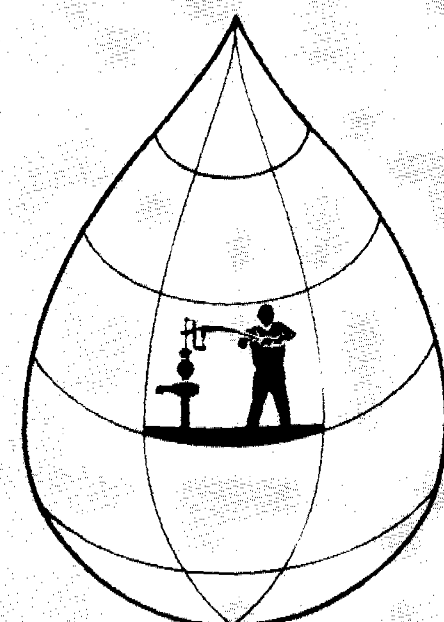
Experiences in the Development of Small-scale Water Resources in Rural Areas

Proceedings of the International Symposium on Development of Small-scale Water Resources in Rural Areas

21-25 May 1990
Bangkok and Khon Kaen
Thailand



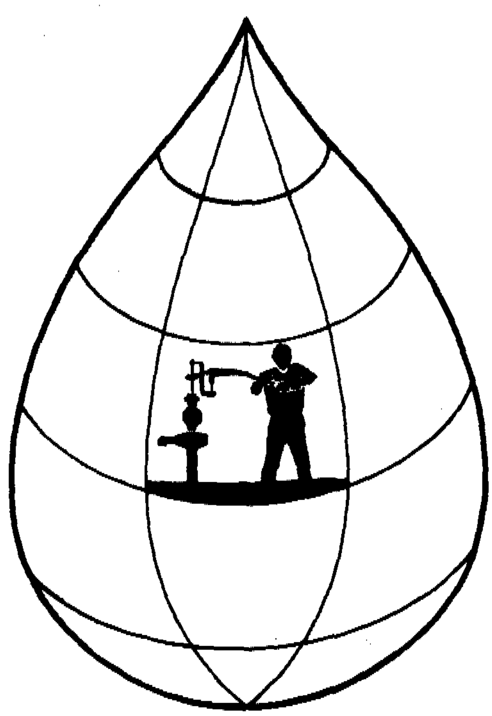
EDITORS:

Günter Tharun
Mendeluz Bautista
Edwin Calilung
Ma. Doreen B. Canillas

Experiences in the Development of Small-scale Water Resources in Rural Areas

Proceedings of the International Symposium on Development of Small-scale Water Resources in Rural Areas

21-25 May 1990
Bangkok and Khon Kaen
Thailand



EDITORS:

Günter Tharun
Mendeluz Bautista
Edwin Calilung
Ma. Doreen B. Canillas

Carl Duisberg Gesellschaft
South East Asia Program Office
Bangkok, Thailand

EXPERIENCES IN THE
DEVELOPMENT OF SMALL-SCALE
WATER RESOURCES IN RURAL AREAS

ISBN 974-8256-37-5

CONTENTS

Foreword vii
Acknowledgements viii

Part 1 Introduction and Keynote Speeches

Introduction 3

Water Resources Development and Management in Asia and the Pacific: A Brief Overview 5
C. Ertuna

Community Participation in Small-scale Water Resource Development: The Experience of the Population and Community Development Association 11
M. Viravaidya

Part 2 Management Approaches and Strategies

Appropriate Small Weir Project Implementation in Northeast Thailand: The Khon Kaen University - New Zealand Approach 19
B. Worboys, P. Wirojanagud, K. Uttrahong, and K. Smith

An Integrated Approach to Problem Solving for Village Water Supplies: Thai-Australian Project 29
G.R. Anderson

Evolution of Institutions and Efficiency in the Management of Common Pool Flux Water Resources 37
S. Mahendrarajah

Multi-disciplinary Engineering: the Community Organization Method 49
L.J. Abrams

Small Water Resources Development in Southern Africa: Effective Planning, Delivery, and Management through an Integrated Rural Development Approach 57
J. M. Erskine

Community Participation in Water and Sanitation Programs: South African Experiences over the Decade 67
S. B. Mogane

Towards Sustainability: The Application of a "Resources Coverage" Approach to Community Water Supply and Sanitation in Southern Africa 75
F. Kwaule and M. Seager

Planning and Development of Small-scale Water Resources 87
J. H. Krishna

Part 3 Technologies, Tools, and Training

Developments in Rainwater Catchment Systems: Technology and Implementation Strategies in the 1980s and Lessons for the 1990s 95
J. E. Gould

Tools for Small Water Resources Implementation and Management in Rural Thailand 107
P. Wirojanagud, V. Vanvarothorn, and P. Chindaprasirt

Natural Coagulants for Small Scale Water Treatment: Potential Applications 115
G.K. Folkard, J. P. Sutherland, and W. D. Grant

An Integrated Summary of Evaluation Studies on Several Community Potable Water Supply Projects in the Philippines 125
C. M. Gendrano and M. M. Perez

Evaluation of Small-scale Drinking Water Supply System in Rural Areas of China 137
Bo L.

The Thai-German Self-help Training Project on Small-scale Water Resources Development 145
P. Chindaprasirt

Project Casework Training Approach for Self-help Training Program for Small Water Resources Development 153
G. Tharun

Training on Low-cost Water Supply and Sanitation: An Indonesian Experience 173
J. S. Slamet

Part 4 Case Studies

Mueda Plateau Water Supply: A Complex Rural Case 181
J. M. Salomão

Impact of State Intervention: A Case Study of Two Anicut (weir) Systems in Sri Lanka, State-sponsored vs. Farmer-managed 187
R. S. Ariyabandu

Small-scale Irrigation Command Area Development in Bangladesh: Problems and Prospects 195
M. R. Hoque, M. Idris, M. A. Samad, and S. Islam

Provision of Potable Water to Smaller Communities in the Gezira Irrigated Area - Sudan 209
A. A. El Gaddal

Part 5 Abstracts of Selected Poster Presentations

Farmer Participation in Small-scale Irrigation Projects in Northeast Thailand 219
S. Patamatamkul

Development of Small-scale Hydraulic Works for Irrigation in the Rural Areas of Vietnam 220
Nguyen D.

Approach to the Development of Small-scale Water Resources in the Rural Areas of China 221
Xu J.

Pumping in Small Water Supplies with Renewable Energy Power Sources with Focus on Hydro-power Drive for Pumping 222
V. Schnitzer

Rainfall Intensity Analysis as a Tool for Water Resource Planning 223
J. Morin

Artificial Recharge of Groundwater for Small-scale Water Development in Rural Areas: A Case Study 224
A. Kowsar

A Method for Rainwater Collection, Storage, and Utilization for Small-holder Hydroculture Systems 225
W. Hogland, R. Berndtsson, and M. Larson

Rainwater Cistern Systems Training Initiatives in Nepal: A Study of Three Cases 226
S. P. Upadhyay and R. L. Chitrakar

Farmer Participation in the Operation and Maintenance of Government Assisted Small-scale Irrigation Projects: A Comprehensive Approach 227
V. A. Gillespie

Some Aspects of Community Participation in Rural Development in Sri Lanka: Implications for Small-scale Water Resource Development 228
A. Wanasinghe

Women, Water Supplies, and Sanitation: A Case Study of Domestic Shallow Well Water Supplies in Thailand 229
K. Khatikarn

Factors Determining the Development of Shallow Dug Well as Safe Drinking Water among Women in Five Villages of Viengpapao District, Chiangmai Province, Northern Thailand 230
P. Agamanon, S. Panvisavas, K. Khatikarn, P. Oon-ob and U. Gerdpial

U.S. Peace Corps (Thailand) Water Resources Development 231
U.S. Peace Corps (Thailand)

Strategies for Operation and Maintenance of Rural Water Supply Systems in Zaire 232
K. Ntambwe, F. Baer, D. Sambe, K. Nsenga, and I. Y'Olunki

Appropriate Well Drilling System for Northeast Thailand 233
V. Sriboonlue, C. Buaphan, and P. Wirojanagud

The Khon Kaen University - New Zealand Type 2 Weir: A Weir Design for Everywhere 234
K. Smith, K. Uttrahong, S. Tongsuk

Part 6 Symposium Recommendations

Foreword

The *International Symposium on the Development of Small-scale Water Resources in Rural Areas* was a major undertaking jointly implemented by the Carl Duisberg Gesellschaft - South East Asia Program Office (CDG-SEAPO), the Thai Ministy of Interior's Department of Local Administration (DOLA), and the Faculty of Engineering of the Khon Kaen University (KKU). It convened representatives of national and international bodies, non-governmental organizations, donor agencies, academic institutions, and other professionals worldwide who are actively involved in small-scale water resources development. The Symposium effectively served as a forum for presentation and discussion of relevant examples of innovative small-scale water resources development projects/ programs, analysis of universal problems and bottlenecks as well as practical solutions to these, definition of possible paradigms of development which can guide future project planning, implementation and management, and, most of all, fostering the exchange of information and experiences among participants.

This publication documents the papers and posters presented during the Symposium as well as the overall Symposium recommendations. More importantly, this document extends one major Symposium objective of promoting exchange of information and experiences, by making available to other concerned people and organizations the relevant papers and results generated in this conference.

Günter Tharun

Acknowledgements

The editors wish to thank all the authors of papers and posters that make this publication a rich source of information and insights, many of them offering truly innovative solutions to very challenging problems. Indeed they were instrumental to the shaping of the Symposium discussions and recommendations.

The efforts of the Symposium co-implementing agencies, namely Khon Kaen University and the Department of Local Administration of Thailand, as well as the three Symposium Committees, namely the Advisory, Organizing and Technical Committees, are deeply acknowledged. They were the prime-movers behind the Symposium and it is to their credit as well that the material of this publication has been produced. Likewise, the editors are very grateful to Ms. Sangsuree Suree for her valuable editorial and compilation assistance.

The editors are indebted to the German Federal Ministry for Economic Cooperation and Development (BMZ) for sponsoring the Symposium and the publication of the proceedings.

Special thanks are due to the German Embassy in Bangkok, especially to H.E. Mr. Bernd Oldenkott, former German Ambassador to Thailand, for the enduring support and cooperation that they provided to CDG-SEAPO not only for this Symposium, but also for the umbrella project, the *Thai-German Self-help Training Project on Small Water Resources Development in Rural Areas* in Northeastern Thailand.

Part 1:

Introduction and Keynote Speeches

Introduction

Symposium Background

Water supply is at the core of developmental activities as it encompasses public health, nutrition, basic hygiene, and agricultural production. The scarcity of this resource is most acutely felt in rural agricultural areas in developing countries which are not reached by irrigation networks and drinking water utilities. In such areas, the development of **small-scale water resources** becomes a critical element for the subsistence and sustenance of economic productivity.

