors of EPADP, i.e. East Delta, Middle Delta, West Delta, Middle Egypt and Upper Egypt (see Figure 4.2.). Planning, design and general administration are centrally managed while implementation, operation and maintenance are decentralized at a regional scale. The pumping stations throughout the country are operated and maintained by the Mechanical and Electrical Department under the Ministry of Water Resources and Irrigation.

The Ministry of Agriculture and Land Reclamation (MALR) is responsible for land improvement, melioration and for the installation of open field drains in the newly reclaimed areas through its own public companies or by contracting out installation to the private sector.

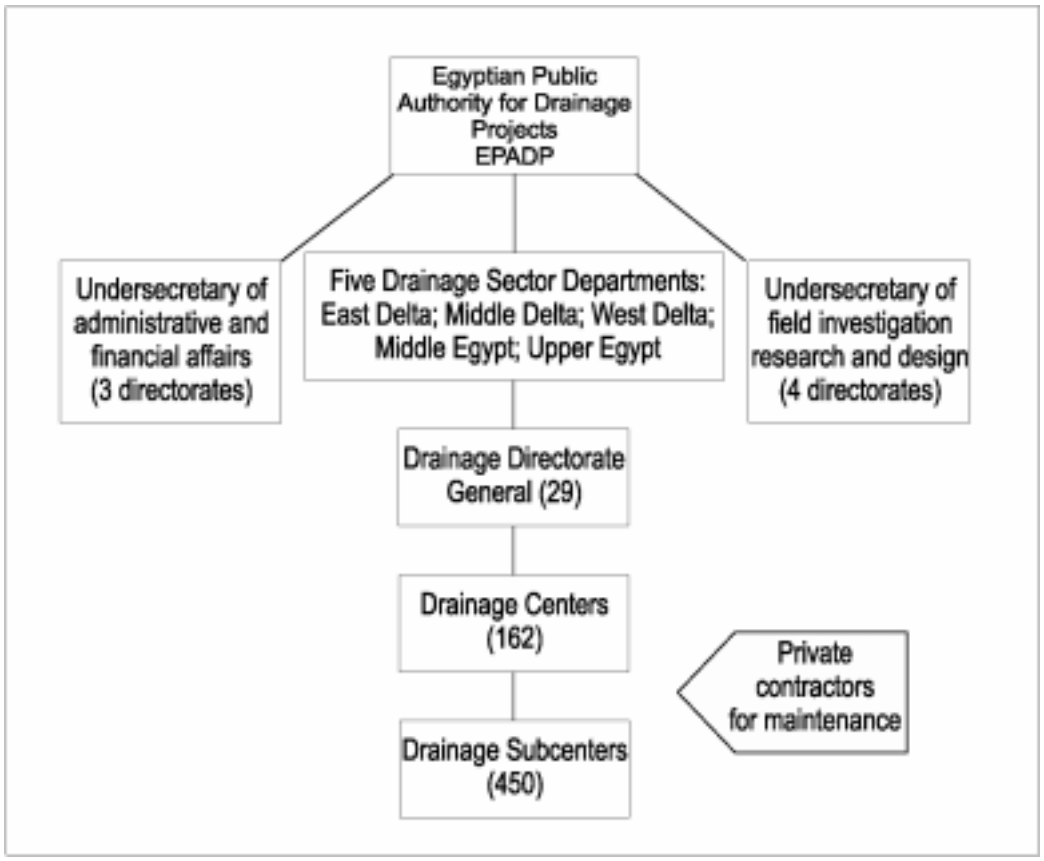
Egypt has a strong industry of local contractors with the necessary experience for installing subsurface drainage systems. The partly privatized local drainage industry works relatively autonomously and is only to a limited extent dependent on foreign suppliers and know-how. PVC drainage pipes are still manufactured in seven production facilities by EPADP, which are geographically distributed to minimize cost of pipe transportation to construction sites; privatization is intended as a part of National Drainage Program 2.

Figure 5.1. Organizational set up for drainage in Egypt.



The Ministry of Water Resources and Irrigation monitors through specialized institutes of the Water Research Center water quality in the Nile, canals, drains and groundwater to maintain water quality. While EPADP operates and maintains drainage infrastructure, which also includes protection of water quality within drains, enforcement of pollution standards from nonagricultural sources are outside its jurisdiction. The EPADP identifies some 1,800 violations per year, resulting in legal action taken against the offenders. Several other ministries are involved in dealing with water quality problems, namely the Ministry of Health, the Ministry of Interior, the Ministry of State for Housing and Reconstruction and the Egyptian Environment Agency.

Figure 5.2. Organizational structure of EPADP.



5.4.3 Farmers' Participation in Drainage

Egypt has a long tradition of top-down decision-making in water management, and until recently, farmers were generally not involved in designing, planning, implementation, construction, operation and maintenance of land drainage schemes. They were merely informed about the installation of drains in their fields. Although farmers are charged by law for the costs of drainage improvements on their land over a period of 20 years interest-free, drainage infrastructure remains owned and maintained by EPADP.

Irrigation systems are handled in a different way: with respect to property rights of irrigation systems, Verstappen et al. (1997) make a distinction between main and secondary canals, and tertiary and field canals. Main and secondary canals are public property and are managed by the Irrigation Department; tertiary (mesqa) and field canals are the private property of a group of farmers, and are fully owned, controlled and managed by these farmer groups. In the last few years the establishment of Water Users Associations was initiated at the tertiary level in the areas of and through Irrigation Improvement Projects,[11] based on Law 213 (1994) amending the Irrigation and Drainage Act (1984).

[11]Circumstances for WUA formation are specified as follows: in the so-called new lands; in the old lands at tertiary level, but only if substantial investments are being made.

Meanwhile the idea of Collector Users Associations (CUA) to take O&M responsibility for subsurface drainage schemes was implemented on a small-scale. There are about 2,881 CUAs,[12] where farmers are informally organized for carrying out simple maintenance works in pipe collector drainage schemes. Their command area comprises pipe collector schemes, which cover an area of between 100 and 300 ha. More complex maintenance work is realized by EPADP's Drainage-Centers and Subcenters (see Figure 4.2.).

The eight Water Board Pilots intend to transfer O&M responsibility for secondary canals and subsurface drains to WUAs within a defined command area of a secondary irrigation canal including a network of tertiaries and mesqas (El Afty 2000, personal communication), and drainage infrastructure (field drains, open surface drains). The representative assembly of a Water Board will have representatives from agricultural, residential and industrial base units that elect the Water Board's Executive Committee. In the older Egyptian-Dutch Fayoum Water Management Project, currently under the authority of the Fayoum Irrigation Department, several ways of initiating farmers' participation in drainage maintenance are being tested.

However, the views towards farmers' participation for O&M of drainage infrastructure are mixed. Croon (1997) is of the opinion that farmers are, in general, aware of the necessity of drainage. The population puts strong pressure on the authorities to install subsurface drainage. He assumes no major problems concerning the acceptance of drainage. Van Steenbergen (1997) considers that the establishment of farmers' organizations for drainage system management would not receive a good response. The reason might be that it is more difficult to establish farmers' organizations in already operating drainage systems. He assumes greater chances for group action if farmers are involved in the process of planning and installing new schemes. In general, farmers involvement in drainage seems to be more feasible through irrigation-based organizations than through single-purpose farmers organizations for drainage.

MWRI is in the process of shifting more towards privatization and management transfer to users in the irrigation and drainage sector. The new vision of the ministry on privatization has been recently issued to define options and priorities for users/stakeholder participation and involvement of the private sector in investment, operation, maintenance and service delivery of irrigation and drainage.

5.4.4 Drainage Research

The Drainage Research Institute (DRI) was established in 1975 as a part of the National Water Research Center of the MWRI and works closely together with EPADP. Its research focuses mainly on design and technology of subsurface drainage, economic evaluation of drainage projects, water management in rice fields and the reuse of drainage water for irrigation. Economic and environmental impacts of drainage systems are also a matter of concern of the DRI. It collaborates with many national and international research institutes and universities. Several technical research projects are carried out by DRI with financial support from the African Development Bank and the government of the Netherlands (MPWWR 1996b).

[12]Civil Law No. 32 (1964) regulates the establishment of nongovernmental organizations in general.

A Drainage Research Program that started in 1994 as bilateral cooperation between the governments of Egypt and the Netherlands, is now undertaken by DRI, the International Institute of Land Reclamation and Improvement and Euroconsult in close cooperation with EPADP. Its main objectives are to determine the feasibility of trenchless drainage.

The Soil and Water Research Institute of the Ministry of Agriculture is involved in drainage research from an agronomic point of view, such as the response of soils and crops to drainage.

In 1975, the Governments of Egypt and the Netherlands reached an agreement on a program for technical cooperation that aims at assisting EPADP in developing ways of accelerating drainage implementation to control waterlogging and salinity. Part of this agreement was the establishment of an Advisory Panel on Land Drainage in 1976. It is composed of high-level experts from both countries. Several Dutch institutions such as the International Institute for Land Reclamation and Improvement, the Dutch Institute for Land and Water Management, the Public Authority for the Ijsselmeerpolders and the International Water Supply Consultants provide technical support.

In the beginning the Advisory Panel oversaw the implementation of the Egyptian-Dutch program comprising four research projects: The Pilot Areas and Drainage Technology Project, the Recycling of Drainage Water Project, the Fayoum Water and Salt Balance Model Project, and the Vertical Drainage Project (Abu-Zeid 1995). During recent years the Advisory Panel has expanded its focus to the more complex issue of water resources management and converted into a kind of a ‘think tank’ that provides advice on strategic issues.

5.4.5 Training in Drainage

The Drainage Training Center was established in 1991 by EPADP to provide classrooms and practical training to the staff of EPADP and Drainage Contractors. Regular courses are organized annually on design, construction and maintenance of drainage systems. Operators and mechanics are trained on the use of laser-controlled drainage machinery, maintenance and repair of construction and maintenance equipment. The center is equipped with modern technology visual and hands-on training modules. Training is part of EPADP career development policy and provides incentives to contractors to train their operators.

5.5 Operation and Maintenance of Drainage Systems

As previously mentioned, the main institution with responsibility for O&M of drainage infrastructure is the EPADP. EPADP implements maintenance activities in surface and subsurface infrastructure according to an annual plan which is shaped by the condition of the area, availability of maintenance equipment and the budget allocated. The annual maintenance program is planned by Regional Drainage Directorates and carried out by Drainage Centers and Drainage Subcenters. Each Drainage Subcenter has a service area of 2,100 hectares and one Drainage Center maintains tile drains in 16,800 to 21,000 hectares (MPWWR 1996a). In the case that maintenance work is contracted out, contractors are supervised by the Maintenance Directorates of EPADP. Extension service has been added recently to the responsibilities of the Drainage Centers.

Maintenance of surface drainage infrastructure has become an increasing problem in spite of EPADP's programs for drainage maintenance, the reasons of which are many:

- Insufficient budget allocations hinders implementation of programs;[13] programs require that de-weeding and de-silting of drains are carried out every 2 years; instead the interval exceeds to 3-4 years which is inadequate due to enhanced growth rate of weed caused by relatively low salty water, agricultural and municipal nutrients and warm weather;

- Civil Engineers who dominate the supervision staff of the Drainage Centers lack interest in maintenance activities compared with design and construction work;

- Insufficient number of staff for monitoring; EPADP relies on individual farmer's complaints;

- Farmers lack of basic understanding of system functioning due to their non-involvement in the planning and design of the system;

- Lack of attention to the establishment of an effective interface between farmers and engineers.

Drainage infrastructure, which was implemented 30-35 years ago is in a state of gradual deterioration due to aging and deferred maintenance. Certain parts of the system can no longer be used. This has led to the initiation of a rehabilitation program aimed at remodeling open drains and rehabilitating subsurface drainage systems, wherever they are ineffective. As previously mentioned, several rehabilitation plans (five-year plans) and a National Drainage Program have been established; in addition, the African Development Bank financed a drainage project in the Nile Delta and in Upper Egypt.

5.6 Financing Drainage

5.6.1 Financing Investments

Compared with other developing countries in arid regions,[14] Egypt has heavily invested in land drainage for controlling salinity and waterlogging. From 1974 to 1992, Egypt allocated approximately 40 percent of the total capital costs of irrigation projects to drainage, whereas in the other countries under consideration, investment for drainage and drainage components reached only 6 percent (Croon 1997). Drainage investment was supported by foreign financing agencies, namely the World Bank, the International Development Agency, the European Investment Bank, the African Development Bank, the Islamic Bank, the German Bank for Reconstruction, the Government of the Netherlands and the African Development Fund (MPWWR 1996a). From 1975

[13]For the fiscal years from 1994/95 to 2000/01, O&M budgets of EPADP did not change in real terms.

[14]The examined countries are China, India, Pakistan, Mexico, Kazakhstan, Turkmenistan, Uzbekistan, Egypt, Iran, Iraq, Morocco, Syria and Turkey (Croon 1997).

to 1999, the World Bank contributed about US$1,5 billion towards drainage projects in 16 arid countries, of which Egypt alone received 25 percent (Abdel-Dayem 2000).