In line with the Water Decade, governments have formulated enabling policies, development plans and strategies to spearhead development in this area. With the help of bilateral and multilateral organizations, tremendous amounts of funds have been and are being funneled into small-scale water resources development projects in order to meet the drinking, domestic, and agricultural water needs of the rural population.

These projects take on many forms and are implemented under the aegis of various sectoral agencies. Most are primarily construction projects with some elements of community participation; others are integrated into rural development programs focusing on grassroots involvement; while many projects lie somewhere within this broad spectrum. Development activities range from construction, rehabilitation, extension services, institutional development, training, community development, and various combinations of these. Likewise, foreign assistance from bilateral and multilateral agencies could be a combination of technical assistance or cooperation, grant aid, and loans. Evidently, these projects have met with various degrees of success and failure.

At the turn of the decade, the Carl Duisberg Gesellschaft - South East Asia Program Office (CDG-SEAPO), the Thailand Ministry of Interior's Department of Local Administration (DOLA), and the Faculty of Engineering of Khon Kaen University (KKU) deemed it timely to convene national and international bodies, non-governmental organizations, donor agencies, academic institutions, concerned professionals, and representatives of beneficiary groups in order to update one another on the progress made so far on small-scale water resources development for the benefit of rural communities. The *International Symposium on Development of Small-scale Water Resources in Rural Areas* was, thus, conducted on 21-25 May 1990. This activity was quite momentous as it called for the assessment of the efforts so far contrived and is expected to set the foundation and direction of future endeavors.

The Symposium had the following major objectives:

1) To present and discuss various innovative cases and approaches in planning, delivery, and management of small-scale water resources development projects/programs.

2) To analyze the universal problems and bottlenecks that impede successful implementation of projects/programs and propose practical strategies to overcome these.

3) To define possible paradigms of development to guide future planning, implementation, and management of small-scale water resources development projects/programs.

4) To foster exchange of information and experiences among the various countries actively pursuing small-scale water resources development.

The five-day Symposium centered on two main themes, which were, *Theme A: Technology and Management Innovations* and *Theme B: Pitfalls* and *How to Deal with Them.* Before the symposium proper, a one-day trip to Nakhon Ratchasima Province was conducted to provide the participants with some insights on small water resources projects going on in the Northeastern region of Thailand, as well as to stimulate informal discussions before the formal sessions in Khon Kaen. The paper presentations under each theme were preceded by keynote speeches and culminated with small group discussions on prescribed topics. The group discussions gave the delegates the chance to have a more effective exchange of information and ideas on the different problem issues presented. Rapporteurs later presented the results of each group's discussion to the plenum. Moreover, poster papers under each theme were also displayed and presented. A workshop to formulate the Symposium recommendations, followed by the final plenary session on the Symposium recommendations were held on the last day.

Organization of the Proceedings

The publication consists of six Parts, as follows:

Part 1	Introduction and Keynote Speeches
Part 2	Management Approaches and Strategies
Part 3	Technologies, Tools, and Training
Part 4	Case Studies
Part 5	Abstracts of Selected Poster Presentations
Part 6	Symposium Recommendations

The two Keynote Speeches in Part 1 were delivered during the Symposium opening program. The first one presents an overview of the water resources situation in the region, while the second one expounds on some of the ingredients of successful water resources development projects.

The papers presented at the Symposium are contained in Parts 2, 3, and 4. In Part 2, the papers describe some of the management innovations and practices in the development of small-scale water resources in Asia, Africa, and America. Part 3 presents some of the developments in, as well as the results of, technology application and training interventions. Valuable lessons can be gleaned from location-specific case studies from four countries in Africa and Asia, which are contained in Part 4.

Aside from the abovementioned papers, posters were also exhibited and presented at the Symposium. The abstracts of the selected posters are included in Part 5. Lastly, after much constructive deliberations, the Symposium participants drew up a statement of recommendations that embody the principles and directions that should propel the development of small-scale water resources into the next decade. These recommendations are documented in Part 6.

Water Resources Development and Management in Asia and the Pacific: A Brief Overview

Cengiz Ertuna
Officer-in-Charge
Natural Resources Division
United Nations Economic and Social Commission for Asia and the Pacific
Bangkok, Thailand

on behalf of

S.A.M.S. Kibria
Executive Secretary
United Nations Economic and Social Commission for Asia and the Pacific
Bangkok, Thailand

1. Introduction

The ESCAP region displays various types of physical features, from arid deserts to the most humid areas of the world. Distribution of precipitation is extremely uneven between different parts of the region. However, not only is there a marked difference between the total annual precipitation in each country, but the amount of precipitation also varies considerably during the year.

The rainfall in a number of countries in the region is characterized by a monsoon climate of very significant seasonal variations. The wet season in many countries accounts for 70 to 90% of the annual rainfall, whereas a water supply shortage is experienced in the long dry season every year. The failure or delay of the monsoon rains causes abrupt reduction in crop production and contributes to widespread disaster for the population, whereas frequent severe flooding caused by typhoons and cyclones produces extreme damage in many countries in the region.

The Asia and Pacific region, which is endowed with tremendous water resources, contains some of the world's most important river systems. These systems include the Mekong, Ganges, Indus, Brahmaputra, Chanjiang, Hwangho, Irrawaddy and Chao Phya rivers, which have a total drainage area of more than 6 million sq km, much of it heavily populated. Therefore, the economic development and the welfare of people in the region are strongly interlinked with the progress made in the development and management of the region's water resources.

In pursuance of the recommendations of the United Nations Water Conference, which came to be known as the Mar del Plata Action Plan, ESCAP has periodically undertaken regional reviews of the progress achieved in the implementation of the Plan by circulating questionnaires to the member countries. To update the earlier reviews and to implement the recent General Assembly and Economic and Social Council mandates, similar surveys were conducted in 1988-1989. Responses to this survey were received from sixteen countries and territories in the ESCAP region. The material presented in this paper is based mainly on this survey, supplemented by other information gathered from various sources.

2. Assessment of Water Resources

Most of the countries/territories reported that they have adequate and reliable precipitation data collection networks, with plans for extension. The survey also indicated that data collection networks for surface and ground water resources assessment are inadequate but are of sufficient reliability in eight countries. Hydrogeological networks, borehole and observation well data are neither adequate nor of sufficient reliability in most of the reporting countries/territories.

Most of the reporting countries/territories have plans for extending their water resources data gathering networks, and have taken initiatives to improve the adequacy and reliability of their overall data collection methods and programs. Most of the countries are using modern methods of prospecting and measurement such as remote sensing, isotope techniques and geophysical methods for ground water prospecting. Computers are in use in most of the countries/territories in processing, storage, retrieval and dissemination of data regarding precipitation, surface water and ground water. The survey indicated that investigation programs for aerial assessment of surface and ground water resources are inadequate but are of sufficient reliability in most of the countries. However, most countries/territories reported that their governments have investigation programs reaching up to the year 2000.

3. Utilization of Water Resources

In many countries of the ESCAP region, recent years have seen the growing pressure on water resources with increasing demands for agriculture, domestic and industrial consumption, and disposal of industrial effluent and sewage. Water use is increasing rapidly in most countries due to the growth of population, the expansion of irrigated agriculture, and the pace of industrialization. Although most countries seem to have ample water resources to meet rising demands for agricultural, industrial, and other uses, the overall quantity of water available is usually not adequate in places where it is needed nor at the time of greatest demand. Therefore, the steadily growing demands for water are issues of particular concern throughout the region.

Although the demand for water, even by the year 2000, will generally not exceed expected supplies, water management problems will arise in many river basins. In addition, with growing water use, the increase of pollutants released into water bodies is effectively diminishing the amount of usable water in many countries.

3.1 Agriculture

The largest consumer of water is the agriculture sector, essentially for use in irrigation. The economies of the developing countries of the ESCAP region are still mostly agrarian and irrigation plays a crucial role in promoting agricultural development. Since the early 1960s the total irrigated area in the region increased almost 50% and at present includes some 30% of the arable land in the region.

Irrigated agriculture claims from 80 to 90% of total withdrawals in China, India, Pakistan and several other countries which are advanced in the development of irrigation. It is estimated that half the initial withdrawal often returns to the water sources while the rest is consumed through evaporation and transpiration. Therefore the efficiency of irrigation systems, which is in general rather low, is one of the most important issues.

Many countries have considerable potential for the development of irrigation. At today's average rates of water use (some 11,000-12,000 m^3 per irrigated ha per year) and assuming that irrigation continues to expand at a slightly diminishing rate, more than 200 km^3 of water will be needed additionally for irrigation by the turn of the century.

Targets for agricultural water development during the current planning period have been set by most of the countries for new irrigation, rehabilitation of existing irrigation, flood protection, drainage and reclamation, and introduction of aquaculture. Similarly, targets for agricultural water development in future planning periods have been adequately set out in most of the countries/ territories.

The survey also indicates that constraints in the implementation of agricultural water development programs are due to the lack of qualified manpower, a shortage of financial resources, institutional deficiencies and lack of equipment. Virtually all reporting countries/territories have indicated that multilateral and bilateral cooperation would assist in overcoming constraints.

3.2 Industry

The second biggest water user in several developing countries of the region is the industrial sector, which accounts for about 10 to 15% of the total withdrawals. Producing energy from fossil fuel plants is by far the largest single industrial use of water. Industries return water which is often polluted with by-products of the manufacturing process. Each liter of polluted water which is discharged untreated contaminates many additional liters of fresh water in the receiving stream. The disposal of synthetic chemicals and heavy metals, which pose dangers even in extremely low concentrations, is an especially grave threat to the quality of water supplies. Without adequate treatment, the growing volume and toxicity of wastes would render a large portion of the regional water resources unsafe in 15-20 years.

In developed countries that have established industrial base and water pollution laws, industrial water demands are relatively stable or even decreasing due to the introduction of water saving technology. In developing countries of the region, however, water demands for power production, manufacturing, mining and material processing are increasing. Industrial water use, if these countries adopt water-intensive technology, could therefore, easily double by the year 2000. Accordingly, increased volumes of effluents will be discharged into water sources.

3.3 Domestic Use

Domestic use of water accounts for about 5 to 6% of the total water withdrawals in many countries of the region. The volume of water used by households for drinking and cooking, bathing, washing clothes and other activities varies greatly with both income levels and the way in which water is supplied. In urban households with piped water, daily use typically ranges from 100 to 350 liters per person. In rural areas of the developing countries, the per capita water consumption averages 40 to 60 liters, while on small islands in the Pacific the level of water usage may be close to the biological minimum (from two to five liters per person daily) during the dry season. However, drinking water supplies are not yet universally available. The World Health Organization has estimated that currently, only about 75% of urban dwellers and 40% of the rural population in the developing countries of the region are supplied with drinking water. Providing safe water to the growing population of the developing countries will probably result in the doubling of domestic water demands by the end of the century.

The International Drinking Water Supply and Sanitation Decade was launched by the United Nations General Assembly in 1980. In the majority of the countries reporting in the survey, the portion of budget allocation for the Decade was at, or less than, 4% of the national development budget, and in others it varied between 4 to over 10% in the current planning period. Compared with the previous planning period, the budget allocation generally increased.