The general pattern for investments in irrigation improvement is that capital costs are to be recovered for mesqa level investments, and that no cost recovery is foreseen above the mesqa level. The mesqa is the communally owned tertiary delivery channel which is operated by the farmers. A similar approach is followed for drainage investments: open main drains are constructed by EPADP, considered as public property, and paid out of public resources, while open field drains are installed and paid for by farmers. Investment costs for subsurface drainage is assumed to be partly financed by farmers. According to Egyptian Law, construction costs of subsurface schemes are repaid over a period of 10 to 20 years without interest, allowing a grace period of 5 years after construction. In nominal terms subsidies amount to approximately 50 to 55 percent[15] (World Bank 2000), in real terms beneficiaries may pay far less than 50 percent of construction cost. According to data given by the German Bank for Reconstruction (2000a), users would contribute 40-45 percent towards investment cost of drainage infrastructure which is actually only 10 percent because it is interest-free and refers only to the tertiary drainage systems.

The total cost of drainage projects include installation of field drains; crop compensation for damage resulting from construction activities during installation; deepening and widening of existing main open drains or digging of new ones; construction of drainage pump stations or increasing the capacity of existing pump stations; management, administration and supervision of drainage projects; operation and maintenance of subsurface and open drain systems and training and evaluation programs (Abdel-Dayem 1986). Farmers would not financially suffer from the installation as a result of damage to the standing crop, because about 10 percent of investment is available for crop compensation (Croon 1997).

5.6.2 Financing O&M

For operation, maintenance, rehabilitation of irrigation systems the Irrigation Department, and for remodeling and maintenance of open main drains the EPADP receive their budgets out of the national treasury. The amount allocated to each is determined by the Ministry of Water Resources and Irrigation based on annual estimations prepared by each organization. However, the annual budget allocation for maintenance by the treasury has never matched the planned investments although for the fiscal years from 1994/95 to 2000/01, O&M budget of EPADP did not change in real terms; an increase is regarded as necessary.

Subsurface drainage schemes, comprising lateral and collector drains and manholes, are maintained by EPADP and are publicly financed. Maintenance of open field drains which are considered private property of the farmers, is executed by the farmers with their own (re)sources (manpower). If farmers fail to fulfill their O&M obligations below the tertiary irrigation/drainage channels, which is their responsibility, the Irrigation and Drainage Law makes provision for the work to be undertaken by the Irrigation or Drainage Department and charges the cost to the farmers in addition to an overhead cost.

Public provisions cover the major share of O&M costs, while farmers finance 35 percent of O&M costs through land taxes (Abdel-Dayem 1986; 2000). There is growing tendency for applying a cost recovery approach in which water users pay for the services of water distribution and network maintenance rather than being a fraction of the land tax.

[15]Perry (1996) assumes that subsidies on capital investments are 60 to 75 percent.

5.7 Innovative Approaches and Constraints

The development of drainage has been substantial for Egypt's agricultural sector and to Egypt's economy. Drainage is required to sustain irrigated agriculture, to control and prevent waterlogging and salinity and to reclaim new lands.

Over the years Egypt has developed an institutional framework where the tasks of agricultural drainage are addressed mainly from one government entity. The need to increase the utilization of the country's limited water resources and arable lands has been faced by government strategies that called for subsurface drainage on all irrigated lands to prevent waterlogging and salinity. Egypt has succeeded in implementing subsurface pipe drainage systematically on a large scale and in developing a partly privatized local drainage industry.

Financial contributions from beneficiaries towards drainage investments amounts up to 50 percent and is regarded as a successful cost-sharing arrangement. The beneficiaries would have indicated that they are willing to pay for further investment (World Bank 2000). Subsurface drainage schemes are considered to be well-maintained if compared to surface drainage infrastructure mainly because of inadequate budget allocations. However, the following aspects need due consideration:

Institutional Aspects

- In the past decades high public investments were made in surface and subsurface drainage infrastructure. With its increasing age their maintenance has become an issue. A shift of maintenance responsibility of irrigation and drainage infrastructure has taken place by the establishment of Water Users or Collector Users Associations, but only at an experimental level. In-depth analysis would foster understanding of their performance.

- Coordination between the different units and organizations of the MWRI that deal with operation and maintenance of irrigation and drainage systems is limited. This causes problems particularly at the secondary and main system levels. The ministry is in the process of examining several modalities for management at secondary canal catchment level following a participatory approach in which all stakeholders will be involved. Water Boards will integrate irrigation and drainage at the levels where beneficiaries are engaged, and they will be the locus of agricultural and nonagricultural stakeholders. However, a similar integration or coordination at the level of state agencies is lacking.

- Some advocates suggest that it would be advantageous to give the responsibility for overall drainage to a single organization within the ministry in charge of irrigation.

Environmental Aspects

- Drainage channels, which are designed to collect drainage effluents from agricultural land also receive increasing quantities of untreated or only partly treated industrial and communal wastewater, sludge and even solid wastes. As a result, some drainage water has not only become more saline, but also contains high concentrations of various pollutants such as heavy metals, pesticides, fecal coliform and organic matter. Water quality standards are relatively high but enforcement is poor. It seems that state responsibilities do not adequately address water quality management issues.

- Groundwater in the Nile Valley and Delta Region is only recharged by seepage losses from the River Nile, canals and drainage networks, and from deep percolation of irrigated fields. If canals are lined and excess water drained, groundwater recharge may become problematic. The same applies to drainage water as more irrigation improvement resulting in less water losses increases drainage water salinity and lessens the quantity of drainage water. This may affect the policy of promoting reuse of drainage water. However, the water balance in this closed basin under an improved water management scenario suggests that the overall available water for use would be the same but with better quality.

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6. INDIA

6.1 Natural Environment

With 3,287,590 square kilometers, India is the seventh largest country in the world and with 944.58 million inhabitants the second most populated country. India has five principal physio-graphic regions: The Himalayan mountains, the Indo-Gangetic plains, the great Indian desert, the Deccan Plateau and the coastal mountain belts.

Almost the entire territory is situated in the tropical or subtropical region. The climatic features are diverse on both regional and seasonal basis due to its size, peninsularity, topography and geographical conditions. The climate ranges from tropical wet to arid and semi-arid, and weather conditions have even greater variations. The climatic conditions, which are characterized by frequent droughts and floods, influence to a great extent India's utilization of water resources. About 80 percent of annual precipitation is concentrated in a period of about 3 months, during the monsoon season. The main water resources in India are rainfall and snowmelt of glaciers in the Himalayas that feed the rivers.

Floods and droughts are regular phenomena. Floods occur between June and October as a result of cyclonic storms. An area of 40 million hectares (or 12 percent of the total land area) is estimated to be vulnerable to floods. These areas are situated predominantly in the eastern part of the Ganges basin and the north-eastern part of the country.

6.2 Irrigation and Drainage Development

India's irrigated agriculture has been fundamental for economic development and poverty alleviation. According to the World Bank Sectoral Report (1998), 28 percent of India's GDP and 67 percent of its employment is based on agriculture,[16] and about two-thirds of the total agricultural output on irrigated agriculture. In 1997, the irrigated area comprised 90 million hectares. About 80 percent of India's farmland grow main foods such as grains and pulses, and the major cultivated cereals are millet, maize, rice and wheat. Groundwater contributes 35 percent to irrigation, and is particularly used in minor schemes; surface water supplies 52 percent and is primarily used in major and medium schemes, and 13 percent in minor schemes. In 1991, the total drained area was estimated at 5.8 million hectares, which is 12 percent of the irrigated area (FAO 1999).

Irrigation can be dated back to prehistoric times. Old irrigation structures still exist in different parts of the country. Modern irrigation started under the British colonial regime in the nineteenth century with the construction of canals, storage facilities and river diversion. In 1947, the year of India's independence, an area of about 22 million hectares were under irrigation. Since then, a major emphasis of India's governments has been the implementation of irrigation projects with the aim to increase food production. Since 1951, Five-Year Plans have been worked out and major, medium and minor irrigation schemes have been implemented. The growth of irrigation and food production has been phenomenal since the introduction of the Five-Year Plans and this has consequently made India the largest irrigated area in the world (Singh and Datta 1997).

[16]In 1996, 73 percent of its population lived in rural areas.

However, during rapid irrigation development, planning and construction of drainage facilities in irrigated areas did not keep pace. Investment in drainage has been widely neglected compared with irrigation. After implementation and operation of many irrigation projects, a rise in the water table with following degradation of soil through waterlogging and salinity was observed. The first notice of waterlogging in irrigated fields was made in 1850 in the State of Punjab followed by other irrigation and canal projects in other States (CWC 1997).

Land drainage development with subsurface drains is of recent origin comparing with India's long tradition of surface drainage. Vertical drainage has been applied on a limited scale. In addition to structural measures, bio-drainage and various crop-water management techniques have been applied to deal with drainage problems (CWC 1997).

In 1974/75, the Indian government launched the centrally financed program for Command Area Development. Its primary objective has been to increase efficient utilization of irrigation water and to improve agricultural productivity in irrigation commands. This program is realized through major and medium irrigation projects comprising different components of water resource management. Concerning drainage, the program includes on-farm development through field channels and field drains, the reclamation of waterlogged areas (since 1996) and the encouragement of participatory irrigation management. Furthermore, it contains development and maintenance of main and intermediate drainage systems. The program is expected to be implemented by Command Area Development Authorities (CADA) under the Ministry of Water Resources. Where CADAs have not been constituted, the program is administered through the States' Irrigation Departments (MOWR 2000).

A new generation of irrigation projects – the Water Resource Consolidation Projects - are assisted by the World Bank. Their main objectives are the improvement of institutional and technical capability of managing water resources, rehabilitation and completion of irrigation schemes and farmers' participation. The Ministry of Water Resources mentions three projects recently completed or under implementation in the States of Haryana, Orissa and Tamil Nadu (MOWR 2000).

Concerning floods protection, the National Flood Commission introduced a national flood control program in 1954 after disastrous floods. By 1990, 15,675 kilometers of embankments and 30,857 kilometers of drainage channels had been constructed, providing protection to about 13.8 million hectares in flood-prone areas. At present, most of the emphasis is laid on flood forecasting, flood warning and other non-structural measures. The implementation of flood control has been started in the Ganga River Basin (Kitamura et al. 1997).

India takes part in the South East Asian Drainage Program which is a regional program prepared by IPTRID (International Program for Technology and Research in Irrigation and Drainage) using Dutch funds. The countries involved are Australia (North- East), Bangladesh, Cambodia, China (South), India (East), Indonesia, Japan (South), Laos, Myanmar, Malaysia, Nepal, Papua New Guinea, the Philippines, Taiwan, Sri Lanka, Thailand, and Vietnam. Main objectives of the program are to strengthen drainage development and management capacities in the collaborating countries. In December 1999, a preparatory meeting[17] with representatives of the World Bank, IPTRID, ICID and six countries of the South East Asian region was held in Kuala Lumpur, Malaysia, for elaborating a drainage program. There, the Malaysian Minister of Agriculture assumed that only 4 percent of agricultural land in the South East Asian Region is

[17]The meeting was hosted by the Malaysian National Committee on Irrigation and Drainage and attended by the Malaysian Department of Irrigation and Drainage.

provided with some form of improved drainage, regular on-farm drainage being virtually nonexistent.

6.3 Drainage Problems

In earlier times, drainage problems were handled with moderate canal realignment and improvement of drainage systems, but today's problems are much more complex. The large scale development of irrigation projects caused waterlogging and soil salinity in many irrigation commands. Despite the experience gained in surface drainage so far, maintenance and control of weeds are still inadequate. Kitamura et al. (1997) report that attention for drainage development and improvement focused more on irrigation-induced problems in arid and semi-arid regions, and less on rainfall-induced problems. Where investment for drainage has been made, lack of proper maintenance has led to siltation of many drains. Irrigation and drainage infrastructure is generally in a poor state. Rehabilitation requirements represent an increasing part of the investment.

Estimations about the total area affected by waterlogging and soil salinity are of a very questionable nature with respect to their magnitude and relevance. The existing lack of standardization for classifying the problems of waterlogging and salinity is mentioned as a reason Singh and Datta (1997). Kitamura et al. (1997) note the difficulty to differentiate between rainfall-induced and irrigation-induced waterlogging. Data on the extent and distribution of salinity face similar difficulties because it needs to be differentiated between areas affected by secondary, i.e. irrigation-induced, salinity and primary salinity.

This results in different figures for the magnitude of the problem. The Central Water Commission estimates the area affected by waterlogging and soil salinity as follows:

- About 8.5 million hectares are waterlogged, whereof about 2.46 million hectares are suffering from waterlogging under irrigation.

- A total of 5.5 million hectares are affected by salinity, whereof about 3.06 million hectares are estimated to be affected due to irrigation-related problems.

- The total affected land under waterlogging and salinity is 14 million hectares of which 5.52 million hectares would suffer from inadequate drainage in irrigated lands (CWC 1997).

India's wide range of climatic, physiographic and geo-hydrological conditions are leading to varying patterns of waterlogging and salinity. The Central Water Commission (1997) differentiates drainage in five main geographical zones:

1. *North-West India*
   This zone is located in the States of Punjab, Haryana, north-western Rajasthan and western Uttar Pradesh and has semi-arid to arid climate. Due to the lack of natural outlets, excess irrigation water and salt cannot be evacuated efficiently, leading to the twin-problem of waterlogging and salinity.

2. *Central Peninsular India*
   This zone, covering the States of Madhya Pradesh, Maharashtra, Karnataka and western Andra Pradesh, is of a hard rock area generally with shallow soil cover and undulating topography. Drainage problems are caused by seepage from canals and percolation from irrigated fields and are of a local nature. Waterlogging and salinity occurs in some areas where the soils are more mineralized.

3. *Eastern Plains and Deltas*
   This zone comprises the States of eastern Uttar Pradesh, Bihar and West-Bengal, Orissa, Andra Pradesh and Tamil Nadu. Its main problem is waterlogging due to high monsoon rainfall. Persistently high water levels in the main drains lock the outfall. In some areas introduction of irrigation has aggravated waterlogging. Soil salinity represents no problem because of high rainfall.

4. *Coastal Area of Western India*
   In the State of Gujarat, large areas of the coastal zone are affected by excess salinity, which is primarily of marine origin. Irrigation leads to an aggravation of the problem. Additional factors that increase the problem are deficient salt leaching due to low rainfall, the poor natural soil drainability and rising water tables.

5. *Sodic Land of Western Gangetic Plains*
   Sodic soils are predominantly found in the States of Haryana, Punjab, Uttar Pradesh and parts of Bihar, mostly in the upper layers of depressions. It is considered that sodicity occurs due to prolonged ponding of surface water. At some places where groundwater is used for irrigation, which contains carbonates, soil sodicity occurs.

6.4 Institutional Arrangement for Land Drainage

6.4.1 Legal Regulations

India is a union of twenty-five States and seven territories, and responsibility between States and Central Government is determined by three categories, i.e. the Union List (List I), the State List (List II), and the Concurrent List (List III). According to the Indian Constitution, water resources development for irrigation and flood control is the responsibility of the States. “Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power is subject to the provisions of Entry 56 of List I.” According to Entry 56 (List I) the Central Government is responsible for regulation and development of inter-State rivers and river valleys (MOWR 2000).

Most of the States in northern India still follow the Northern India Canal and Drainage Act which was inaugurated in 1893. This act defines that the State Governments are vested with power to plan drainage works for irrigated land and for flood protection, to levy drainage tariffs (cess) and “to order removal of obstructions of drainage channels.” Aspects concerning farmers’ involvement in the planning of drainage facilities and their operation and maintenance are not included. Drainage in the eastern States of India is governed by rules which are similar to the Northern India Canal and Drainage Act (CWC 1997).

Andra Pradesh is the only State with detailed acts and rules concerning power and responsibility for drainage, which relate to e.g. levying, collection and administration of drainage *cess* (CWC 1997).

6.4.2 Organizational Set Up

Irrigation and drainage in India is dominated by the public sector. The scale of most schemes has necessitated governmental funding, as well as their operation and maintenance.

According to the Indian Constitution, water is the responsibility of Federal States. Planning, execution, operation and maintenance of water resource projects are issued by the respective Federal State Governments. The main ministerial organizations dealing with drainage are the Departments of Irrigation and the Departments of Agriculture. Technical departments are in charge of investigation, planning, execution, operation and maintenance of the infrastructure. In a few States, separate drainage wings exist under the technical departments, exclusively concerned with drainage.

The Central Government of India is concerned with overall planning, financial allocations and coordination of works. The Ministry of Water Resources and the Ministry of Agriculture are concerned with drainage-related matters at the central level (Figure 5.1). The Ministry of Water Resources is responsible for overall planning, policy formulating, coordination and guidance in the water resources sector, including drainage. It is also responsible for technical guidance and monitoring of irrigation, flood control and multipurpose projects on major and medium scales (MOWR 2000).

The Central Water Commission (CWC) is the technical arm of the ministry. It is responsible for initiating and coordinating schemes for control, conservation, utilization and development of water resources for irrigation, flood control etc. It provides general logistics, technical and research support for water resources development at State level. The Commission has three technical wings, namely, the Design and Research Wing, the Water Planning and Projects Wing, and the River Management Wing. There are 13 field organizations which are responsible for monitoring and management of projects and flood forecasting. CWC is presently engaged in collection and compilation of data relating to waterlogging and soil salinity in irrigation commands. A statewide collection of data and status reports are in progress.

The States' Irrigation Departments are responsible for planning, surveying, designing, construction and operation of all engineering works related to irrigation, drainage and flood control. Chief Engineers are the administrative and professional heads of irrigation and drainage development in the States.

6.4.3 Drainage Research

India has a long history of salinity research that dates back more than 100 years focusing on drainage, the reclamation of saline and waterlogged soils, establishing that subsurface drainage is effective and financially feasible (Singh and Datta 1997).

There are two prime research institutions established by the Central Government: The Central Soil Salinity Research Institute in Karnal founded in 1969 and the Central Arid Zone Research Institute in Jodpur. Various research programs have been initiated through the agricultural universities of the country. A model for developing subsurface drainage has been elaborated in the operational pilot project Haryana. Its aim is to develop a service organization that is able to construct subsurface systems on farmers' land against full or subsidized charges.

Several research efforts were made for the solutions of drainage problems including drainage investigations for both surface and subsurface drainage, drainage design criteria, drainage materials, installation of drainage system, leaching of salts, disposal of drainage water and economic aspects of land drainage. However, in some instances drainage could not be implemented due to institutional constraints, lack of trained manpower and unwillingness of farmers to share the costs.

6.4.4 Farmers' Participation

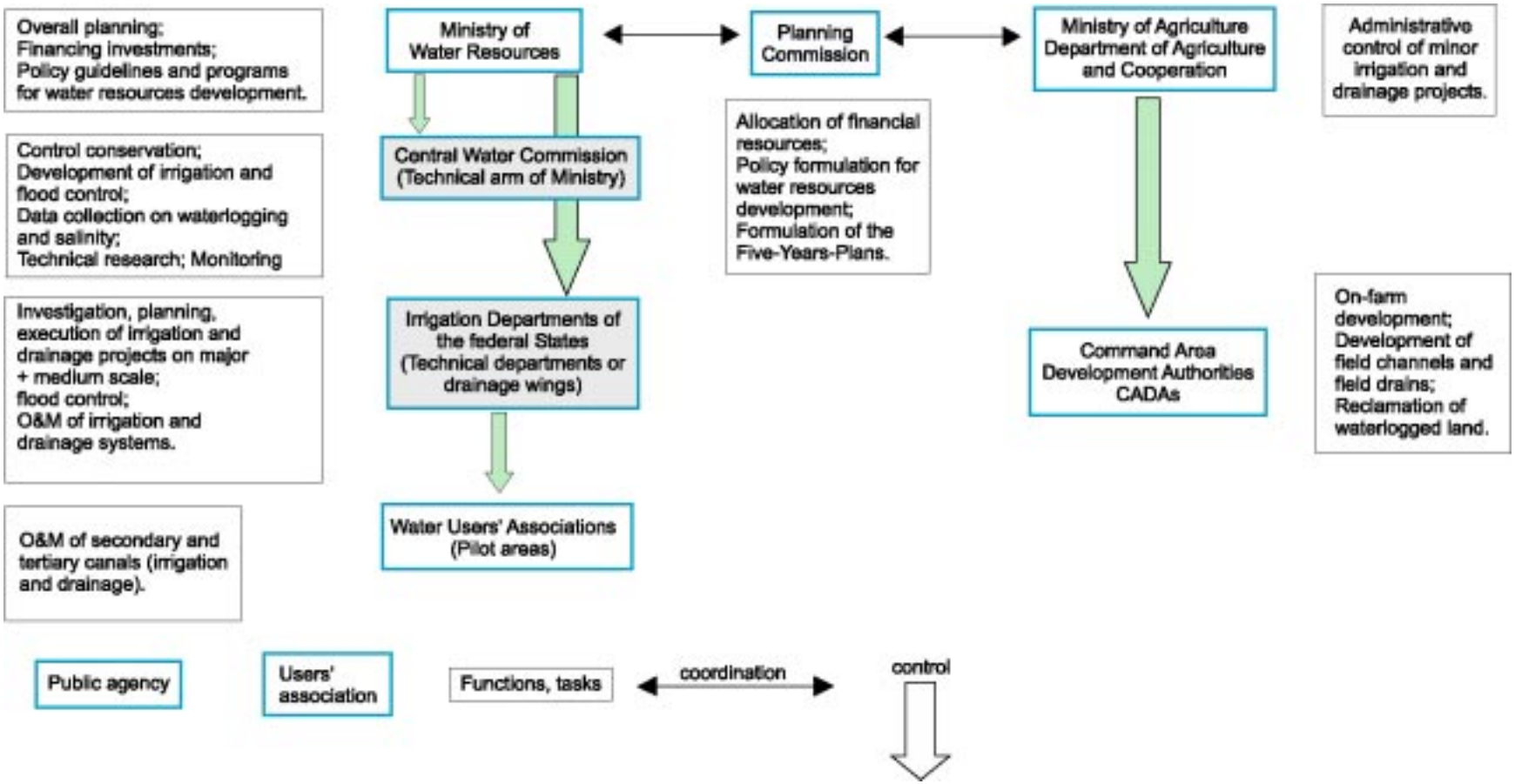
India relies much less on nongovernmental bodies for irrigation scheme management than other countries. However, it has a long tradition of community participation in irrigation and in particular in the management of smaller irrigation schemes such as tank irrigation and groundwater irrigation. Community irrigation management has decreased due to the increasing governmental involvement in irrigation during the last century. It was only recently that farmers' organizations were encouraged to take over operation and maintenance in small irrigation and drainage schemes.

The first attempt to promote farmers' participation in irrigation management was with the Command Area Development Program in 1974 (World Bank 2000). The first Water Users Associations (WUA) for irrigation were established in the 1980s. The State Governments formulate executive guidelines regarding formation and work of the WUAs. However, a legal instrument or central legislation concerning the establishment, objectives and obligations of WUAs and their members do not exist yet. Only the State of Andhra Pradesh has passed legislation for farmer management in irrigation systems. WUAs were federated into Distributaries Committees in 1997. Rehabilitation and maintenance of minor canals and distributaries by WUAs and Distributaries Committees started in 1998. Improvement of main canals, main drains and headwork is implemented by the Irrigation and Command Area Development Department.

In 1994, an Integrated Water and Agricultural Management Program was initiated as part of the Rajasthan Agricultural Research Project, introduced in 1992 with the objective "to develop, demonstrate and evaluate improved and integrated water management procedures for optimum production and sustainable agriculture with active involvement and participation of farmers" (Srivastava et al. 2000). Farmers were motivated through training programs to adopt the latest irrigation technologies and to organize in WUAs. A great success was observed in water and agricultural management. Today, farmers have been highly motivated to maintain their watercourses and field drains at their own cost. The introduction of a Participatory Drainage Management is discussed, comparable with the Participatory Irrigation Management implemented in the 1980s.

The World Bank's Uttar Pradesh Sodic Lands Reclamation Project is a recent successful experience about beneficiary participation supported by effective use of Non Governmental Organizations to motivate beneficiaries to organize themselves to participate in the planning and implementation of the program. Beneficiaries profited greatly from knowledge shared through field trips. Farmers visited successful pilot projects in other parts of Uttar Pradesh and passed on what they learned to other farmers in their area. Modern technology like remote sensing applications in drainage was used for understanding the present status, planning, monitoring and sustainability of project interventions; and the value and need to involve local village institutions at all stages of planning, operation and maintenance to achieve project sustainability.

Figure 6.1. Organizational set up for drainage in India.



6.5 Financing Drainage

6.5.1 Financing Investments

From 1951 to 1990, the creating of a huge canal network through major and medium irrigation schemes including drainage components was financed through massive public resources. Emphasis was on increasing agricultural production at a very fast rate in order to achieve self-sufficiency in food production. Per unit construction costs varied widely depending on size, type of water resource and whether it was a gravity or lift scheme, and are as follows in major and medium public schemes: Rs 1,200/ha (1951-56), Rs 19,271/ha (1980-85), and Rs 26,872/ha (1985ff.). On the average, costs per hectare of constructing new irrigation systems has risen almost 20 times. Gulati et al. (1994) estimate total investment at Rs 600 million (1988/89 prices) of which direct financial recovery from beneficiaries was only about 0.5 percent. However, irrigation projects are not to recover entire capital investment. But the share of repayment has been set higher than what has actually been achieved.[18] Efforts to increase capital charges failed due to farmers' resistance and their politically strong lobbies.

The primary source of external assistance in India's water resources sector is the World Bank. Financial assistance is also assured by the EEC, Germany (KfW), Japan (OECF) and the Netherlands. The Annual Report of the Ministry of Water Resources counts 23 ongoing irrigation projects, including drainage components with external funding (MOWR 2000).

Public investment in drainage has been predominantly in surface drains but in comparison with other countries like Egypt and Pakistan it had been significantly less. The average cost for drainage works is estimated at US$280/ha, and costs are estimated at about US$560/ha for reclamation of alkaline soils (FAO 1999). Singh and Datta (1997) report that although subsurface drainage has proved cost-efficient in the Rajsthan Agricultural Drainage Research Project, it remains a problem to arrange financial resources for on-farm drainage technology. Financial and economic criteria would justify their replication in other parts of India to reclaim saline or waterlogged soils. However, farmers with small and medium farm sizes may not be able to finance investment of subsurface drainage technology on field level. Subsidies are required to help small and medium farmers to cover costs and improve development of subsurface drainage (Barla 2000).