4. Policy, Planning, Legislation, and Institutional Arrangements

It has been recognized that in a number of countries there is a need for the formulation of a national water policy within the framework of, and consistent with, the overall economic and social policies of the country concerned, with a view to helping raise the standard of living of the entire population. According to the ESCAP survey under review, some countries still do not have a national water policy, while in others, national water policies have been established by various actions such as decrees, cabinet decision, and legislations. However, most reporting countries/territories noted that existing legislation, generally dealing with ownership of water, right to use water, and the protection of water quality, is neither sufficient nor compatible with their development plans. Amendments or revisions are being formulated by all countries/territories that reported insufficiency and incompatibility of legislation with development plans. The survey also indicated that only half of the countries/territories have a comprehensive water master plan and that the others have not yet formulated such a plan.

It appears that more than half of the reporting countries/territories have a central mechanism for coordinating all water interests at the national level. These mechanisms are responsible for the preparation, implementation, and evaluation of plans and policies for water development and management. However, most of the countries/territories have indicated the need to modify their present institutional arrangements. The countries without central mechanisms are striving to develop such mechanisms.

5. Education, Training, Research and Development

Half of the reporting countries/territories have carried out a survey of manpower needs in the last five years. Deterioration of the manpower situation has been indicated by surveys of manpower needs in various aspects of water development and management. In some countries it is critical, while in others the situation is improving.

The deterioration of the manpower situation in some countries cannot be attributed to any single cause. Many factors, such as transfer of resources in other fields, movement to other countries, lack of suitable candidates, and lack of funds to employ manpower have contributed to the situation. To alleviate shortages of manpower, many countries/territories have taken action to establish new institutions or to enlarge their existing institutions.

All countries/territories reported that assistance in the form of external cooperation, technical advice on strategies, institution building, foreign teaching staff, and fellowships will be required.

All reporting countries/territories have research institutions or centers, although research fields and facilities differ from country to country. Two-thirds of the reporting countries/territories have facilities for research in hydrology and assessment, irrigation and drainage, water supply-waste treatment, hydraulics, hydrobiology and hydrochemistry, and planning and management; half have facilities for research in structural and geotechnical engineering. The impact of research on practical activities was reported in the survey by 14 countries/territories. About 35% of these countries/territories report the impact as maximum, 50% as moderate and the remaining 15% as minimal. Lack of financial resources is considered the major constraint encountered in the area of research.

6. ESCAP's Involvement in Water Resources Development and Management in the Region

The ESCAP Water Resources Section was established over 40 years ago initially as a unit responsible for flood control and the mitigation of damage ensuing from floods, drought, and tropical storms, and was later combined with other sections to form the Natural Resources Division in the early seventies. Elements of ESCAP's work program reinforce member countries' efforts and are concentrated on the promotion of rational development, management, and utilization of water resources.

The role of ESCAP in the 1990s in the water resources sector will be to continue to assist the member countries in solving their main problems in water resource development, which include: (1) the lack of national laws, policies and programs for water resources development and conservation, which are compatible with their national economic and social development plans; (2) the enormous annual damage caused by cyclones, floods and drought; (3) the deterioration of the water quality of surface water and ground water bodies; (4) the inadequate number of properly trained and experienced technical staff for sound planning, development, and management of water resources; and (5) inadequate drinking water supply and sanitation facilities in many developing countries, especially in the least developed and island countries.

The Water Resources Section carries out these tasks through: (1) studies; (2) the organization of technical conferences, seminars, expert group meetings, training courses and technical missions; and (3) the provision of advisory services and the publication of manuals, guidelines and other informative materials. The current strategy is to support the efforts of countries in implementing the recommendations of the United Nations Water Conference and in achieving the goals of the International Drinking Water Supply and Sanitation Decade, and to take an active part in undertaking activities in line with the goals of the International Decade for Natural Disaster Reduction.

Community Participation in Small-scale Water Resource Development: The Experience of the Population and Community Development Association (PDA)

Mechai Viravaidya
Secretary General
Population and Community Development Association
Bangkok, Thailand

1. Introduction

In order to devise effective models for small scale water resource development, it is absolutely necessary to tailor them to the specific local condition and attitudes.

Water resource development projects relate to a variety of developmental issues addressed by PDA, such as health, agriculture, animal husbandry, ability to generate income, forestry, community organization and the establishment of local self-help institutions, exposure to conventional lending sources, and improvement of quality of life.

The PDA's water resources development projects include the construction of weirs, irrigation canals, deep wells, shallow wells, rainwater catchment systems (tanks, jars, and community ponds), and village piped water systems, among others.

2. The Water Decade of the 1980s

There has been a great deal of work concentrating on the establishment of hardware while the topic of software, or utilization of the infrastructure, has been largely ignored. The result, therefore, has been the inability of many projects to reach their initial objectives.

Errors that may have been made relate to:

- Lack of knowledge on the part of project planners about the social framework of the community;
- Improper needs assessment due to lack of consultation with the target population;
- Lack of attention paid to establishing a community infrastructure, i.e. putting responsibility and knowledge into the hands of the people who will be using the hardware;
- Lack of participation on the part of the target population in the planning process, even though villagers understand local conditions and preferences far better than external sources;
- Lack of participation in the construction process (if villagers don't feel a sense of commitment to the project, maintenance may become a problem as the villagers, who are ultimately responsible for the hardware, do not understand how it works);
- Lack of training provided to village-based institutions on needs assessment, utilization, management, maintenance, follow-up and simple accounting (this information should be left at the village-level upon completion of the project);

- Lack of funding in irrigation projects for the purchase of complementary hardware as necessary;
- Lack of coordination amongst all concerned bodies (coordination leads to the sharing of resources, experience and ideas).

The end results of projects that fail to adequately address these pitfalls can lead to:

- Established infrastructure which is in a state of disrepair or under-utilization;
- Health situation which has not significantly improved;
- A sense of mistrust for outsiders;
- Increased social disparity in the village as the project may only bring benefits to a small portion of the target population;
- Creation of an attitude of dependence;
- Excessive financial burden placed upon the community.

3. Methods of Motivating the People and Soliciting their Help Based upon PDA Experience

The Population and Community Development Association (PDA) defines local participation as active involvement of the target population in all aspects of the project with particular attention paid to decision making.

3.1 Active Social Preparation

Establishment of mutual trust and understanding between the target population and the project implementors is very important. Villagers must understand the overall intention of the organization, i.e. to help improve the quality of life, and the implementors must have faith in the villagers' willingness to play an active role in this process.

PDA uses family planning as an entry point into the village and, therefore, establishes a good working relationship with the villagers.

3.2 Establishment of Village Level Institutions

The idea is to share the responsibility for all aspects of the project among all concerned parties, such as the donors, implementors and villagers. This may take the following forms:

- Construction committees for each water resource in the village
- Water management committees
- Revolving fund committees
- Maintenance groups, etc.

This could be accomplished through:

- Support of headman and elders
- Identification of informal village leaders
- Election if there is no existing committee
- Involvement of all villagers including women, youth, landless, etc.

The project, through the various committees, must represent all levels of the village society. If it meets this requirement, then it is in a better position to carry out the objectives. Schisms should not be created by neglecting the interests of any one group.

The committees must lead by example and must be unified. Their responsibilities include:

- Needs assessment
- Project selection
- Organization of labor force
- Oversight of financial matters
- Liaison with the project staff.

3.3 Utilization of all Available Resources

The use of available resources of all groups involved in water resources development is an effective strategy. This is especially true of the government and the armed forces in certain situations. It also is important to stress the fact that the project is designed to **complement** and not compete with the existing programs sponsored by these groups. In addition, credit for success should always be given to the cooperating parties.

The following groups could be utilized::

- Donor agencies
- Government agencies
- Educational institutions
- Other NGOs
- Armed forces
- Financial institutions (to get assistance in obtaining conventional sources of credit for the villagers)
- Private sector (e.g. Thai Business Initiatives in Rural Development (TBIRD) Project; Water catchment reservoirs at the Sup Tai Center (Korat) were constructed, but the banks were too steep - consultants from Siam Technology, Inc. assisted in the redesign).

3.4 Technology and Implementation

The utilization of appropriate technology is a key principle. It does not have to be the best, but it must be:

- Usable;
- Cost-effective;
- Easily understood; and
- Materials are readily available.

For example, bamboo reinforcement for *Tungnam* (water tank) fits these characteristics. This has been changed since to steel which is also available and can reduce maintenance charges. Skills of the villagers have been developed, enabling them to use this new material.

The following strategy could be adopted in delegating the construction process to villagers.

Identify, recruit, and train villagers who possess technical skills initially, to assist in the construct-ion process and organization of other villagers. Later on, they could be assigned to supervise the process and finally to take responsibility in all aspects, such as identifying new members, procure-ment of materials, arrangement of transportation, supervision of construction, revolving fund collection, and follow-up. To ensure that the villagers understand all these aspects, they should be trained and allowed to work step by step.

Thus, in PDA projects, tanks and latrines are built by the villagers, with each household that has requested one unit providing one laborer during the construction process. Jars are built by teams of two. The PDA staff take care of procurement of materials, arrangement of transportation, project supervision, and organization of construction and labor.

The village technicians are responsible for technical supervision, organization of construction and labor, act as project foremen and as leaders by example.

The villagers provide all the labor requirements.

3.5 Financing and the Use of Revolving Funds

PDA does not do charity work but provides an opportunity for villagers to help themselves. Seed money for the establishment of the revolving fund comes from the support of external funding agencies.

For individual household facilities, such as tanks, jars, latrines, shallow wells, revolving funds are necessary to make maximum use of the scarce funds. To encourage repayment of funds, social pressure is used. If one member does not pay, it reduces the opportunity for another to borrow funds.

For facilities that involve multiple users, PDA adopts the following system. Since the cost of financing a weir is prohibitively expensive, approximately Baht 20,000 per meter or a total of Baht 300,000, villagers put up 10% of the estimated cost which serves as a maintenance fund. This could be used for expenses during period of payback. The investment on the part of the villagers demonstrates a commitment to make the project work and also provides a sense of ownership.

In the installation of deep wells, the villagers are required to repay 10% of the material costs to the project. In the construction of village piped water systems in which multiple-tap village water tanks are used in conjunction with deep well, there is a 10% maintenance charge upfront. A monthly rate is imposed as determined by the committee and is based upon per unit charge or per head charge. This also covers electricity charges associated with the pump. The payback period is based upon villagers' preference and ability to pay.

3.6 Training and Education

This is the single most important component which is often neglected. Villagers must understand how to maximize the hardware which has been provided. There are different types of training required.

- **Organizational:** Teaches villagers to identify needs and work together to achieve the common goal. This also includes grouping to take advantage of bargaining power when marketing goods. Moreover, it tries to unite the village's society.

- **Technical:** Technical training provides know-how of how the system works and how it can be easily maintained.