6.5.2 O&M Budget Allocations and Financing Recurrent Costs

The norms for allocating funds for operation and maintenance vary from State to State and even for different projects in the same State. The general practice is to fix a certain rate per hectare of irrigated area. The funds for operation and maintenance are provided from the Revenue budget of the States, and it is generally observed that budgets are grossly inadequate for upholding satisfactory levels of services. From 1986/87 to 1990/91, for example, O&M expenses increased steadily, with the major share of total expenditure being spent on covering personnel costs (labeled as 'establishment' costs). Funds for maintenance works simultaneously decreased. According to Indian practices, the personnel can be concerned with operational matters or maintenance activities. However, separate figures for maintenance in general, and for drainage maintenance in particular,

[18]No detailed information is available on the share of repayment.

are not available. While in earlier years a higher proportion of the O&M budget was dedicated towards the work portion, nowadays, establishment has increased in all States, receiving about two-thirds of the budget. Separate figures for drainage components within irrigation systems are not available in any of the literature reviewed (Desai and Jurriëns 1993; Singh and Jain 1993; World Bank 1998; Gulati et al. 1994a and 1994b; Saleth 1997; Chitale 1992).

Desai and Jurriëns (1993) mention that figures on budget allocations relate to actual expenditure but not to what is required for good maintenance. Funds allocated were insufficient for essential repair and maintenance, and in 1983, e.g., the Public Accounts Committee of the Union expressed concern that O&M of irrigation systems would not receive due attention because of inadequate allocations. In subsequent years it was felt by Finance Commissions that water charges should generate sufficient revenue to pay for operation, maintenance, depreciation and to yield some interest on capital invested.

Fixing water charges, however, is under the responsibility of the States and provinces and vary widely both across and within the States. Water charges are levied, as a rule, on the basis of area irrigated, crops and season, except for groundwater irrigation systems, where charges are based on time or volume. There are a number of parameters which determine the setting of water charges, such as O&M cost recovery with or without interest; capacity of irrigators to pay (e.g. gross earning or net benefit of irrigation); water requirements of crops; sources of water supply; classification of land; linkage with land revenue system; or a combination of various elements stated above (FAO 1999). However, revenue from water charges collected from beneficiaries are usually far below targeted amounts. The reasons are given as follows:

(1) Water charges are extremely low and not set to actually recover expenses. Prior to 1997, they had been kept constant over many years and had progressively eroded in real terms to comprise only a fraction of O&M costs. Implementation of higher water charges has often been impossible due to political factors, although the release of the New Economic Policy in 1991 has advocated the need to recover O&M costs, plus 1 percent of capital costs and depreciation allowance.[19]

(2) Actual collections are below assessments. Collection rates vary from 62 percent in Madhya Pradesh (1986 to 1991) to 93 percent in Uttar Pradesh including arrears (Desai and Jurreins 1993, p. 208). Collection procedure consists of assessment of crop and areas, billing and collection, and is institutionally fragmented. Responsibility lies with the Irrigation Departments and Revenue Departments. Nevertheless, it is mentioned that even with perfect collection efficiency, water charges would result in inadequate revenue due to changes being too low.

There is growing concern on the Central and State government level that users of public irrigation (and drainage) systems must meet the cost of providing these services, and that additional provisions are needed for example, maintenance of drainage systems. While water charges incurred to beneficiaries are too low to meet ever growing O&M expenses, it is believed that in order to improve the (financial) performance of major and medium public irrigation systems, there is a

[19]Bhatia estimates that indirect resource transfer from farmers practising irrigated agriculture with canal water to Central and State governments is high (1989, p. 279ff).

need for fundamental change in the organizational set up and incentive structure of the managing agencies. It has been suggested that Irrigation Departments should be made financially autonomous, i.e. their income depends on the revenue they themselves collect for irrigation and drainage services (Gulati et al. 1994).

In addition to cost recovery, it is argued that water-use-efficiency needs to be promoted in the face of increasing water scarcity through a water charging system that would set incentives for farmers to conserve water (Saleth 1997).

6.6 Innovative Approaches and Constraints

The irrigation and drainage sector in India is dominated by public authorities. However, a clear institutional framework and organizations with defined responsibilities concerning drainage development and management is lacking. Funding for drainage construction and O&M works are handled differently from State to State and could not be identified sufficiently.

The World Bank (1998) notes that irrigation and drainage management issues in India is common to many developing countries. The Federal States would face a number of physical, institutional and financial constraints, where irrigation and drainage management is handled separately by each State. Most surface irrigation and drainage infrastructures in India are in a severe state of disrepair and urgently need maintenance. Canals and drains are heavily silted. The extent of irrigated areas have diminished because of waterlogging, salinization and the break down of storage facilities. The World Bank criticizes the highly centralized administration of India's irrigation and drainage sector. The Irrigation Departments of the Federal States are generally large government departments without linkage to farmers. Staff and organizational structures of most State Irrigation Departments are orientated toward construction and not towards service provision. Capabilities to carry out operation and maintenance are poor. A main financial constraint is the very low water fees. Operation and maintenance need continuous subsidies provided by State Governments.

Several irrigation and drainage projects were implemented with the aim to improve drainage performance. Evaluations concentrate on technical aspects. A unionwide coordinated data collection concerning recent drainage experiences with respect to institutional aspects, legal regulations, accountability, financing investments and recurrent costs, experiences with farmers' participation in drainage management would be interesting in order to identify factors contributing to good or bad drainage performance.

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7. PERU

7.1 Natural Environment

Peru covers a total area of 1,290,000 square kilometers with the Andes as the characteristic feature of the Peruvian geography. It stretches in a south-easterly direction almost bordering the Pacific coast. This Cordillera shapes three different physiographic areas with particular geo-morphological and geological characteristics that are of varying agricultural and economic importance.

About 10 percent of Peru's area is located in a narrow coastal strip between the Pacific Ocean and the Andes, where agriculture is possible only under irrigation. Currently some 717,000 hectares are irrigated in the many coastal valleys (53 in no.). Sixty percent of Peru's agricultural GDP is generated in this zone.[20] Thirty percent of Peru is mountainous, made up of valleys and the western Andean plateau. Here precipitation suffices for one crop a year and second cropping is an option if supplied with irrigation water. About 310,000 hectares are irrigated, usually in small irrigation schemes that are managed by community organizations. Sixty percent of the country is located in the Amazonian watershed comprising the eastern plateau of the Andes and the low lying Amazonian rain forest. It is hardly used for intensive agricultural purposes. Only 10 percent out of 1 million hectares is irrigated.

The bulk (98 percent) of Peru's water resources is located in the Amazonian Basin with only limited agricultural potential. The fertile coastal region is totally dependent on water supplies from rivers originating in the Andes. Almost 80 percent of Peru's total water use is consumed by irrigated agriculture, which is about 40 percent of the cropped land. Three-fourth of the country's agricultural output is produced under irrigation (WCD 2000).

Peru is not an agricultural economy but its agricultural potential is far greater than what has been exploited including that of underutilized irrigation schemes.

7.2 Irrigation and Drainage Development

Irrigation has been practiced in Peru since pre-Colombian times. When the Spaniards arrived in Peru, agriculture was widespread with sophisticated irrigation techniques which had been developed by different cultures over centuries. During the Spanish conquest many irrigation systems and techniques were destroyed or abandoned. New rules were implemented and existing rules and regulations concerning administration and management of water were modified. Irrigated agriculture was concentrated in the coastal valleys on a large scale, while agricultural lands (terraces) in the mountains were widely neglected.

Since Peru's independence, several projects were implemented to improve water supply and extend irrigation areas. Peru belongs to those countries in the world where pressure on cultivated area is high (person/ha). Therefore, a plan to increase the cultivated area by one million hectares was announced in 1964 comprising programs for the coastal zone (i.e. 18 irrigation and reclamation projects with a total area of 225,000 ha) and two other program components with irrigation improvement projects in the highlands and several land reclamation projects in the forest region (Framji 1981).

[20]Out of 24.8 million inhabitants one-third of Peru's labor force is employed in the agricultural sector.

During the 1960s, public interest on necessity for agricultural drainage arose and as a result the Center of Drainage and Land Reclamation (CENDRET) at the Agricultural University in Lima was established in 1968. It was transferred to the Ministry of Agriculture in 1971, and renamed as Subdivision of Drainage and Land Reclamation (SUDRET). A study by SUDRET revealed the necessity of drainage measures for the coastal zone (Chanduvi 2000 personal communication). Drainage pilot areas were established and training measures for professionals realized.

Between 1974 and 1986 drainage projects were implemented, and in 1986 about 24,000 hectares of salinized land were rehabilitated, whereas 16,000 hectares are still waiting for rehabilitation. However, problems increased and existing infrastructure continued to deteriorate; studies revealed that problems were underestimated in some areas (De la Torre 1986).

In 1974, a commission with Peruvian engineers and Dutch technical advisors formulated the National Plan of Drainage and Land Reclamation (REHATIC) for the coast which recommended priority areas for execution. The main components of the rehabilitation plan were:

- to improve main irrigation infrastructure in the valleys;
- to improve irrigation and drainage infrastructure in areas which suffer from poor drainage and are affected by salinity at farm level;
- technical assistance for farmers and water users organization, especially for operation and maintenance, and to improve irrigation efficiency at farm level;
- to provide water users with machinery and appropriate workshops (De la Torre 1986).

REHATIC had been executed in three phases: REHATIC 1 concentrated on six valleys and comprised irrigation improvement, drainage and reclamation requirements, and field drainage requirements. Total investment was in the order of US$47.8 million and was partly financed by the World Bank. REHATIC 2 dealt with areas affected by drainage and salinity problems in the lower Piura Valley being part of the Chira-Piura Irrigation Project. The cultivated area comprised 50,000 hectares out of which 35,000 hectares showed drainage and salinity problems. Improvement of main and collector drains and installing new collectors was part of the project. However, approximately 25,000 hectares still suffer from salinity due to the lack of farm drains. Although funding was guaranteed by a World Bank loan (US$90 million), the project was not completed because high and unusual precipitation (El Niño) flooded the lower Piura. REHATIC consisted of seven small projects: two in the Sierra region and five at the coast. The total irrigated area was 69,554 hectares of which 49,478 hectares needed drainage and soil reclamation. REHATIC 3 was intended to be completed in 1987.

De la Torre (1986) mentions projects for irrigation improvement that have drainage components, e.g. the irrigation and drainage improvement project Jequetepeque-Zaña. It comprises about 6,000 hectares that have drainage problems and 15,000 hectares that suffer from soil salinity due to shortage of irrigation water. The ongoing CHAVIMOCHIC-Project is an integrated Four-Valley-Project, namely the valleys Chao, Virú, Moche and Chicama, and intends to improve availability of irrigation water by diverting water from the Santa River. It includes improvement of existing drains, excavation of new drains, installation of new and replacement of aged subsurface drains. Soil salinity in CHAVIMOCHIC affects 21,061 ha, the reason for which is not known.

In 1990, the National Project of Irrigation and Drainage (PRONARDRET) considered irrigation and drainage improvement but soon was deactivated by law in 1992 (Decree No. 25902).

7.3 Drainage Problems

7.3.1 Land Drainage

Land drainage differs in its characteristics, origin and economic importance among the regions: The **coastal region** is seriously affected by soil salinity and waterlogging. A World Bank Study (1995) estimates that 2-300,000 hectares would show serious damages, and Hendriks (1990) mentions that more than 300,000 hectares land would suffer from salinity to a different degree. Soil salinity originates from low irrigation efficiencies, the marine origin of the soils and poor natural drainability of the lowlands (De la Torre 1986). Approximately 250,000 hectares (i.e. 30 percent of the best agricultural land) would require reclamation, and at least one half of the irrigated area is badly in need of rehabilitation and modernization. Excessive water use in the upper regions of the irrigation systems has contributed to soil salinity in the lower parts of the coastal valleys. It is assumed that between 20-60 percent of irrigation water is lost due to seepage from irrigation canals, which leads to ponding and soil salinity in the lower parts. Exclusive priority would have been given to new irrigation projects instead of improving existing infrastructure.

Drainage problems in the **mountainous region** (also known as the Sierra region) result in high water tables, especially in the lower part of the inter-Andean valleys and in areas surrounding lakes and lagoons. Approximately 120,000 hectares are affected (De la Torre 1986).

Extraordinarily high precipitation, river floods and flat lands cause drainage problems in the **jungle region** with negative impacts on prime agricultural land. These lands are used as pastures and for rice production, and would need little drainage improvement (De la Torre 1986).

7.3.2 Flood Control

Peru is one of the countries that suffers from the global climatic phenomena called ‘El Niño’. El Niño is associated with extreme climatic variability resulting in heavy rains, strong winds in some areas and droughts in others. It occurs in an unpredictable cycle every few years and varies in its magnitude and impact. The coastal zone of Peru is affected by extreme precipitation and severe floods. The latest appearance of El Niño was in 1997/98 with heavy impacts on fishery, agriculture, housing and transportation.

In 1997 the Water and Soil Directorate of the National Institute of Natural Resources (INRENA) started with defining zones for flood protection at the main watercourses along the coast. These zones lie above river banks, rivers, lagoons, ponds, lakes and reservoirs, and must remain unoccupied. Zoning for flood protection already covers as many as 33 (out of 53) main watercourses in the Pacific drainage basin. They are located in the largest irrigated areas of the country (INBO 1998).

The World Bank supported the ‘El Niño Emergency Project’ (1997/98) in order to take preventive measures that may reduce potentially negative impacts of El Niño, and to provide help during emergency and reconstruction phases (World Bank 1997).

7.4 Institutional Arrangement for Land Drainage

7.4.1 Legal Regulations

Development and management of water resources, in general, and for irrigation, in particular, is basically prescribed in the General Water Law (Legislative Decree No. 17752), which was inaugurated in 1969. Together with the Agricultural Investment and Promotion Law (Legislative Decree No. 653, 1991) and respective regulations, they form the legal basis and stipulate that all water resources, i.e. surface and groundwater, belong to the State, including agricultural wastewater accumulating in the drainage infrastructure (Art. 10 and 40, Law 1969).

According to the General Water Law (1969) the State is concerned with operation and maintenance of hydraulic infrastructure. A new decree foresees O&M responsibilities to be transferred to Water Users Associations that are supervised by Technical Administrators appointed by the Minister of Agriculture. Once irrigation systems are completed, responsibility for management and financing O&M services can be transferred to Water Users Associations as it is defined by Law No. 037-89-AG (1989). However, the law does not clearly define users' rights regarding irrigation and drainage infrastructure. Decree No. 047-2000-AG (2000) reinforces that organization and management of water users should be strengthened.

7.4.2 Organizational Set Up

In Peru agricultural drainage is administered by public and civic irrigation institutions that operate and maintain the infrastructure. Water management, irrigation and drainage management in particular, occurs at three levels.

National Level

Irrigation and drainage projects in Peru were realized basically by the State. Until 1983, the Ministry of Agriculture (MAG) implemented the most important projects through its General Directorate for Irrigation. In 1983, the National Institute of Development (INADE) was established under the Ministry of Agriculture as the central organization for managing large-scale irrigation projects. These projects are generally larger than 10,000 hectares and comprise drainage canals. Operation and maintenance of large, not yet completed, hydraulic projects remains with INADE.

The General Directorate for Water and Land (DGAS) under the Ministry of Agriculture is responsible for water management in the agricultural sector while there are other ministries to regulate water use in their sectors (e.g. Fisheries, Health, Energy and Mines). Since 1992, DGAS belongs to the National Institute of Natural Resources (INRENA), which is responsible for the rational use of natural resources with participation of the private sector.[21] It is in charge of improving irrigation and drainage infrastructure, rehabilitation of soils affected by salinity and poor drainage in small-scale irrigation systems (Art. 19, Decree No. 25902, 1992).

[21]INRENA within MAG is an environmental unit with several directorates i.e. water and soils, forestry, rural environment and others.

Regional Level or River Basin Level

Since 1991, along with the Agricultural Investment and Promotion Law (Legislative Decree No. 653) regional water entities would be established in every river basin. These Autonomous Hydrological Basin Authorities (AACH) formulate master plans for catchment-wide management of natural resources, for implementing irrigation and conservation activities. An AACH has a board that is chaired by the Irrigation District's Technical Administrator.[22] The board members are representatives of regional governments, the Ministries of Energy and Mines, Housing and Construction, the National Development Institute (INADE) and five representatives of producer groups or associations. Until October 1993, only three AACHs had been established. They are all located in the north of Peru in the valleys of Lambayeque-Chancay, Jequetepeque and Chira-Piura (World Bank 1995).

Irrigation Districts

Peru has 97 Irrigation Districts throughout the country. One Irrigation District commands the irrigation area of at least one river basin. The Irrigation Districts' command area is then subdivided into irrigation sectors and irrigation subsectors. While the boundaries of Irrigation Districts are generally defined by a hydrological boundary (watershed), Irrigation Sectors are supplied by a main canal and Irrigation Subsectors by a secondary canal. Accordingly, Technical Administrators who are appointed by the Ministry of Agriculture, are responsible for one Irrigation District and oversees the Water Users Association. The tasks of the Technical Administrator are:

- to ensure the rational use of water resources;
- to approve cropping and irrigation plans and supervise their implementation;
- to authorize and approve the studies and infrastructure construction associated with requests for licenses and permits for water;
- to issue water licenses and permits;
- to approve and keep water use registers up-to-date;
- to establish, modify and cancel water rights;
- to impose restrictions on water use for conservation purposes;
- to resolve conflicts amongst water users;
- to support and approve the creation of water users associations;
- to propose and set water tariff levels, and
- to approve plans for the O&M of the irrigation and drainage systems (World Bank 1995).

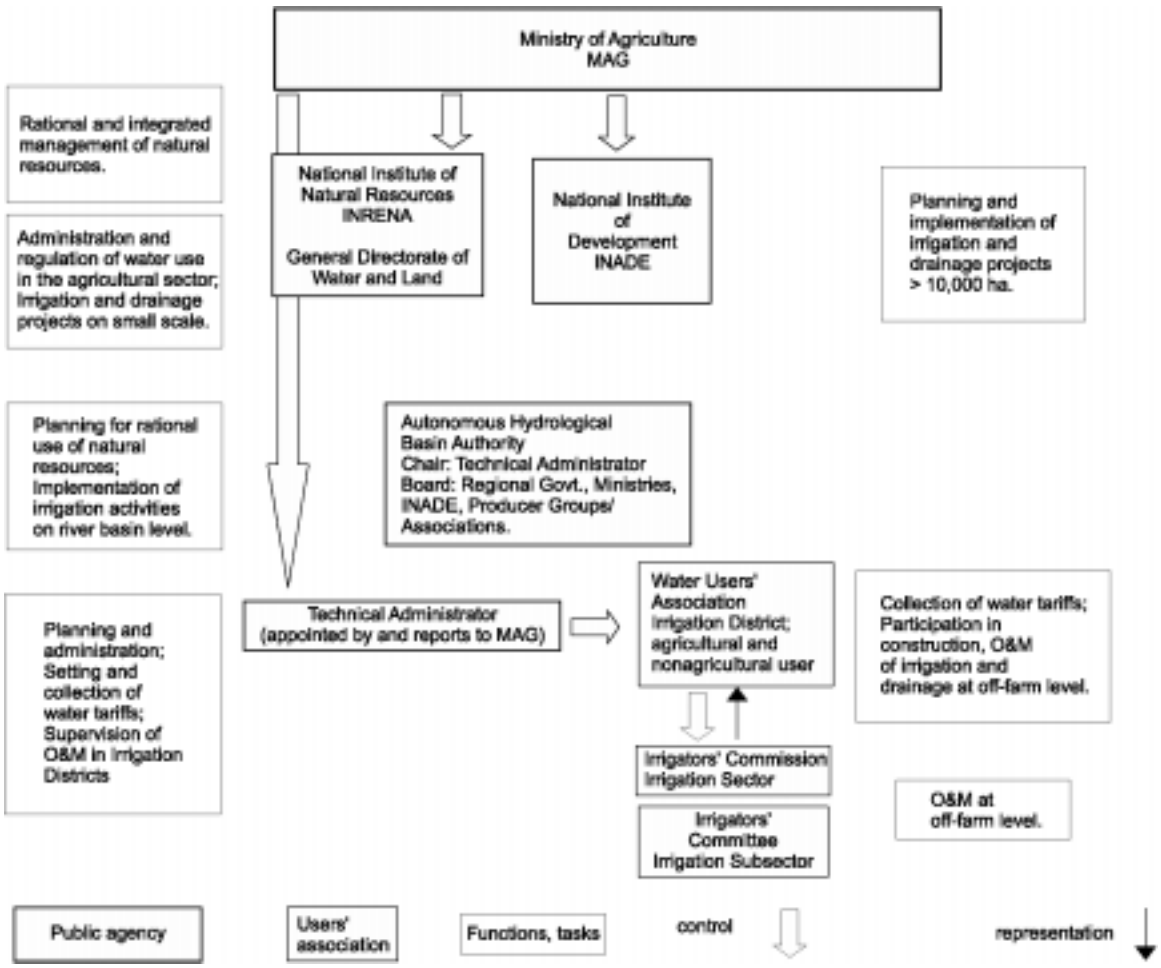
[22]Irrigation Districts can be greater than one basin.

However, with the Presidential Decree NO. 037-89-AG (1989) operation and maintenance of irrigation and drainage systems was transferred to Water Users Associations. Since then, they are responsible for development, preservation and rational use of water and land resources in the irrigation districts. WUAs are private organizations and legally entitled to collect water fees, operate and maintain the irrigation and drainage works in coordination with the Technical Administrators. Today WUA membership, statutes and by-laws are regulated by Presidential Decree No. 047-2000-AG. A WUA may consist of representatives from all water users, i.e. agricultural and nonagricultural users, within one irrigation district. But actually, not all nonagricultural users cooperate with agricultural users, as such establishing separate organizations can result in more than one WUA in an Irrigation District. However, at least one WUA exists in each of the 97 irrigation districts. According to Guerra et al. (1993) associations were not prepared and willing to take over such responsibility because the irrigation infrastructure is in a very poor and deteriorated state.

On the **Irrigation Sector** Level (area supplied with irrigation water by a main canal, between 3,000 and 10,000 hectares) agricultural water users organized themselves in Irrigators Commissions. On the **Irrigation Subsector Level,** (area supplied by a secondary canal, between 1,000 and 2,000 hectares) Irrigators Committees were formed. These Commissions or Committees are responsible for operation, maintenance and improvement of the hydraulic infrastructure in their respective command areas to guarantee the use and disposal of drainage water (Water Law 1969, Art. 20).

O&M of any agricultural drainage project is programed together with O&M for irrigation systems and is organized in Irrigation Districts. The Peruvian law clearly defines responsibilities of each organization but cooperation between farmers, water users and government organizations has been poor. As a result, operation and maintenance has been inadequate, sufficient funds are lacking and there is no powerful authority.

Figure 7.1. Organizational set up for drainage in Peru.



7.5 Financing Drainage

7.5.1 Investment Costs

Between 1975 and 1980, about 85 percent of investments in the agricultural sector was dedicated to irrigation. Out of this, 96 percent was invested in new irrigation projects, and only 4 percent was used for improvement of irrigation, rehabilitation, recuperation and for drainage.[23] Drainage projects in Peru usually include measures for improving irrigation systems because soil salinity is most frequently associated with seepage from irrigation infrastructure. In order to find solutions to the problem of seepage and the soil salinity associated thereto, from the 4 percent of investment delegated for improvements, about 43 percent thereof were dedicated for improving irrigation

[23]Recent data are not available.

systems, i.e. lining of canals, improvement of intake structures, improvement of groundwater wells and equipment. Approximately 38 percent of the improvement investments were invested in drainage infrastructure, including the main drainage systems, farm drains and land preparation for leaching. Nineteen percent of the amount is used for machinery, equipment and buildings for operation and maintenance (De la Torre 1986).[24] Project costs neither include investments for O&M of irrigation and drainage systems nor for management training (Guerra et al. 1993; Hendriks 1990).

Between 1974 and 1986, Peruvian drainage projects were partly financed by foreign sources like the World Bank or the Dutch Government. The amount of the World Bank's investment for drainage between 1975-1999 is about US$70 million (Abdel-Dayem 2000).

7.5.2 Farmers' Contribution towards Capital and Recurrent Costs

Peruvian farmers are required to contribute towards investment and O&M costs by paying water fees. Accordingly, legislation (Decree No. 003-90-AG) prescribes two classes of water tariffs, one for agricultural and a second for nonagricultural water users. They are based on the volume of water used. Water tariffs for agricultural use include three components (see CEPES 1984; World Bank 1995):

- *Income of Water Users Associations*
  To recover costs for O&M of the Irrigation District and to finance the operating budget of the Technical Administrator and the Water Users Association.

- *Water Levy*
  A water levy for the use of water representing 10 percent of the first component.

- *Amortization Component*
  To recover public investments in irrigation and/or drainage infrastructure (10 percent of the first component).

In addition to water tariffs, special water levies (called *cuotas*) are collected by WUAs to meet extraordinary expenses (e.g. specific works or activities) in their Irrigation District. As the water tariffs are too low for meeting O&M expenditure, special levies have helped to improve O&M especially after management transfer of irrigation infrastructure to water users. The amortization component is far too small to recover total construction costs. Actually, from 1 to 3 percent of the total construction costs are covered by farmers' payments (World Bank 1995). Some Irrigation Commissions would only pay the special water levy (Chang-Navarro et al. 1993).

Collection of water tariffs is administered jointly by the Technical Administrators and the Water Users Associations that belong to the same Irrigation District. Farmers can pay at once or in monthly installments. Water is then delivered for the time period that has been paid for, only after payment has been received.

[24]Figures are given without reference to time period.