- **Health:** Teaches villagers how small adjustments in their lifestyle (washing hands before meals) combined with utilizing water resources (fresh water collected in clean pots) can dramatically improve their health. Villagers are also taught that lids on water jars and cleaning drainage gutters reduce mosquito breeding activity.

- **Water usage:** Helps villagers make maximum use of the water sources, i.e. controlling the level of water in a reservoir through removal of wooden slats, placement of water-lifting equipment, digging of irrigation canals to allow for proper drainage, sharing the benefits to those who live further away from the water source, and using water drips for growing fruit trees in the dry season.

- **Marketing:** The villagers may be provided with access to water but they will need to know what the market is for dry season vegetables if they have never had the opportunity to grow them. Product selection is important too.

- **Financial:** This training concerns the establishment of revolving fund, setting rates for monthly returns, differentiating between electric charges which must be paid and repayment, accounting, collecting and bringing the villagers into contact with local lending sources (very important for future development).

- **Monitoring:** Enables villagers to evaluate their work and determine steps which can be undertaken to improve it.

Training and education can take the form of seminars bringing together villagers and committee members throughout the area of implementation so that they may discuss various experiences. Village level meetings are more practical as the villagers feel relaxed and open to new concepts within their own environment. Field trips and study tours are highly effective as villagers can see the benefits of the activity with their own eyes.

Sufficient levels of staff training are also necessary in order to ensure that the staff are knowledgeable about what is going on in all areas relating to water resource development.

4. Methods of Distributing Benefits to Disadvantaged Groups

Diversification within a single program which allows all strata of society to participate should be explored. The program should be suited to meet the needs (health, financial, etc.) of the target population. For example, public school and temple land can be distributed to the poor and the landless villagers. A single deep well can be installed to provide water during the dry season for the growing of vegetables. Small revolving fund can be made available for the purchase of agricultural inputs/complementary hardware as necessary. Technical assistance can be provided to this group by project staff and other villagers who possess knowledge in vegetable growing and especially irrigation (i.e. small canals, drainage patterns, crop selection and marketing potential).

5. Conclusion

The necessity for bottom-up design and implementation of project activity can never be overemphasized. Complex and capital intensive projects that do not work within the framework of the village life or have the effect of radically altering that life will not succeed.

PDA has enjoyed significant amount of success in its water program not because it is a water resource agency with advance technology, but because it knows and can work with the people.

Part 2:

Management Approaches and Strategies

Appropriate Small Weir Project Implementation in Northeast Thailand: The Khon Kaen University - New Zealand Project Approach

Brian Worboys
Senior Engineer
Department of Scientific and Industrial Research
New Zealand

Prakob Wirojanagud
Project Leader
Thai-New Zealand Small Watershed Development Project
Faculty of Engineering
Khon Kaen University
Thailand

Kraiwudh Uttrahong
Project Manager
Thai-New Zealand Small Watershed Development Project
Faculty of Engineering
Khon Kaen University
Thailand

Kevin Smith
Technical Advisor
Thai-New Zealand Small Watershed Development Project
Faculty of Engineering
Khon Kaen University
Thailand

Abstract

In 1978, the urgency for the promotion of small-scale solutions to the water problems of the Northeast region of Thailand was beginning to be felt. Sensitive to these needs, the New Zealand Government began supporting the creation of a Center for Small-Scale Water Resources Development at the Faculty of Engineering, Khon Kaen University (KKU) with the appointment of an Advisor in Water Resources Development, the co-author (Brian Worboys) in 1978.

At this time, small-scale development was not an established concept. Few resources were available, and specialists in this area in the Northeast were experimenting, seeking to assess the concepts, and trying to find the best way to demonstrate how many pilot projects should become part of the central government strategy for alleviating the water shortage problems facing the rural poor of the region.

Starting with a very small budget in its first year, experimentation with small-scale village projects began, concentrating mainly on small concrete weirs. By year four, an innovative and appropriate weir design was developed which was both structurally and hydraulically appropriate for the Northeast, and allows construction to be undertaken by the villagers with minimal supervision.

With the continuing support from the New Zealand Government, KKU showed that the weir met a real need of the rural communities and 10 years after the work began, the Department of Local Administration adopted it into its village self-help program. At present, within this program over 1,600 weirs of this design are currently being constructed annually.

1. Background

New Zealand and the Northeast region of Thailand both depend totally on agricultural production for economic survival. New Zealand, since early 1960s has maintained a series of assistance programs aimed at helping the rural population of the Northeast attain a stronger economy and an improved standard of living. Initially, the projects focused on agriculture. In 1977, however, there was a growing realization that the increasing population density and the demand to produce cash crops for income generation were being restricted by a water shortage problem, and the New Zealand Ministry of Foreign Affairs paid attention to this water problem.

Throughout the past 20 years, the Thai Government had commissioned several large dam and irrigation schemes in the Northeast, but even when fully operational, these schemes were able to contribute to the needs of only a very small proportion of the population. The situation was clearly defined in a 1978 report, "Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources", prepared by the Asian Institute of Technology. This report identified 80% of the rural population as living in areas that can never be feasibly served with water from major rivers. These people could only look towards small-scale developments in seeking to alleviate their growing water shortage problems.

Khon Kaen University (KKU) had been founded with the intention of promoting and facilitating the development of the Northeast. From the first years that KKU was established, New Zealand had been present with the contribution of teaching staff, buildings, and other resources. From amongst the students in these early days, a group emerged who were keen to contribute their knowledge and energy to boost rural development. Each year a student volunteer project was carried out and increasingly the projects most requested and most successful were small-scale weir projects. These were concerned with water diversion and storage structures. New Zealand contributed to these projects in a small way.

Having seen the potential of these very low cost and socially favorable village level projects, and being very impressed with the ability of the University to make such a practical contribution to rural development, the New Zealand Government was responsive to a request from KKU to support the establishment of a Center for Small-Scale Water Resources Development (now the Water Resources and Environment Institute, WREI) at the Faculty of Engineering.

2. The Need for an Appropriate Approach

The years leading up to the mounting of the KKU-NZ Project were interesting ones in Thai politics. Some novel rural development initiatives were undertaken, including the release of some government funds designated for rural development to villagers, with very little government supervision of the projects executed with the funding. These were the Rural Job Creation or "Khor Sor Chor" projects. Many small-scale water resources (SSWR) development schemes were built with this funding. The KKU-NZ Project studied the results of this program in the field, and two points clearly emerged:

(a) The villagers did have the resources to build significant structures at reasonable cost.
(b) There was a lack of technical input causing a failure rate in the first year after construction, estimated at 90%.

Clearly, if small-scale development was going to address the water needs of 80% of the population of Northeast Thailand, some way of building more reliable structures would have to be found. This was imperative for two reasons:

(a) No country can afford to continue to invest in development with a known high failure rate.
(b) A development management strategy had to be designed urgently, before small scale water resource development became generally regarded as a waste of money.

The biggest handicap to solving the problem was the lack of appropriately trained technicians. The potential number of small-scale projects in the Northeast had been estimated to reach up to 20,000 schemes. The technical resources existing in established government departments were quite inadequate to even contemplate this task, and in any case, they were fully committed to existing development programs.

The impression obtained from working with these projects was that the technical resources existing in Northeast villages were at a relatively high level. Although most of the "Khor Sor Chor" projects failed, sound basic construction skills were available in the villages. The failures were caused by a few definable errors.

The focus of the KKU-NZ Project in the early years was to:

- Identify and offer solutions to the main reason for failure of existing small-scale water resources construction.
- Demonstrate how reliable structures can be built with minimal help from outside the jurisdiction of the smallest local office of the local government.
- Foster and participate in training programs aimed at producing competent village level technicians.

The project involved itself in a number of difficult types of small-scale water resources development structures, but the main interest became small concrete weirs, and associated structures. It was with the small concrete weir development for domestic and agricultural water supplies that the greatest benefit to the rural communities was achieved. This then became the thrust during the early years of the project.

The activities undertaken during the early years in developing the weir design and implementation concept are summarized as follows:

Year One (November 1978 - October 1979)

The first year consisted mostly of studying and understanding the problems, and gaining village level experience with direct involvement in just two weir projects. With a construction budget of only NZ$ 4,300 (Baht 77,000), the designs of the two weirs built were quite different from each other, and meant to suit the limited funds and construction time available. The most pressing need for training of village level technicians was realized at this time. The Faculty of Engineering organized training programs for a group of local government District Offices, and for US Peace Corps Engineering Volunteers. The KKU-NZ Project supported and participated in these programs.

Year Two (November 1979 - October 1980)

The project had now found its feet. Four small weirs were built and a sub-district study of SSWR development needs and villager expectations was undertaken. Construction funding during this period increased to NZ$ 31,000 (Baht 560,000), and a standard method of organizing the work was beginning to emerge. The steps were generally:

(1) The villagers, hearing of the project, request assistance with a weir project they had planned.
(2) The KKU-NZ Project staff visit the site and assess the feasibility and benefits.
(3) If funds and the program allows, an arrangement is agreed upon with the villagers for the KKU-NZ Project to provide design, materials and supervision, if the village provided labor and leadership.
(4) If arrangements are satisfactory to all, construction will proceed immediately.

A standard design of weir was beginning to emerge, as various prototype designs were tested and the most successful features were noted.

Year Three (November 1980 - October 1981)

Construction funding was NZ$ 39,000 (Baht 695,000), and seven weir projects were completed, along with 10 large rainwater tank projects. Both the weir and tank construction were now being carried out under a standard system.

The KKU-NZ Project continued to support and participate in the increasing number and size of training seminars that the Faculty of Engineering was organizing for government officers and other agencies.

Year Four (November 1981 - October 1982)

This was the final year of the co-author's (Brian Worboys) involvement on this project. In this year, fifteen weirs were built. In addition, eight rainwater tanks were also built. These construction works cost NZ$ 70,000 (Baht 1,350,000) and most were constructed according to a standard plan published by the KKU-NZ Project.

The volunteer workforce on these projects were usually not familiar with reading plans. The project discovered that the understanding of the proposed weir construction by the villagers concerned could be facilitated using models made of wood or plastic foam.

During this year, several weir construction projects were initiated by villagers and local government officers utilizing government funding and experience gained from working on KKU-NZ projects in previous years. In this case, the standard plans produced by the KKU-NZ Project were usually employed and the seed was now sown for implementing the design concept on a larger scale. By 1985, over 50 weir structures had been built following this (or very similar) design. However, it took a further five years of effort by the KKU-NZ Project before the Department of Local Administration, Ministry of Interior, recognized the value of the concept and started to institutionalize it. But once it did, it became one of the largest village self-help programs in the country, the *People's Volunteer Weir Program.*

3. The Appropriate Weir Design

The weir design had to be safe, durable, economical, easily constructed, operated and maintained by the villagers, but above all, appropriate in meeting the needs of the communities. Small weirs in Northeast Thailand are multipurpose in that they must divert water into the rice fields during periods of streamflow, pass flood flows during the peak of the wet season, and store as much water as possible in the dry season when the streams stop flowing, for domestic, livestock and fishing purposes.