The collected funds have not been sufficient to adequately maintain the hydraulic systems.[25] Collection of water tariffs has been the basic problem that hampered proper operation and maintenance of drainage systems. Only 5-10 percent of the actual costs is collected due to an inefficient collecting system. It is estimated that between 25 and 30 percent of the farmers do not pay their dues although water tariffs are low. However, Chang-Navarro et al. (1993) note that the calculated water tariffs are too low to meet the real O&M costs and that their collection is realized with a delay of between 2 and 3 years.

7.6 Innovative Approaches and Constraints

Governmental initiatives for drainage development began in the 1960s and ended in 1990 with the deactivation of PRONADRET. A shift from governmental management responsibility in the irrigation and drainage sector to an increasing participation of beneficiaries can be observed. Compared with other countries, e.g. the Philippines and Mexico, Peru is not very successful in participatory irrigation management, let alone drainage.

Peru has a sufficient number of qualified engineers in the state and private sector; Peruvian companies have demonstrated great capacity and have developed experiences in the execution of almost all drainage projects. A serious problem, however, would be the lack of skills for installing subsurface drainage. Maintenance is one of the main problems lacking a solution. Absence of proper organization as well as lack of administrative and legal regulations are mentioned as principal reasons. In addition, Peru has enough professionals with experience for reclaiming saline soils, but responsibility of implementation rests with farmers who lack adequate training.

The World Bank (1995) considers that the institutional and policy framework of the Peruvian irrigation and drainage sector would appear rational but realization has proved to be difficult. Several authors mention the precarious institutional situation of the Peruvian State which led to mismanagement, in general, and to a striking situation in the irrigation and drainage sector, in particular:

- The inability to set and collect water tariffs that results in a lack of financial resources to adequately operate and maintain irrigation and drainage systems. Most of them are in an advanced stage of deterioration.

- Excessive water consumption at on-farm level leading to waterlogging and soil salinity.

- Preferences for crops with high water requirements such as sugarcane and rice.

- Few incentives to move towards more efficient irrigation techniques such as sprinkler or drip irrigation.

Carrasco et al. (1995) note the administrative weakness of the Irrigation Districts and points out the lack of technical staff for operation and maintenance and, in general, the lack of funds. Technical Administrators at Irrigation District level would operate with extremely limited financial

[25]Internal decision-making on allocations for O&M of either irrigation or drainage infrastructure is not known, figures not given.

funds, little technical support and few staff to carry out their functions. And as a result irrigation and drainage are poorly managed. Water tariffs are too low to meet the actual investment costs and expenditure for operation and maintenance. About 30 percent of the users are unwilling to pay and sanctions for delay are not foreseen.

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8. THE PHILIPPINES

8.1 Natural Environment

The Philippines is a tropical country that consists of more than 7,000 islands, covering an area of 300,000 square kilometers. It is one of the largest island groups in the world and is divided into three major island groups, i.e. Luzon (142,000 square kilometers), Visayas (56,000 square kilometers) and Mindanao (102,000 square kilometers). The country has 12 water resource regions, the hydrological boundaries of which are defined by physiographic features and homogenous climate, and generally correspond with existing political regions.[26] The Philippine islands are generally mountainous but have low lands, valleys and broad plains. There are 421 rivers which supply water for 90.2 percent of the area that is irrigated.

The climate of the Philippines is characterized by a dry summer (November-May) and a rainy season (June-October). The islands are located in the tropical and monsoonal climate zone, with a uniform temperature of 27°C on an average throughout the year, high relative humidity (>70 percent throughout the year), low solar radiation, irregular rainfall and high frequency of tropical cyclones. The average rainfall is estimated at 2373 mm/year (1961-1990) with variations between 961-4051 mm/year. The archipelago lies in the typhoon belt, and two to three typhoons hit the country each year. Many islands are affected by extensive flooding and damages during the typhoon season between June and December.

8.2 Irrigation and Drainage Development

The Philippines is an agriculturally based country. About 11.6 million hectares are classified as agricultural land. The total cultivated area is estimated at 9.5 million hectares. A total of 3.1 million hectares is irrigable, whereas, the developed irrigation command area only comprises about 1.53 million hectares. In 1993, the drained area was about 1,5 million hectares (FAO 1999).

Agriculture plays a vital role in the Philippines' economy. Approximately 30 percent of the Gross Domestic Product and 60 percent of the total export earnings is generated in the agricultural sector, where almost 41.5 percent of the labor force is employed (in 1996). Agriculture is characterized by extensive land use, intensive labor use, relatively low yields, low per capita income and farms of small, medium and large size. Small farm sizes of about 2 hectares dominate and are managed by families who produce for subsistence and/or for commercial production. The main irrigated crop is paddy (wet-rice). Prime agricultural lands are located near main urban and densely populated areas.

In earlier centuries irrigation development, for example, in the Banaue rice terraces, which are approximately 2000 years old, was undertaken by rural communities. During the Spanish regime irrigation was extended to the plains and new irrigation techniques and designs were introduced. In addition to government-supported irrigation development, communities continued to develop irrigation systems independently, i.e. the irrigation societies called *zanjeras.* They were created from 1630 onward and are still operating. Major irrigation investment was undertaken in the 1920s,

[26]Administratively, the islands are divided into regions, provinces, cities and municipalities, further being subdivided into *barrangays*, i.e. the smallest unit of political representation, comparable to a village.

the post-war period, the 1970s and the early 1980s when public involvement in the irrigation subsector was at its maximum.

Apart from private groundwater pumping schemes which irrigate only 9.9 percent of the irrigated area, there are two types of surface irrigation systems:

National Irrigation Systems (NIS) cover 42.2 percent of the total irrigated area. Their construction, operation and maintenance is realized by the government through the National Irrigation Administration (NIA). Development costs of irrigation and drainage infrastructure are covered by NIA with contributions from farmers.

There are about 165 NISs covering an area of about 650,000 hectares. NISs are generally, relatively small run-off-river schemes, but there are three large NISs which receive irrigation water from reservoirs, covering about 35 percent of NIS' total service area. One NIS scheme usually serves more than 1,000 hectares (NIA 1999). NISs are jointly operated and maintained by the National Irrigation Administration and Irrigators Associations.

Raby (1997) states that, as a rule, National Irrigation Systems are characterized by poor system design for flood control and drainage, inadequate drainage and on-farm facilities, deteriorating canal structures, silted and defective diversion works. Natural disasters such as typhoons and floods negatively contribute to the deterioration of these systems.

Communal Irrigation Systems (CIS) have a longer tradition than National Irrigation Systems. Traditionally, they were created by farmers and only recently initiated by NIA. After construction by NIA they are turned over to Irrigators Associations for operation and maintenance. The 6,200 CISs cover an area of 734,104 hectares which is 47.9 percent of the total irrigated area.

Since 1991, local governments were authorized to use their own funds for developing their own Communal Irrigation Systems, small water impounding projects, drainage and sewerage, flood control and similar projects. CISs are characterized by full repayment of investment costs through beneficiaries, who are responsible for O&M after transfer. According to FAO (1999), the associations bear 10 percent of capital costs for construction immediately and pay back the balance within 50 years at an interest rate of 10 percent.

However, it is difficult to estimate the extent of the irrigated area drained. In traditional terraced paddy cultivation, which is the most frequent crop in the country, water flows from one plot to another either through irrigation channels or directly. No distinction can be made between irrigation and drainage, as irrigation canals serve also as drains. The figure of 1.5 million hectares is considered as a maximum for the area drained. On farm level, farmers may construct drainage facilities which are financed through irrigators' own resources. However, drainage improvement has the least priority (Undan 2000, personal communication). The Irrigation Development Program (1999-2004) foresees besides implementation of new irrigation projects and improvement of existing irrigation structures, the improvement of 739 kilometers of drainage and flood protection systems within national and communal irrigation systems (NIA 1999). As of 1998, extensive networks of flood control structures, such as dikes, river walls, channel improvement and dredging have been undertaken in the major river basins. Major components of a flood control and drainage program in Metro Manila have been built, e.g. additional main drains, pumping stations and improvement works.

The Philippines participates in the South East Asian Drainage Program (SEADP), which is a regional program prepared by IPTRID (International Program for Technology and Research in Irrigation and Drainage) using Dutch funds. The other countries involved are Australia (North East), Bangladesh, Cambodia, China (South), India (East), Indonesia, Japan (South), Laos, Myanmar, Malaysia, Nepal, Papua New Guinea, Taiwan, Sri Lanka, Thailand, and Vietnam. Main

objectives of the program are to strengthen drainage development and management capacities in the collaborating countries.

In December 1999, a preparatory meeting with representatives of the World Bank, IPTRID, ICID and six countries of the South East Asian region was held in Kuala Lumpur, Malaysia, for elaborating a drainage program (Smedema 2000). There, the Malaysian Minister of Agriculture assumed that only 4 percent of agricultural land in the South East Asian region is provided with some form of improved drainage, regular on-farm drainage being virtually nonexistent.

8.3 Drainage Problems

During the wet season too much water is the problem that has to be dealt with. Major problems with respect to flood control and drainage of agricultural lands are as follows:

- high rainfall intensity;
- excessive floods and water flows (runoffs) originating from denuded watersheds;
- silting-up of drainage channels;
- inadequate infrastructure for flood control and land drainage;
- insufficient budget allocations for maintenance, repair and improvement of drainage infrastructure.

Soil salinity and waterlogging caused by irrigation does not seem to be a problem for the Philippine's agriculture. Instead, the Philippines suffer from considerable flooding and drainage problems during the monsoon period. Great parts of the agricultural land have not enough drainage capacity to cope with high rainfall and its intensities and, therefore, are badly affected by flooding and waterlogging during the monsoon period. In the Philippines about 1.07 million hectares have been declared as flood-prone areas. The main region affected is Central Luzon with the provinces of Pampanga, Zambales and Tarlac (FAO 1999).

During the Seventh ICID Drainage Workshop held in Malaysia 1997, it was noticed that drainage problems of the South East Asian region are quite different from those of Western European or Latin American countries, and would require specific regional solutions and approaches to be elaborated within the SEADP. Monsoon flooding and waterlogging are the most serious drainage problems of all member countries, although some of them have drier regions with no or different drainage problems.

8.4 Institutional Arrangement for Land Drainage

8.4.1 Legal Regulations

The Water Code of the Philippines was enacted in 1976 and includes basic principles that define appropriation, control and conservation of water resources. The Water Code prescribes policies for water use, rules and regulations for implementation. Construction, financing, operation and

maintenance of drainage infrastructure is defined in Chapter IV (Utilization of Water), Art. 44-48 of the Water Code as follows:

- "Drainage systems shall be constructed that their outlets are rivers, lakes, the sea, natural bodies of water, such other water course as any be approved by the proper government agency.

- "When a drainage channel is constructed by a number of persons for their common benefit, cost of construction and maintenance of the channel shall be borne by each in proportion to the benefits derived.

- "When artificial means are employed to drain water from higher to lower land, the owner of the higher land shall select the methods of drainage that will cause the minimum damage to the lower lands, subject to the requirements of just compensation."

8.4.2 Organizational Set Up

Drainage of agricultural land in the Philippines, its administration, organization, operation, maintenance and its financing is assigned to irrigation institutions.

As all waters belong to the State, control and regulatory functions are exercised through governmental agencies, i.e. the National Water Resources Board (NWRB) formerly known as the National Water Resources Council under the Department of Public Works and Highways (DPWH). The NWRB is a collegiate quasi-judicial body with six Cabinet Secretaries (i.e. Department of Public Works and Highways, National Economic Development Authority, Department of Energy, Department of Trade and Industry, Department of Environment and Natural Resources, Department of Health). The National Water Resources Board heads four agencies, namely the Metropolitan Waterworks and Sewerage Services, the Local Water Utility Authority, the National Irrigation Administration (NIA) and the National Power Corporation, that are involved in the water sector and coordinates their activities (irrigation, hydropower, flood control, navigation, pollution, water supply, waste disposal, watershed management). NWRB formulates policies and guidelines on water resources development and management; regulates and controls the utilization, exploitation, development and protection of water resources; adjudicate and grants water permits, supervises and controls all water utilities (except those falling under the jurisdiction of the Metropolitan Waterworks and Sewerage Services and the Local Water Utility Authority).

Two public entities are particularly concerned with drainage: the National Irrigation Administration and the Department of Public Works and Highways. The main agency responsible for irrigation and land drainage is the National Irrigation Administration under the Department of Agriculture, which undertakes irrigation, drainage and land reclamation at off-farm level (Undan 1997). Off-farm drainage infrastructure for flood control, including its maintenance, is a task of the Department of Public Works and Highways as well as flood protection. It declares flood control areas and promulgates guidelines for managing flood plain lands (Water Code 1976).

The National Irrigation Administration (NIA) was created in 1964 as a semi-autonomous agency, authorized to investigate, study, improve, construct and administer irrigation systems. NIA is a government corporation under the Department of Public Works and Highways.[27] Additional

[27]The then Department of Public Works and Communications.

responsibility for flood control, land drainage, land reclamation, domestic water supply, hydropower development, construction of roads and highways and reforestation was given to NIA in 1974, under the Presidential Decree No. 552. NIA was required to become financially autonomous for its operating budget, but not for capital investments.

In 1992, the National Irrigation Administration was transferred to the Department of Agriculture to enable it to play a more effective role in agricultural development and food production. NIA is the authority that sets and collects water fees from the beneficiaries to finance the services it provides. The National Irrigation Administration receives its funds from foreign or international loans and grants, capital stock subscriptions of the government, annual appropriations for communal irrigation development (from the General Appropriation Act), and revenues earned for its services, including water fees from irrigation beneficiaries and a fee of 5 percent from loan funds for administrative and overhead costs associated with the supervision of construction of systems (Small and Adriano 1989).

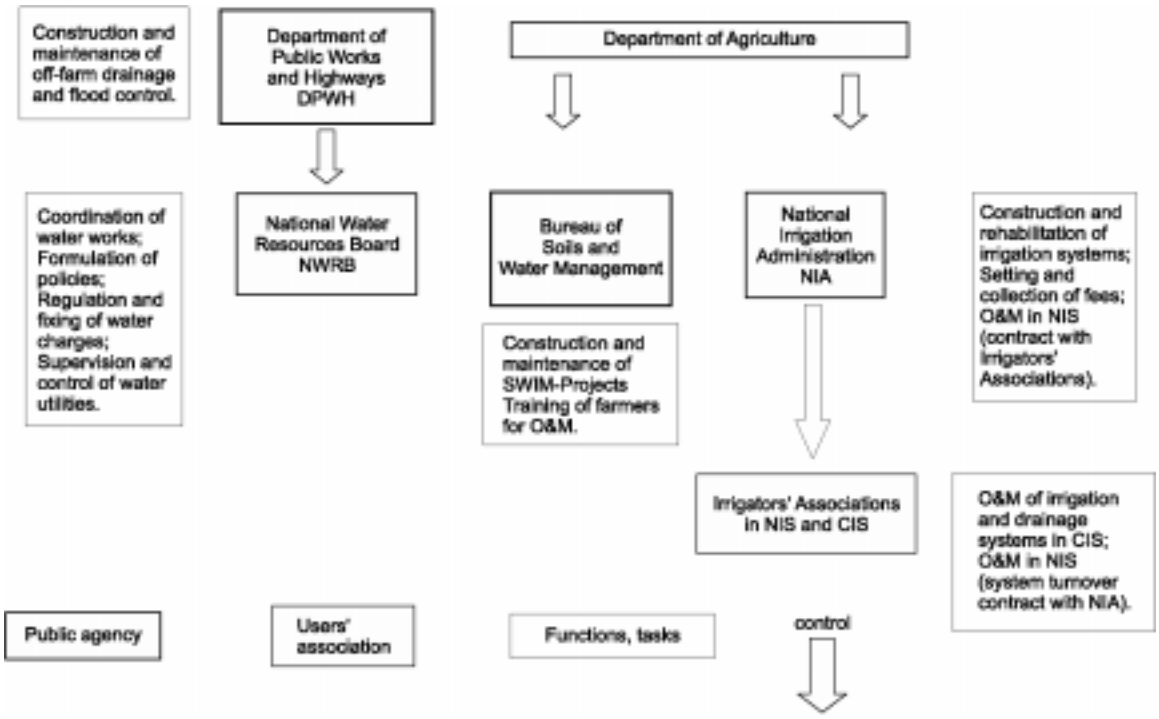
Rehabilitation and improvement of the National and Communal Irrigation Systems is done by NIA. These activities comprise of, among others, the repair and restoration of damaged irrigation facilities; repair and rehabilitation of drainage and flood protection systems to prevent flooding and waterlogging, and to allow the reuse of drainage water. Construction is under its Engineering Division, operation and maintenance of irrigation systems is the task of Operation Divisions.

The Bureau of Soils and Water Management of the Department of Agriculture implements different projects relating to soil and water resources inventory, conservation and management for agricultural productivity. For example, it handles construction and maintenance of Small Water Impounding Management (SWIM) – Projects. These projects are initiated by the government for mitigation of damages caused by frequent floods during the rainy season and damages brought about by insufficient water supply throughout the dry season. Construction of small impounding multipurpose dams e.g. flood control and irrigation and soil erosion control significantly reduced the extent, depth and duration of flooding. The SWIM-program remains to be implemented according to the National Development Program (1999-2004). The Bureau of Soils and Water Management provides training for farmers who operate and maintain the Projects after being completed and turned over to them.

8.4.3 Farmers' Participation

In the Philippines, participatory irrigation management has its roots in indigenous irrigation societies. The turnover of management responsibility for irrigation systems to users has been practiced in the Philippines since the late 1970s, with drainage management being almost neglected. Farmers may voluntarily establish Irrigators Associations which are non-profit, non-stock associations, registered under the Securities and Exchange Commission. Elected farmers' representatives occupy a seat in the boards of the concerned government agency (Salman 1997). The associations sign contracts with NIA, which in detail define respective O&M responsibilities for irrigation systems. There are three types of system turnover contracts determining different degrees of management responsibility ranging from system maintenance to turnover of all or parts of the system. Irrigators Associations are also supposed to take care of the drainage system at the farm- and turn-out level (Undan 2000, personal communication).

Figure 8.1. Organizational set up for drainage in the Philippines.



Before and after the management turnover farmers took and take care of regular cleaning and weeding of the farm ditches adjacent to their fields. In NIA-managed systems field personnel from NIA were expected to clean the major canals before the irrigation season and during harvest time for drainage. Under Irrigators Associations' management the association is responsible for regular cleaning and de-silting of the canal system with technical support provided by NIA.

Farmers pay a membership fee to their respective Irrigators Association that vary from association to association. A review of the irrigators obligations shows no explicit obligations for off-farm drainage infrastructure. Irrigation management transfer has often led to significant improvements in system performance. Whether an improvement in drainage performance can be observed or not, is not mentioned.

8.5 Financing Irrigation and Drainage

8.5.1 Financing Investments

Investments in flood control, drainage and protection of shores in the Philippines' Infrastructure Program (1984-1987) under the Department of Public Works and Highways was about 5 percent of total investments provided for water resources development. Irrigation investment was about 48 percent of the budget for water resources, or 12 percent of the total infrastructure program (Small and Adriano 1989).

From 1995 to 1997, 180 million Philippine Pesos (US$6 million) were allocated to Communal Irrigation Systems for rehabilitation, repair and improvement of drainage and flood protection systems. This was about 5 percent in 1995, 5 percent in 1996 and 4.5 percent in 1997 of the annual irrigation budget. The major share of the budget is allocated for establishing new irrigation systems. Expenditure for drainage is included in planning, design and construction of irrigation projects, although not explicitly indicated. Undan (1997) assumes that certain provisions are made for the accompanying drainage facilities in irrigated areas.

Farmers contribute towards construction costs of irrigation infrastructure in two ways: They contribute labor, material and donate land, and they are required to make annual repayments, which amount to 10 percent of capital costs during a period of years. This financing principle applies to the development of irrigation facilities of National and Communal Irrigation Systems if the latter are constructed by NIA. It is government policy that the government shall bear the cost of interest on all indebtedness incurred for irrigation infrastructure, in particular for areas devoted to cultivation of rice, corn, feed grains and vegetables. It is not known whether farmers do meet the conditions mentioned or not, and whether repayments are made and to what extent.

8.5.2 Financing Recurrent O&M Costs

As a government corporation, NIA earns revenue from Irrigation Service Fees, for generating sufficient funds to cover O&M costs. Irrigation Service Fees are levied on the basis of a flat rate per hectare for each season (wet and dry), and are collected by the National Irrigation Administration. The fee is a charge levied for the delivered water and the cost of delivery. It is assumed that the Irrigation Service Fee is assessed to also cover maintenance costs for drainage systems. Only Tapay (1989) mentions a drainage fee that would be collected by NIA. According to the Philippine Water Code (1979) the costs for constructing and maintaining drainage channels, which are constructed for common benefits, are to be borne by the beneficiaries of the channels, in proportion to the benefits. However, advanced information about drainage financing, fee calculation and collection could not be attained.

Small and Adriano (1989) mention that O&M of National Irrigation Systems has always suffered from fund shortages. Due to inflation, the irrigation fee paid by farmers has been denominated in terms of rice since 1975. The farmers may either pay in-kind or the equivalent amount in cash, based on the government support price of rice. Thus, the cash equivalent of the fee increased with any increase in the support price of rice, but the fee rates declined by about 35 percent in real terms since 1975. In some regions farmers were asked to pay considerably more than the total O&M expenditure, while in other regions payments equal O&M expenditure.

While the major share of NIA's O&M budget was spent for personnel costs (87 percent), a small amount was left for maintenance works. In addition, there was a lack of adequate mechanical equipment for maintenance, and due to deteriorated irrigation facilities adequate and timely distribution of water could not be guaranteed. This caused the farmers not to pay their dues. NIA improved its services to enhance farmers' willingness to pay. Apart, from that it reduced its personnel and changed its guidelines for wages. It improved the procedures for collecting fees and introduced incentives for farmers associations to participate in collection (e.g. on time payment entitled a farmer to a 10 percent discount); it transformed marginal irrigation systems that generated revenues less than O&M costs to Communal Irrigation Systems and transferred entire irrigation systems or sections to farmers' associations.

However, the literature reviewed does not mention how availability of funds does affect internal decision-making on maintenance expenditure, and whether revenue generated from irrigation service fees has earmarked components for drainage.

NIA sources state that the burden of Communal Irrigation Systems on the national budget is substantially less than that of National Irrigation Systems because of the full cost recovery of investment costs and full responsibility of the irrigators for O&M (NIA 1999).

8.6 Innovative Approaches and Constraints

Land drainage in the Philippines is done by irrigation institutions, and the Department for Public Works and Housing is responsible for construction and maintenance of flood control means and for off-farm land drainage. The exact assignment of drainage tasks remains still unclear, and we could not identify whether and how coordination is organized.

Drainage infrastructure in National Irrigation Systems is characterized by poor system design for flood control (the Philippines is one of the disaster prone countries in the South East Asian region) and for land drainage, and by deteriorated and silted canals. Detailed information about the drainage conditions of the Communal Irrigation Systems could not be attained. The irrigation management transfer from governmental agencies to farmers' organizations since the late 1970s led to significant improvements in irrigation system performance. If operation and maintenance of drainage systems is included in the management transfer, and whether drainage performance improved, needs investigation.

Strategies for land drainage in the Philippines would have to focus on the problem of too much water during the wet season. An integrated strategy needs to combine different aspects, i.e. watershed management (reforestation, construction of dams); river canal dredging and flood control (flood dikes); improvement of canal capacities and protection of low-lying areas from inundation; and an integration of constructing drainage facilities as a part of irrigation systems.

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9. SOUTH AFRICA

9.1 Natural Environment

South Africa has a total area of 1,220,000 square kilometers (122 million hectares) of which 18 million hectares (i.e. 15 percent) is considered as cultivable land. Major parts of the country have arid climate (21 percent has less than 200 mm/year rainfall) or semi-arid climate (44 percent has between 200 and 500 mm/year). Average rainfall is 475 mm/year, but about 65 percent of the country does not receive enough rainfall for dry-land farming making irrigation essential for successful agriculture. South Africa can be considered as a country with water shortage problems, and water is the restricted resource not land.

There are two main natural drainage basins separated by mountains in the eastern part of the country. The Orange River drains almost 48.5 percent of the total land area, but contributes only 25.5 percent to the total runoff. The rivers draining the eastern slopes drain only 13 percent of the total land area but account for approximately 43 percent of the total river runoff.

9.2 Irrigation and Drainage Development

Although agriculture is of minor economic importance and contributes only to 4.5 percent to South Africa's GDP (1997) and employs 9.8 percent of the economic active population, it significantly contributes to foreign exchange. With the resources available, the production of high value crops exceeds what is needed for food security (van Coller 2001, personal communication).

The total irrigated area comprises 1.3 million ha. The geographical distribution of suitable land for agriculture and limited water resources pose constraints on further expansion of irrigated agriculture. The National Department of Agriculture estimates an additional area of 200,000 hectares which could be brought under irrigation. Approximately 54 percent of South Africa's water is used for irrigation although with decreasing tendency because of increasing water demand from other sectors. An area of 1.1 million hectares is irrigated by surface water and 0.2 million hectares by groundwater (Vaughan 1997). Development of groundwater resources will receive more attention especially in the western part of the country which lacks perennial rivers. Irrigation technology is frequently used in South Africa with 53 percent sprinkler irrigation, 28.5 percent flood irrigation and 18.5 percent micro-irrigation (Backeberg 2000). About 54,000 hectares are provided with subsurface drainage installed with government subsidies (FAO 1995).

Although changes in South Africa's water sector are radical since implementation of the National Water Act in 1998, management of irrigation systems can still be categorized as follows:

- **Private Irrigation Schemes** (PIS) cover approximately 40 percent of the irrigated area. Costs for irrigation development were met by the landowners, and in many cases private parties undertook drainage investment on their lands, manage and finance maintenance of drainage infrastructure. If private drainage systems are linked with state drainage infrastructure, a contract between the parties determine responsibilities.