With unreliable rainfall from May to November and no rain for the rest of the year, large flood flows of short duration in the months of September and October, and no flows in most of the streams from December to June, there are real problems with water management. The villagers have traditionally built earth weirs across the streams but with the sandy, silty soil found throughout the region, keeping them intact or avoiding erosion of adjoining land during the wet season is difficult. There was a need for a more permanent and more manageable replacement, but which emulated the existing village implementation, operation and maintenance systems.

The two major reasons for the failure of the "Khor Sor Chor" projects were inappropriate design and inadequate hydraulic sizing. Whereas the typical Thai Government agency-built structures were grossly oversized and too low for the small streams and paddy watersheds, the "Khor Sor Chor" weirs were often too narrow, with crests too high. A middle road had to be found.

Structurally, this was not difficult to do, and using vertical sidewalls with counterforts, a buttressed straight drop crest, energy dissipation blocks, and flared downstream wingwalls, all the "Khor Sor Chor" structural problems were overcome.

However, the real necessity was to resolve the hydraulic design question. Observations of structures (earth and concrete) over the early years provided the answers. In streams where unrestricted berm flow naturally occurred during flood events, the effect of a weir in the stream merely increased the quantities of berm flow to some extent. Provided that the weir passed the approximate "natural" channel capacity flow, then the weir effect on increased berm flows was insignificant. Studies showed that if the weir was the width of the natural channel with a concrete crest not exceeding 60% of the natural stream depth, then it was hydraulically appropriate.

In order to divert water onto the rice fields during periods of low flow, timber stoplogs were incorporated on top of the concrete crest to raise the water to the desired level. For storing water in the dry season, a second set of stoplogs were included, with the annulus filled with clay or soil to make a seal.

About 50% of the land area of the Northeast consists of farmland, of which 70% is rice paddy, and therefore the majority of the sites fell into this unrestricted berm flow category.

For sites where berm flow was restricted or where berm flow did not naturally occur, e.g. in hilly terrain, then recognition of the size of the watershed, and determination of the channel flood flow capacity was necessary. Emergency by-washes or water control stopbanks were used to minimize the size of the concrete structure.

The weir design is known as the KKU-NZ TYPE 1 (1984) design and is suitable for sites up to 20 m in width and 3.5 m in depth. This is shown in Figs. 1 and 2.

As part of the project's efforts to produce a low-cost design, safety factors were set according to the needs of the design. These included considering construction using (in some cases) unskilled labor. As the weirs were built in relatively flat areas, when flooding occurs, water levels usually rose gradually so that water also accumulated on the downstream apron of the weir. The weirs also did not retain large quantities of water as in a reservoir or dam situation, and as a result of these conditions, failure may cause only some localized damage, but would not present a major hazard to life or property.

Based on this concept of "channel capacity" design, the material cost of the structure was only approximately 20% of the cost of the typical agency weir design for the same sized stream. As the

Fig. 1. Small weir of the KKU-NZ type 1 (1984) design in Ubon Ratchatani province (note the concrete block construction)

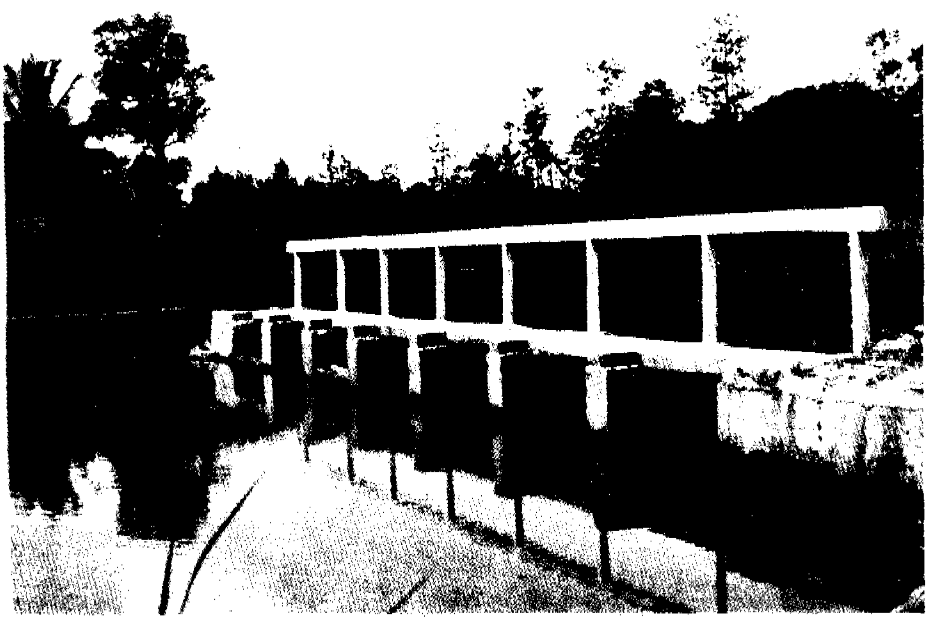


Fig. 2. Upstream view of the small weir in Ubon Ratchatani province, built under the People's Volunteer Weir Program

weir can be easily constructed by the villagers themselves (often on a voluntary basis), the approximate overall cost of a weir project was only 10% of the equivalent agency structure.

4. Evaluation

In 1986, an in-depth study entitled "Lessons from the KKU-NZ Weirs" was carried out by the Water Resources and Environment Institute, Khon Kaen University. This thorough economic analysis of 52 structures built over a six-year period concluded that the type of weir construction carried out were economically well-justified based on increased benefits from rice production alone, not including dry season crop production, livestock, and fishing benefits.

Experience has also shown, however, that there were other benefits (not easily quantifiable) which were additional to the increased rice production and other direct returns. These included:

- Improved diet from kitchen gardens irrigated by the new water source.
- Improved health and hygiene as a result of more water available for washing and cleaning.
- Stronger positive community feeling and village pride coming from a beneficial communal project.

It was noted that the 1986 evaluation found a failure rate of only 10%. This was over an average lifespan of more than three years and compared favorably with the estimated 90% failure rate of the earlier "Khor Sor Chor" projects in their first year. None of the failures were caused by inadequate structural strength, but were site-specific hydraulic design inadequacies such as a weir built on curved stretch of stream causing flow concentration against its upstream embankment, and a weir with its sidewall lower than field level causing scouring of sidewall embankments when submerged.

These same 52 weirs were resurveyed in late 1988, and it was observed that no further failures had occurred. The earliest weirs at this time were 10 years old and were still functioning well.

5. Conclusions

The authors believe that the main outcome of the early years of the KKU-NZ Project was that SSWR development was proven to be a feasible development strategy. The authors acknowledge that this was not the only project in the Northeast that yielded similar confidence in SSWR development.

The benefits in involving foreign resources (engineers and funding) in this early development strategy work included:

- *Low Impact*: Should the tests have proven to be quite unsuccessful, then the main drive of the Thai Government rural development program would have suffered from a fruitless diversion.
- *Technology Transfer*: The expert could bring a range of practical experience from outside the region which was beneficial. At the early stages of evaluating the feasibility, and before a large funding is committed, it is best to consider and test as many new ideas as possible.

However, the success of any externally funded program must be judged on how effectively the program is adopted by the host government's development strategy. The effective bilateral assistance program is one where the management and initiatives pass from the pilot project to the local managers, and where the need and use of the foreign funding of the program can progressively change the direction of, or strengthen development in a managed fashion.

The success of the design lies in the fact that it was developed for the particular conditions of the Northeast, and in doing so, combined engineering technology with the knowledge of local farmers. The willingness to experiment and take risks and the goal of a truly low-cost design were major factors encouraging innovation. The KKU-NZ TYPE 1 (1984) design development showed the benefits that can be achieved from working within existing systems with a little outside support.

References

ARBHABHIRAMA, A., et al. (1978) "Water for the Northeast: a strategy for the development of small-scale water resources", Asian Institute of Technology, Bangkok, Thailand.

DAYSON, E. (1983) "KKU-New Zealand Small-scale Water Resource Project: Final Report", Office of Water Resource Development, Khon Kaen University, Khon Kaen, Thailand.

MURRAY-NORTH INTERNATIONAL LTD. (1987) "Implementation guidelines for small-scale weirs in Northeast Thailand", Chaiyaphum, Thailand, Thai-New Zealand Village-Based Water Resource Development Project.

SETHAPUTRA, S., et al. (1986) "Lessons from the KKU-NZ weirs: an evaluation of the Khon Kaen University - New Zealand Small-scale Water Resources and Environment Institute", Khon Kaen University.

SMITH, K. E. (1990) "Evaluation of weir and canal construction methods used by the Thai-NZ Village-Based Water Resource Development Project, Chaiyaphum 1983-1987", Thai-NZ Small Watershed Development Project, Khon Kaen University.

WORBOYS, B. (1982) "Village level weir construction", Seminar on Dissemination of Technology to Rural Communities, Faculty of Engineering, Chulalongkorn University, Thailand.

__________ (1979) "Village spillway construction", Khon Kaen University, Thailand.

WREI (1988) "Structural analysis of the Khon Kaen University - New Zealand standard spillway (KKU-NZ TYPE 1 1984): summary of analysis and recommendations", Khon Kaen University, Thailand.

Acknowledgements

The authors would like to thank the Director, Development Assistance Division, New Zealand Ministry of External Relations and Trade, for his permission to present this paper.

Appendix
New Zealand's Contribution to Water Resources Development in Thailand, 1978-1990

In 1978 the Government of Thailand asked New Zealand to cooperate with Khon Kaen University in setting up a small-scale water resources program by providing technical and financial support. The KKU-NZ Water Resources Project was started in the same year when the co-author (Brian Worboys) was appointed as an adviser to the project. The objectives of the project were:

(1) To support extension work by the University, by building of series of small-scale projects in villages. These exercises could be the basis for demonstrating techniques taught in training seminars run by the Faculty of Engineering.
(2) To acquire practical experience and understanding of small-scale project construction.
(3) To provide small-scale projects in villages that improve the water resources of the rural areas and at the same time demonstrate the kind of projects that can be implemented by villagers themselves.

In 1983, based on the experience of the KKU-NZ Project, the New Zealand Government in cooperation with the Department of Local Administration (DOLA), established the Thai-NZ Village-Based Water Resource Development Project in Chaiyaphum Province. Its objectives were:

(1) To develop a standard weir design for use in larger streams than those for which the KKU-NZ TYPE 1 weir was appropriate.
(2) To provide technical advisers to the Provincial Small Water Resources Development Committee, and assist with matters relating to water resources planning and management.
(3) To work alongside the Royal Thai Government agencies, principally DOLA and the Provincial Office for Accelerated Rural Development (one of the many agencies involved in water resources construction), in order to integrate appropriate small water resources facility designs, such as weirs.

This was a five-year project with an annual construction budget of NZ$ 200,000 (over Baht 3,000,000), half of which was from New Zealand, and the other half from the Thai Government. The co-author (Brian Worboys) was appointed project leader for the first 18-month period.