- About 30 percent of the irrigated area is managed by **Irrigation Board Schemes** (IBS). The government subsidized one-third of capital costs but gave no assistance for operation and maintenance. According to the new National Water Act No. 36 (1998) the Irrigation Board Schemes will be transferred to Water Users Association (WUA).

- **State Irrigation Schemes** (SIS) comprise 30 percent of the irrigated area. Full capital costs and substantial operation and maintenance subsidies were provided by the government although O&M costs should be recovered through water charges imposed on farmers. For the time being, SISs are state-managed through the Department of Water Affairs and Forestry (DWAF) but it is intended to transfer them to Water Users Associations. SISs provide a main drainage network into which farmers dispose drainage effluent water from their land. Maintenance costs will be recovered from taxes levied on private land; taxes are based on water used and paid to the Department of Water Affairs and Forestry.

- Irrigation schemes that belonged to **homelands** and that were managed by agencies appointed by homelands, are in the process of being transferred to Water Users Associations.

9.3 Drainage Problems

Figures on waterlogging and salinity vary considerably: (Ghassemi et al. 1995) note that, in general terms, the relative extent of waterlogged and salt-affected lands in South Africa would be much less than in other countries. Possible explanations for this favorable state were the emphasis on potential for waterlogging and salinization and their prevention in selection criteria for irrigated soils, the government assistance for financing drainage network, and the small size, greater slope and good surface drainage in the irrigated areas.

However, waterlogging and soil salinity has become an issue. The Soils and Irrigation Institute (1985) estimates that, in 1980, salinization occurred on 100,000 ha, and waterlogging on 37,000 ha; (Saleth et al. 1999) assume that about one-forth of the area currently under irrigation is affected, while the Water Research Commission estimates an area between 6 and 26 percent (Backeberg 2000).

Waterlogging and salinization of soils are irrigation-induced phenomena and are caused by significant water losses in the irrigation conveyance system. Approximately 30 percent of gross releases from dams get lost between dam off-takes and farm borders, 20 percent of the volume delivered to the farms get lost by on-farm distribution, and 10-15 percent get lost due to over irrigation. Improving water management on both farm and irrigation scheme level would allow eradication of waterlogging and soil salinity (Ghassemi et al. 1995). Many soils have a tendency to become saline when irrigated, which requires leaching salts from the soil profile in order to reclaim soil for irrigation purposes. Since 1992 an estimated area of 25,000 hectares has been rehabilitated, which is about 13 percent of the total degraded lands.

9.4 Institutional Arrangement for Land Drainage

9.4.1 Legal Regulations

South Africa's present legislation and policies inducing radical changes in the water sector were only recently inaugurated. The Water Law from 1956 was replaced in 1998 by the National Water Act No. 36 and forms part of the economic and political reconstruction of the country. It aims to correct existing inequalities in the water sector, defines a modern framework conducive for decentralization, marked-based water allocation, full cost recovery, and economically rooted water management. According to the new law, water is a public property but it allows private and tradable use rights. The law determines the creation of new administrative and management structures like river basin entities (Catchment Management Agencies) where existing water agencies like irrigation boards and municipalities may participate as stakeholders along with farmers groups. Prior to Water Users Associations farmer liaison committees existed in sugarcane zones and in state irrigation systems. With the new Water Act it is expected that Water Users Associations will play an active role in water management (Saleth et al. 1999).

9.4.2 Organizational Set Up

The Republic of South Africa is a federal system with national, provincial and local governments. Planning and development of water resources, in general, is the national government's task. Agriculture, the major water user, is under provincial governments. Local municipal governments are responsible for domestic and industrial water supply.

A new government level - the District Councils - are responsible for infrastructure development projects in their areas of concern, including irrigation and drainage. This would effectively mean that communities decide on projects, and that a District Council has the responsibility to ensure sound development, coordinate funding, provide technical inputs, implement, operate and maintain the project.

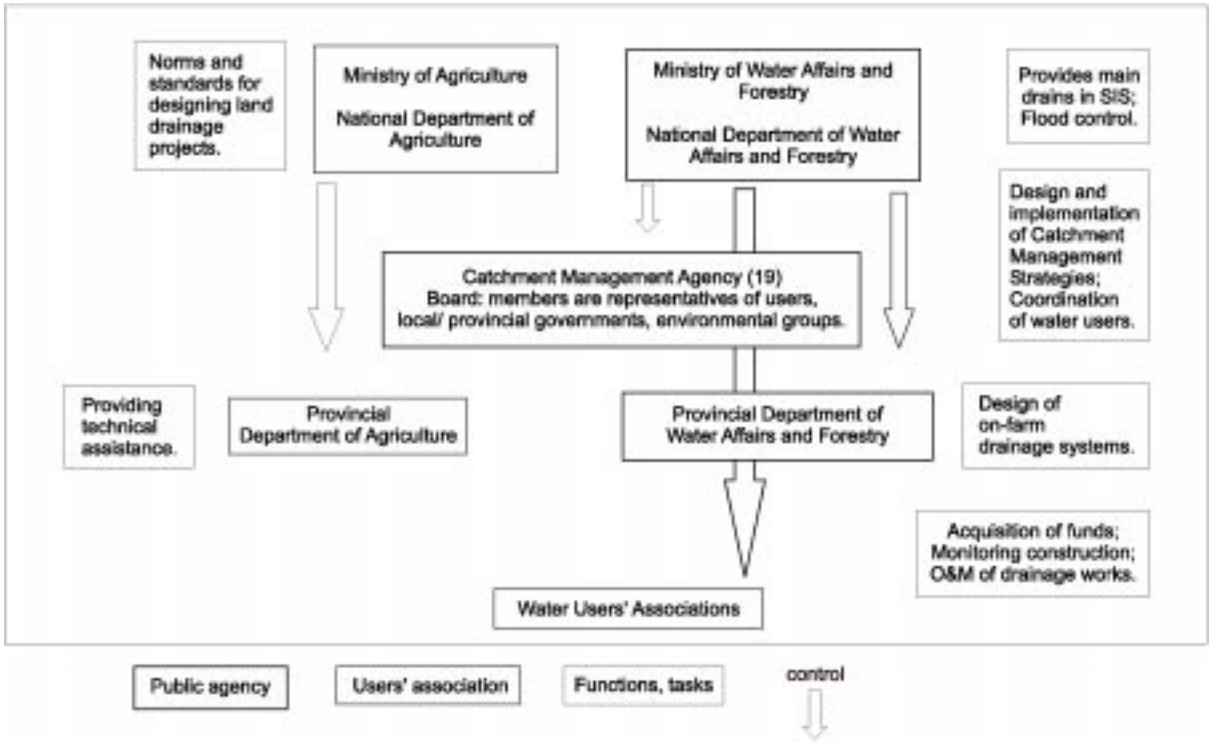
National norms and standards for designing drainage systems are set by the National Department of Agriculture. The responsible organizations for drainage of irrigated land at the provincial level are the nine Provincial Departments of Agriculture (PDA). They provide e.g. technical assistance regarding the engineering aspects of the on-farm layout of irrigation and drainage systems, and the agronomic aspect of irrigation, as well as funds for soil conservation schemes. PDA assists Water Users Associations to take over management and ownership of the government-owned schemes (NDA 2000). In the still existing State Irrigation Systems the Department of Water Affairs and Forestry (DWAF) provides main drainage systems.

The Conservation of Agricultural Resources Act No. 43 (1983) requires that natural resources such as water and land are used in a sustainable manner. If soils are waterlogged or salinized, farmers should inform the nearest extension service office; if soil reclamation is required, farmers may receive technical assistance for investigation, survey and determination of the problem, for elaborating plans and specifications on possible solutions, and control inspections during the construction phase. If more than one land user is affected, a development plan will be figured out considering the need of all land users. A contract between the parties involved will define obligations, so that maintenance and repair work on the system is carried out according to a predetermined system. Public agencies are not involved in managing on-farm drainage infrastructure.

National and provincial governments have concurrent responsibility in environmental management and it is not clear who will address waterlogging and soil salinity.

The National Water Act (1998) introduced the establishment of Catchment Management Agencies (CMA). It reads: “A catchment management agency may be established for a specific water management area, after public consultation, on the initiative of the community and stakeholders concerned. In the absence of such a proposal the Minister may establish a catchment management agency on the Minister’s own initiative” (National Water Act 1998, Chapter 7). These agencies are corporate bodies where the interests of various stakeholders should be represented. The Minister of Water Resources and Forestry appoints the members to the CMA government board. Main tasks of Catchment Management Agencies are to coordinate the activities of water users and of the water management institutions within its water management area. Community participation in the protection, use, development, conservation, management and control of the water resources may be promoted. (National Water Act 1998, Art. 80) Within the 19 Water Management Areas, CMAs are to develop and implement catchment management strategies.

Figure 9.1. Organizational set up for drainage in South Africa.



A Water Users Association is one of the organizations to which the CMA can delegate functions. WUAs are formed where more than one water user makes use of the same water source. They may be established or noticed by the Minister of Water Affairs and Forestry. WUAs operate at a restricted localized level, and are in effect cooperative associations of individual water users, who wish to undertake water-related activities for their mutual benefit "… A Water Users Association may exercise management powers and duties only if and to the extent these have been assigned and delegated to it." (National Water Act 1998). WUAs may be active in water distribution, system maintenance, water charges collection, water transfer and conflict resolution in general. With respect to drainage one of the principal functions of a WUA can be to construct, purchase or acquire, control, operate and maintain waterworks considered to be necessary for draining land.

With the New National Water Act of 1998, an independent Water Tribunal was established whose members are appointed through an independent selection process, and which may conduct hearings throughout the Republic. Members are appointed by the Minister.

Although there is a strong decentralization focus in the Water Act, a clear hierarchy remains from DWAF to the Catchment Management Agencies then to Water Users Associations. The Department of Water Affairs and Forestry supervises the whole process.

Two **research institutes,** i.e. the Agricultural Research Council and the Water Research Commission, focus on water use efficiency and on means for preventing and controlling of waterlogging and salinization of irrigated land. The Water Research Commission, a statutory body established in 1971 by the Water Research Act under the Ministry of Water Affairs, promotes and coordinates research. The Act provides for the establishment of a fund which is financed out of levies imposed on water consumption. The Agricultural Research Council receives funds from the Water Research Commission, the National Department of Agriculture and from research projects it undertakes for various bodies (e.g. the Water Research Council).

9.5 Financing Drainage

Until 1998, the national government financed investigation, planning, construction and maintenance of irrigation and drainage works[28] out of the national budget. The government provided subsidies and loans to Irrigation Boards for approved schemes. Water charges paid by farmers are prevalent only in State Irrigation Schemes and were almost sufficient for covering maintenance and operation expenditure.

With the new water legislation, charges had been increased and extended also to the private sector. Not only should they recover costs for operation, maintenance and initial investments but other components such as a research levy and water conservation/ management fee (Saleth et al. 1999).

The National Department of Agriculture has taken steps to stop subsidies for the installation of irrigation facilities and the establishment of on-farm infrastructure. According to the new water policy the Government will not, as a rule, develop new water schemes. Rather, such schemes will be financed, owned, maintained and operated by WUAs. To assist resource-poor farmers in financing new schemes or extension of existing schemes, the National Water Act makes provision for financial assistance in accordance with specific criteria (NDA 2000).

[28]It is not clear whether the national government provided subsidies for all types of irrigation systems.

The pricing strategy under the new law differentiates among geographical areas, categories of user groups or individual water users. The charges should cover direct costs and related costs of water resources development, management and use. The costs for investigation and planning, for design and construction as well as for operation and maintenance should be recovered (National Water Act 1998).

Drainage infrastructure located within a WUA management area will be funded through levies imposed on water users. These levies can be on the account of those water users that benefit from the system or can be a general levy to all water users within the WUA. The statute of WUAs will determine the method of calculating the levies imposed. If water users use private providers for services and goods they do have to pay them on their own, while if water users make use of publicly provided services and goods they do not pay. The costs for rehabilitating infrastructure may be publicly funded by the Provincial Departments of Agriculture (van Coller 2000, personal communication).

In Soil Conservation Schemes, defined by the Conservation of Agricultural Resources Act (Act No. 43, 1983), the Provincial Departments of Agriculture subsidize one-third of the costs of infrastructure needed to drain farm plots. If more than one farmer is involved, a formula determines individual contributions which represent a part of the total cost compared to the cost involved when a farmer would have had installed a single system for himself (van Coller 2001, personal communication).

9.6 Innovative Approaches and Constraints

The South African water sector is undergoing radical changes: the National Water Act (1998) fosters decentralization in administration and management, cost recovery for investments and for operation and maintenance. Access to literature on drainage issues prior to the reform has been difficult, and information about recent experiences in the agricultural drainage sector under the new legislation is available at local levels only.

Future developments and experiences in the water sector are interesting to evaluate such as:

- Cooperation and coordination between the Department of Water Affairs and Forestry, the National Department of Agriculture, and the Provincial Departments of Agriculture;
- Cost recovery system for drainage investments and for O&M;
- Drainage performance under the new established Water Users Associations and coordination with governmental agencies in jointly managed systems;
- Willingness of farmers to pay increasing water charges and the fulfillment of their O&M tasks;
- Involvement of all water users in financing drainage infrastructure investments and means for its improvement.

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