From 1986 to 1987, a new project led by the co-author (Prakob Wirojanagud), the KKU-NZ-Ubon Volunteer Weir Project, constructed 20 weirs of the KKU-NZ design in Ubon Ratchathani Province. The material costs for 10 of the weirs were met by the NZ Government, and the other 10 from Provincial DOLA. The implementation of weir construction was carried out by the district officers, district staff, and village technicians who were trained and assisted by the Project staff. Construction was by the villagers themselves on a voluntary basis. The success of this project led to the adoption of the design and implementation concept by DOLA and the establishment of the People's Volunteer Weir Program in 1988. Under this program, 411 weirs were built in 1988, 600 in 1989, and over 1,600 were to be completed in 1990. The objective was to build 2,000 weirs per year for 5 years.

From January 1988 to December 1990, the New Zealand Government supported the Thai-NZ Small Watershed Development Project at KKU, which has assisted DOLA to establish a systematic, planned approach to water resources development and management. With a total budget of NZ$ 2 million, support was given in four areas, identified as key management tools for development.

(1) Acts, By-laws, Policies and Water Rights
(2) Decentralized Development Systems, i.e. programs instigated at district, sub-district and village level
(3) Watershed Development Planning
(4) Geographic and Management Information Systems

The co-authors (Prakob Wirojanagud, Kraiwudh Uttrahong, and Kevin Smith) served as Project Leader, Project Manager, and Technical Advisor, respectively.

An Integrated Approach to Problem Solving for Village Water Supplies: Thai-Australian Project

Geoffrey R. Anderson
Project Manager
Thai-Australian Northeast Village Water Resource Project
Khon Kaen, Thailand

1. Introduction

This paper attempts to deal with some of the pitfalls encountered and solutions tried with the identification, site selection, hardware selection and use of small facilities for village water supply.

2. Overview of the Thai-Australian Project

The Thai-Australian Northeast Village Water Resource Project (NEVWRP) has operated from the Khon Kaen office since 1983. During the first phase of the Project, activities concentrated on the provinces of Khon Kaen and Mahasarakham and since the commencement of the second phase late in 1986, activities have covered all seventeen provinces of the Northeast of Thailand.

The Project has its formal counterpart, the National Economic and Social Development Board, but cooperates with all agencies of the Royal Thai Government involved in drinking and domestic water. In 1989, sanitation and agricultural water were formally included in the Project activities. This move saw more Government agencies become involved in the Project activities and at that time, the Project team was increased to twelve.

The Project is funded by the Australian International Development Assistance Bureau and is managed on behalf of the Bureau by the Australian consulting firm of Coffey-MPW Pty Ltd.

The disciplines included in the Project Team are varied and include engineers, agriculturists, a planner, a sociologist, a training specialist, a hydrogeologist, a sanitation specialist and a communication/extension specialist.

The Project is made up of four major components. The only component which will not be mentioned in the body of the report is the agricultural water component. This component was established following widespread concern at the lack of use being made of existing small-scale agricultural water facilities in the Northeast of Thailand. This underutilization of technically sound facilities is a concern that the Project is addressing by looking at the social, farming and technical aspects of the facilities in conjunction with various agencies of the Government.

The Project activities discussed in this paper are:

- Management Information Systems and their application as a planning tool in the water sector.
- Groundwater Probability Maps and their relevance to domestic water, agriculture and agro-business as well as their role in conservation and environmental issues.
- Current work being undertaken on submersible pumps: looking at management systems, minimum specification and their role in exploitation of groundwater for all users.

- Water quality in the home, indicating a concern that not all contamination begins at the source of the water.

The paper will attempt to show how these activities, while being quite separate, must in reality be integrated, and experience from one must support the other.

3. Management Information Systems for Planners

A comprehensive Management Information System (MIS) has been developed by the National Economic and Social Development Board, together with the Community Development Department. The system resides on computers at provincial level and data, formatted as required, in hard copy is available for users at provincial and district levels. Data in computerized form can be transferred to and aggregated at regional and national levels. The system operates in DBase IV and data can be presented in either tabular or map form.

Data is generated from field surveys done at two-year intervals at the same time as other national surveys. The system is very simple and ranks villages in terms of need for drinking, domestic and agricultural water. The information can be aggregated to rank sub-districts and districts in terms of need in the same three sectors.

It is most significant that the data is collected, entered, and manipulated at provincial level and available for use in any desired format at provincial and district levels. The information is available for planners at all levels in preparing programs and budget requests and conversely is available for those at national level responsible for the scrutiny and approval of such requests.

The MIS goes a long way towards ensuring that programs and budgets are directed at the areas of greatest need. The next step in selecting the means or the facility to service the need is found in the proper interpretation of the Groundwater Probability Map.

4. Groundwater Probability Mapping

4.1 Introduction

Groundwater in Northeast Thailand is an important resource providing large areas with domestic, drinking, and to a lesser extent agricultural water supplies. To date more than 30,000 water supply bores have been constructed and, the Royal Thai Government agencies are currently drilling in the order of 5,000 more new bores each year.

Recognizing the importance of groundwater to local communities the Thai-Australian NEVWRP has developed a number of activities aimed at allowing improved and more efficient development programs. Critical among these is the provision to water resource planners and groundwater developers of reliable data from which informed development decisions can be made. To improve simplicity of presentation, distribution, and interpretation, a map format has been adopted for this purpose.

4.2 Groundwater Maps

Groundwater or hydrogeological maps can be produced in a range of formats and containing a variety of data. In the Thai situation it was considered necessary to adapt a format suitable for use by both technical and non-technical persons. The groundwater probability map fulfills this requirement by presenting a clear and easily legible picture of groundwater conditions which is of use not only to hydrogeologists and engineers but also to a broader group of users including planners, agriculturists, politicians and the interested public.

The groundwater probability maps use a color and tone index to depict probable bore yield and water quality in any area and also superimpose supplementary geological information. The probability index used is illustrated in Table 1.

Table 1. Probability index used for groundwater quality

	Expected Well Yield (m^3/hr)			
Total Dissolved Solids (mg/L)	< 2	2 - 10	10 - 20	> 20
< 500 (Good)	Light blue	Blue	Dark blue	Dark blue w/ vertical lines
500 - 1500 (Fair)	Light green	Green	Dark green	Dark green w/ vertical lines
> 1500 (No Good)	Light brown	Brown	Dark brown	Dark brown w/ vertical lines

As can be seen a wide range of groundwater conditions can be depicted. The four yield classes correspond roughly to water supply pumping capacities, i.e.:

- hand pump at < 2 m^3/hr;
- small power pumps at 2-10 m^3/hr;
- deep well pumping systems at 10-20 m^3/hr; and
- large scale pumping potential at > 20 m^3/hr.

The water quality indicator used is total dissolved solids, which was chosen to encompass a wide variety of potential mineral contaminants and with categories which correspond with generally accepted standards of water suitability, i.e.:

- < 500 mg/L TDS equates with potable water;
- 500-1,500 mg/L TDS is characteristic of brackish water with severe limitations of use with the exception of some industrial applications.

4.3 Map Production

Maps are being produced by technical staff of the Department of Mineral Resources with support from the NEVWRP. Production is based on interpretation of existing bore-hole data obtained from drilling records of the various implementing agencies together with field survey and extensive program of water sampling and chemical analysis. Data is collated in map format at a scale of 1:50,000 and interpreted in the context of existing geological information. Final map format is reduced to 1:100,000 which provides a workable product for both regional and local applications. Maps are being produced on a provincial basis with up to 10 sheets being required for each map.

4.4 Map Applications

For any specific area the groundwater probability map and supporting information can be used to identify:

- expected well yields;
- groundwater quality;
- geology in terms of rock type and stratigraphy;
- general drilling conditions such as: aquifer depth, expected static water level.

Collectively this information can be used by local communities, provincial planners, central government drilling agencies, and private developers to assess groundwater potential and plan development proposals at local, district and regional levels. Budget allocations and drilling priorities can be determined on the basis of the mapped data and, where groundwater potential is clearly low, the need for alternative water resource options can be identified and planned for. As such the maps are designed and principally aimed at users involved in water resource development planning. However, numerous other applications are also possible. These include:

- regional resources appraisals;
- achievement of improved drilling performance;
- planning for industrial and agricultural development;
- teaching and public education programs;
- project appraisal by financing agencies (e.g. banks);
- environmental appraisal.

In all of these applications the maps bridge the gap between the large volume of existing groundwater data and potential users by presenting the data in a clear and easily understood format.

With the format used it will also be possible to digitize the map index zones into a computerized data base which would then allow comparison with other data base systems covering existing and potential needs. Such a development would further enhance the value of the maps as a planning tool and extend the range of potential applications.

Use of the maps is also being encouraged by an extension program established to teach potential users of what information can be derived from the maps and how it may be used. This program is being convened at each province as the map is produced and made available for distribution. The program is also supported by the production of a separate bulletin for each province, which describes the hydrogeology and groundwater condition together with more detailed information such as drilling conditions and groundwater chemistry. Used in conjunction with the maps, these bulletins provide a detailed assessment of groundwater use potential and limitations.

Finally, initial evaluation surveys show the maps to be well received by users. The Mahasarakham map which has been printed for nearly twelve months has been well used in a surprisingly large range of applications. Users report the maps to be generally accurate and separate evaluation checks using bore data from holes drilled verify this with high accuracy match for both yield and quality parameters.

5. Appropriate Hardwater

Once a bore has been constructed, a number of development strategies are available for delivering water to the users. Thailand has traditionally fitted handpumps. These are operated by individual users and maintained by the agencies involved. After years of working to improve both the hardware and software of handpump maintenance, this system is now very reliable with more than 9 out of 10 pumps operable at any one time.

Circumstances are changing, however. Rural villagers are demanding a higher level of convenience and can afford to pay for it. The economic value of time and energy spent collecting water is being recognized. These changes require a new development strategy for the delivery of water.

An electric pumping system based on either a submersible or a jet pump is the first stage system evolving in Thailand. This can be further developed, either at the time of installation or later, into a reticulated system with public standposts or a full reticulation with individual household connections. Because of financial limitations, it is expected that a pump with outlets at the borehead will be the common replacement for handpumps.

A wide range of electric pumps is available to meet the requirements. Similarly, the pumps can be connected in a number of different configurations. In recognizing the problems associated with the proliferation of dissimilar installations, the Royal Thai Government has moved to achieve compatibility between units constructed by different agencies at different times. Their approach has been to set standards in three areas.

Pump costs vary from Baht 4,000 to 20,000 for a small submersible pump. Quality is also extremely variable. A set of minimum specifications for materials and construction is being prepared to ensure the quality of the product without restricting selection choices. Minimum requirements for safety and protection of the pump and motor against voltage fluctuations, lightning strike and dry running have also been specified.

Unlike handpumps, repairs to submersible pumps and motors will not be possible in the field and it is envisaged that a faulty pump will have to be replaced and taken away to a workshop for repair or reconditioning. It is therefore important that electrical connections and delivery pipe connections be compatible. Standards to ensure compatibility are being prepared.

The Royal Thai Government naturally does not have the resources to replace all handpumps with electric pumps immediately. In fact, some bores have such a low yield that they are only suited to handpumps. Site selection criteria are being developed to identify bores which can be converted and to set priority in accordance with the probability of success. With the phased introduction of electric pumps to the most suitable sites first, initial problems will be identified and rectified before more difficult sites are converted.

It is hoped that with a minimum specification, compatibility of connection fittings, adequate protection devices, and correct screening and selection criteria, the maintenance problems resulting from the uncontrolled introduction of handpumps will be avoided. A smooth transition to electric pumps will provide a boost to the economy and lifestyle of villagers in the Northeast.

6. Contamination of Water Within the Home

One component of the NEVWRP focuses on water users and sanitation. It has basically been concerned with the quality of water supplies, the uses made by village dwellers of various types of water, and the relationship between water use and diseases, specifically diarrhoea, which the Ministry of Public Health statistics show to have the highest morbidity rate of all water-borne infections in the Northeast.

Two major studies conducted with Project support have shown that water from the major local sources (rainwater and wells) is generally of good quality, and that the most significant source of contamination by miroorganisms occurs when water is used in the household after collection and storage. More specifically, it was found that water used for drinking, cooking, and washing clothes was relatively clean, while heavy contamination occurred in water used for toilet cleanliness, dishwashing and food preparation.

The Project conducted further research on household uses of water in order to determine what intervention strategies might be possible to reduce contamination. These showed that soaking dirty dishes in water for long periods and using dishes that were still wet at meal times were common practices, and that dishwashing was often done without detergents. While washing hands before meals was common, washing them after toilet use was not, and in both cases soap was rarely used. A more comprehensive study of household water use in a local village is being prepared, based on 18 months of fieldwork, and the Project expects to publish these results by the end of 1990.

Studies on diarrhoea incidence have also been undertaken because household water contamination had been suggested as one of the causes of the disease. However, detailed research has subsequently shown that the relationship between water use and diarrhoea incidence in the Northeast (late cool season and early rainy season) remain unexplained. Drinking water does not appear to be more polluted at these times, but nutritional deficiencies and climatic influences on different pathogens and on the susceptibility of local residents to disease may also be causal factors, and these are still largely uninvestigated.

Project research on water user behavior in the household and its relationship with disease has shown that the causes of diarrhoea are multi-factorial, and that multi-disciplinary research along the lines instigated by the Project, using medical practitioners, epidemiologists, social scientists, engineers, extension workers and others, is more likely to yield productive results.

In the area of household contamination of water, the Project is currently exploring possible extension strategies to improve the cleanliness of water for toilet use, dishwashing and food preparation. Obstacles to this are the fact that village dwellers tend to regard their current water use behavior as sufficiently clean already, generally do not accept that disease is transmitted by water-borne microorganisms, believe that diarrhoea is caused by bad food rather than bad water, and tend to give health issues a relatively low priority when expressing their needs for improving the quality of life. It is, therefore, clear that any intervention strategy in this area will need to demonstrate clear benefits to village residents before it is accepted, and will need to be part of long-term sustained campaign if behavioral changes are to be affected.

7. Conclusion

What has been demonstrated is the need to take an integrated approach to problem solving when considering small-scale facilities for village water supplies.

Site selection done largely on the basis of need and without appropriate planning tools such as Management Information Systems, is like "shooting in the dark" for the people responsible for program and budget formulation.

Secondly, effective development of resources is of utmost necessity. Facility types must not only address the need as determined from the information system, but they must be appropriate to and compatible with existing natural resources. The information contained on the Groundwater Probability Map is necessary for proper facility selection and was presented in a form, that is easy to read and access.

Software selected must be adequately specified and supported by maintenance systems. The example given has shown that site selection based on need, coupled with facility selection based on resource must be an integrated activity to properly sustain development.

In more general terms, the matter of household contamination of water demonstrates that while great emphasis has been placed on water quality at the source, a high level of training and extension work is also required to ensure that water quality at the point of use remains acceptable.

The Thai-Australian Project has done considerable work in these and other areas related to village water supply and sanitation.

Evolution of Institutions and Efficiency in the Management of Common Pool Flux Water Resources

Sinniah Mahen Mahendrarajah
Lecturer of Economics
Victoria University of Wellington
Wellington, New Zealand

Abstract

Small water resources in rural areas are usually common pools managed by community groups under common property rights. Popular examples are community wells and village tanks and dams, where villagers are the co-equal owners. Literature on common pool ground water resources suggests that due to the absence of private property rights there is a tendency for excessive individual extraction and rapid depletion of common stocks. Nevertheless, in practice, institutions and social rules have evolved endogenously over time through voluntary cooperation, thus, obviating conflicts among users in the extraction of common pools. This article examines the nature of interdependence of individual decisions in common property systems and the evolution of institutions within a cooperative game-theoretic framework. As an illustration, the institutions and collective practices, and the factors facilitating their stability in village tanks in Sri Lanka are provided. The institutional rules also mitigate common property inefficiencies, though they may not eliminate them completely. The efficiency cost can be measured in terms of the sacrifice in benefits under the institutional allocation compared to a hypothetical single ownership alternative for tank. An empirical approach based simulation and optimization of a whole water resource system is also provided to assess the cost in a village tank, where it is estimated at 9% of the potential net benefits in a typical rainfall year. It is also argued that external enforcement mechanisms can play a supplementary role for efficient management of common pools, particularly when the system is in a process of change due to population growth and technological change.

1. Introduction

Community participation in the management of all water resources at local level is now a common practice. In developing areas, States tend to encourage common property management of small water projects, placing an increasing reliance on village institutions. In addition, there are also small tanks and wells developed largely through community efforts for joint use and maintenance. Apart from the cost-saving for the State, the common property management is often claimed to be efficient on grounds of low wastage and absence of bureaucracy.

On the other hand, the literature on common property suggests that the full cost of an individual's current water use from a common pool may not be borne by himself, as the cost of consequent future shortages falls on the whole group. The associated private incentive for excessive extractions leads to rapid depletion of the stock and also causes uncertainties of future availability. On these grounds, public regulation has been advocated to internalize the common property externalities of ground water aquifers (MILLIMAN, 1956; MAPP and EIDMAN, 1976). It is the contention of this article that such divergences between private and social costs do exist in common surface water resources such as tanks. It is the manner at which institutional mechanisms internalize some of the externalities that conceals their presence.

Water institutions transcend generations and are often tied on to the evolution of the village itself. They are based on communication, voluntary cooperation and commitment. Broadly, they may include: (i) ownership and inheritance rules of water and land; (ii) management instruments such as village hierarchy, village bodies, the church and markets; (iii) social norms and customs including reciprocity and altruism; (iv) cohesion mechanisms under adversities such as droughts and floods; and (v) policing and social sanctions. Collectively, they are responsible for the evolution of rules for the harmonious use and maintenance of the tank. Interdependence of individual decisions and the need for binding agreements constitute the basis for institutional rules. On the contrary, a popular approach in the analysis of institutions assumes dominant individual strategies as the basis for their evolution (HARDIN, 1971; SCHOTTER, 1981; OLSON, 1965). In this paper, the evolution of institutional rules in common pool surface water resources is discussed as an assurance problem. The elimination of user conflicts by institutions also mitigates common property problems. The efficiency cost of institutional rules for resolving the latter can be measured in terms of forgone potential net benefit. One of the objectives is to demonstrate an approach in estimating the efficiency cost.

This paper addresses the institutional rules which have evolved for water allocation in the context of Sri Lankan village tanks. The scheme of the paper is as follows. The salient features of the village tank system are described in the next section. It is followed by a game-theoretic analysis of the evolution of institutions for water allocation and some of the features which facilitate their stability. In section 4, features of the collective restraints for resolving user conflicts in village tanks are described. A simulation and optimization approach to estimate the efficiency cost of village institutions in internalizing common property externalities is outlined and demonstrated using data for a village tank in section 5. Conclusions follow in the final section.

2. General Features of Village Tank and Irrigation

Traditional settlements in Sri Lanka are based on a one-tank-one-village system, where village family units are co-equal owners and users of the tank. This is, in other words, a property that is owned in common and used in common by villagers, whilst excluding outsiders. While serving other purposes such as washing and as a source of fish, its chief role is providing irrigation for the village rice land holdings. Generally, a tank depends for replenishment from its own catchment, which also usually demarcates the village boundary (ABEYRATNE, 1956). Often a tank shares the same name as its village and it is not uncommon to find 2 to 3 tanks per square kilometer, particularly in the dry zone landscape. They vary in capacity from 100 to 300 acre-feet and it is estimated that there are at least 3,000 such common property tanks (ARUMUGAM, 1959).

A typical village consists of approximately 50 families, each of which privately owns and operates an irrigated holding of one half to one acre in close proximity to the embankment. The central segment of the block is ancestral property known as *Puranawela,* which is surrounded by relatively recently acquired land referred to as *Akkarawela*. The latter is located at a slightly higher elevation and can be irrigated only through a sluice found at either tail ends of the tank-bund, whereas the *Puranawela* receives supplies from the main channel which traverses from top to bottom of the block originating from the main sluice found at the center of the bund. In fact, *Puranawela* holdings are distributed as narrow strips at right angles to the channel. A strip consists of several small plots separated by low field-bunds. This layout facilitates the diversion of water from the channel to each strip and to a plot-to-plot irrigation within each strip.

The layout of irrigation infrastructures and land holdings themselves constitute a part of the solution to the common pool conflicts. Together with other institutions, they reinforce the interdependence of decisions so that collective agreements among irrigators are inevitable. Cooperative game theory offers a suitable framework for the analysis of the evolution of the institutional rules.

3. A Cooperative Game Framework for Institutions

Agents in a gaming situation are confronted with two constraints, namely, interdependence of one's actions on the others and the uncertainty as to what the others' actions could be. Many early analyses have viewed common property incentives within a non-cooperative game known as prisoners dilemma or isolation paradox (OLSON, 1965; HARDIN, 1971). This assumes independence of one's action on those of others. It is congruent with separable cost functions for crop production for the water users, where one's decision could shift others' functions up or down, but does not affect others decisions at the margin (DAVIS and WHINSTON, 1962). A separable cost function has the property that the cost of crop production at the margin of one water user, i, is unaffected by that of the other, j, so that the cost for i,

$$C_i(q_i, q_j) = f_i(q_i) + f_j(q_j)$$

where q_i and q_j are the crop production levels of two irrigators from the common pool. A separable cost function allows dominant strategies for agents. That is, each user is able and will make own cropping and irrigation decisions regardless of what the others will do. Clearly, this is unrealistic since in irrigation systems, decisions are interdependent.

3.1 Production Interdependence

Water serves as a multi-point input in agriculture, where it is applied in varying quantities several times during the season to derive a single-point output. The final harvest reflects the cumulative result. A failure to meet water demand at any point in the crop growing season has ramifications. At the extreme, it can nullify the growth gains achieved through the previous irrigations and can result in crop losses. Formally, the level of output is a function of all irrigations.

(1) $$q_i = g(w_i), \qquad g' > 0 \text{ and } g'' < 0$$

where q_i and w_i refer, respectively, to the crop yield and the vector of irrigations for user i.

To the extent that the availability of water vector w_i is dependent on how others use water throughout the season, the marginal cost of crop production of irrigator i depends also on the individual water use vectors of the other N-1 co-users of the tank, i.e.,

(2) $$C_i(q_i(w_i)) = C_i[q_i(w_i), q_j(w_j)], \quad i \neq j \text{ and } j = 1,2,..,N\text{-}1.$$

The problem is symmetric for all users. The unique inter-temporal aspects of water use and the associated penalties make the interdependence of decisions transparent to all users of the common pool. For certainty of a harvest, the assurance of a water vector becomes crucial as the season progresses, with the severity of penalty for any deficiency also rising. Water shortage at a point can be a total or partial loss of resources already committed to the crop. In certain situations, it might lead to changes in crop management, such as switching it to a rainfed crop thereafter with a lower input package.

Non-separable cost functions would imply that changes in rates of water use of a user would influence the marginal cost of crop production of the others, hence can change the shape of the entire total cost curve of the others. That is, the externalities of one's water use enters the cost function of the others in a multiplicative way, affecting the marginal conditions for profit maximization. Under this circumstance, neither dominant strategies nor a unique independent choice for any irrigator is feasible. Interdependence and uncertainty are pervasive, which implies interdependent individual choice. The institutional solutions for such decision problems is cooperation, which is known as the assurance problem in game theory (SEN, 1967).

3.2 The Assurance Problem

The assurance problem is a generalized version of a two-person cooperative game known as "battle of the sexes" (LUCE and RAIFFA, 1957). The payoff matrix for this game representing the gains and losses of two individuals associated with two alternative activities is shown in Table 1. Each person has an individual preference, viz., the woman wishes that they both go to ballet, whereas, the man wishes that both go to dog show. Yet each of them prefers to go together to either of these rather than to separate entertainments. The payoffs are symmetric.

Table 1. Payoff matrix for the assurance problem

		WOMAN	
		Ballet	Dog Show
MAN	Ballet	(1,2)	(-1,-1)
	Dog Show	(-1,-1)	(2,1)

The problem is assurance regarding the other person's intended action. The man and woman must correlate their expectations and cooperate through some rule which assures them that wherever they go they go together. When an agreement is reached there is no incentive for them to defect as both parties gain from adhering to the rules. This also holds true when the game is repeated, as in a regular cultivation program.

Allowing coordination of probabilistic decisions or "mixed strategies", the payoff matrix in Table 1 can be translated into Fig. 1 which illustrates all possible attainable equilibria. The "convex hull" bounded by KFGJ represents all feasible payoffs for coordinated action with various rules. Perfect coordination will result at the loci in the frontier KMJ. The convex hull is the same as the equilibrium core (SHAPLEY and SHUBIK, 1969). The outcomes are Pareto efficient compared to the dominant strategy which are Pareto inferior.

Assurance expands the possible equilibria for the villagers. The opportunities confronting two users of a common tank can also be depicted by Fig. 1. Whenever one chooses to irrigate a larger crop the other would be forced to settle for a smaller area. Otherwise, both stand to lose by shortage of water towards crop maturity. Thus, for a user to make rational decisions, the intended action of the other is necessary. The communication of decisions on crop area is central in this situation. Equality of users and symmetry of incentives suggest that one will restrict this crop area if the other does so too. Once reached, agreements are self-enforcing. Besides, other features underlying the evolution of the village itself also strengthen the commitment.

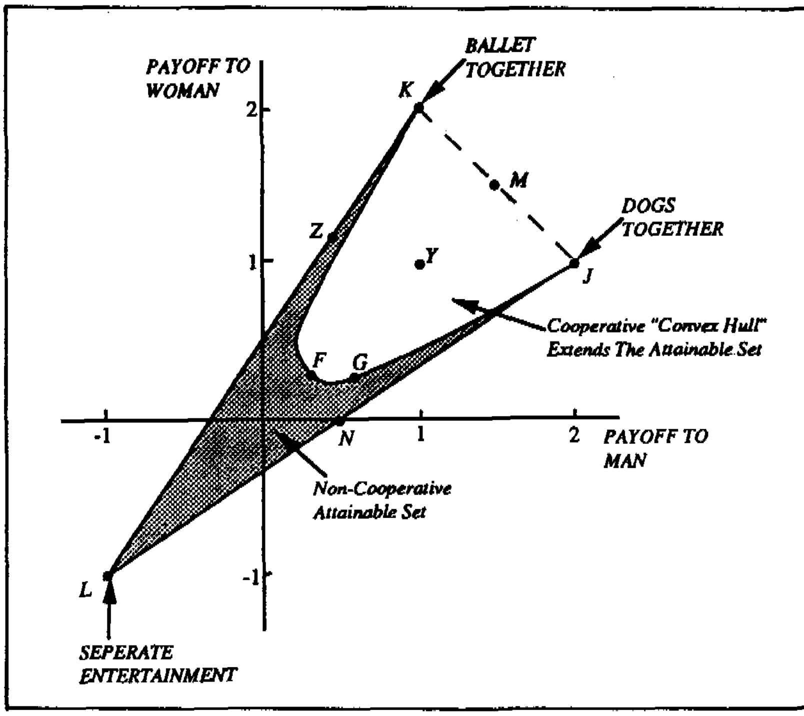


Fig. 1. Payoff space for the assurance problem

3.3 Inheritance Rules, Marital Customs and Village Homogeneity

Historically, the nucleus to each village appears to have been a small group of cousins who broke away from a congested parent village. According to customs, sons are the heirs of family lands. Village homogeneity and coherence are fostered by marital and residence rules, where a bride moves to the groom's village. A village therefore consists largely of male cousins. Besides, sons inherit the cumulative experience specific to their land and water from their fathers and uncles (ROSENZWEIG and WOLPIN, 1985). Altruism and income sharing with relatives in times of adversities are conducive to collective agreements in cropping and water use. Sanctions for violation of contracts include losing one's respect and support among relatives. Because of all this a near perfect coordination of decisions is feasible.

4. The Institutional Allocation Mechanism

The resolution of common property problems in village tanks would involve two restraints, namely, area restraint (AR) and rate of irrigation restraint (IR). The former can be effected at the beginning of the season and is easy to implement and police. In fact, most of the cooperative rules for water use are being laid down in relation to land rather than to water directly.

4.1 Area Restraint (AR)

In the village tanks in Sri Lanka, a system of AR known as the *Bethma* functions in the dry season, which begins in February. A collective decision on an appropriate segment of the block for irrigation is made at a pre-season meeting on the basis of residual storage in the tank. The fragmentation and dispersion of holding facilitate the choice of a portion of the block. Most users own land parcels in the proximal, middle and the distant third of the block (ABEYRATNE, 1956).

In the wet season, which begins in September with the onset of the major monsoon, priority rules are enforced although AR is not crucial. For instance, cultivation is undertaken in the whole *Puranawela* or none at all. Furthermore, *Puranawela* is given priority over *Akkarawela* in the use of storage. Both the cultivation and irrigation of *Akkarawela* are undertaken only in very wet years. The supplementary sluices are not in use in other years. For the example under consideration, it has been reported that the *Akkarawela* was under irrigation in perhaps 20% of the years only (MAHENDRARAJAH, 1978). The AR rules are also free of adherence problems because decisions concerning areas are made at the beginning of the respective seasons.

Possible conflicts in the allocation of irrigation areas between the wet and the dry season are avoided by assigning priority to the wet season. Only the residual storage is allocated for the dry season. Treating both seasons as competing alternatives for the use of storage could enhance the gains. However, it would not be effective without restraints on irrigation rates.

4.2 Irrigation Rate Restraint (IR)

Irrigations are synchronized for all. Whenever a part of the rice field is dry or free of standing water, the sluice is opened for all to irrigate their plots, even up to the brim of the field-bunds. The provision for irrigating one's crop generously until the value of marginal product (VMP) of water is zero eliminates conflicts. This in an important criterion in the decision of total irrigated area. Consistent with the water use practice, all main cultivation decisions such as land preparation, choice of rice variety, planting and harvesting are all coordinated by the villagers. However, this may not be perfect particularly with respect to timing of operations. The communications of intended actions occur informally as well as formally at crucial times such as pre-season planning forums. Given the small size of the village rice land, individual violations can be easily policed mutually. Also, the interdependence of decisions and the threat of sanctions almost guarantee adherence to rules, and enlist individual commitment so long as there is assurance that others will also do "the right thing". Also, given the provisions for generous irrigation, problems of water stealing either from the channel or from adjacent plots are nonexistent.

A stringent water use practice, such that VMP > 0 for irrigation, will bring a larger area of rice under irrigation, especially in the dry season. However, restraints on irrigation rates require agreements on precise quantity measures, for instance, filling only up to half the field-bund or irrigating when most of the plots are dry. The latter could have problems in implementation. Some plots tend to dry faster than others and low-lying fields benefit by seepage influence. Consequently, such differences could have implications on the income distribution in the community, and therefore, could deter the adoption of IR restraints.

4.3 Population Growth, Technological Change and Limits to Assurance

Population growth appears to have led to the breakdown of common property institutions in other contexts (JODHA, 1985). Fortunately, there is no evidence of such consequences in village tanks, although the natural emergence of new villages have ceased. Changes in techniques of water use, such as IR restraints, and planned conservation of storage in the wet season for use in the dry season will enhance the gains. This is particularly so with increasing value of water under new rice technology. However, the endogenous evolution and institutionalization of relevant social rules for coordination would involve considerable experimentation by villagers involving several years.

External enforcement mechanisms may supplement the missing elements of social rules in the interim period and expedite their integration into rural institutions. In terms of Fig. 1, it is tantamount to facilitating the movement of equilibrium at Y to the frontier KMJ. For instance, under the provisions of the Sri Lankan Paddy Lands Act of 1958, an irrigation supervisor referred to as *Vel Vidane* had been appointed to each village to ration water and to arbitrate disputes. Clearly, such instruments are superfluous in deriving the same level of benefit that could have been gained through voluntary cooperation. Since 1972 the practice has been abandoned in favor of consolidating the role of the village Cultivation Committee towards cooperation. The cropping systems improvement program in village tanks which was launched in the mid-seventies had as one of its objectives the implementation of stringent water use. The village extension workers were engaged to provide external assistance. However, external enforcement involves costs and one of the purposes of this study is to provide a basis for setting permissible costs.

5. Optimal Water Use and Efficiency of Institutions

The efficiency of the institutional rules in resolving the commonality problem can be assessed by comparing the gains with that of a single-ownership optimum. A simulation model of the irrigation system and an optimization procedure seem to be adequate to provide an estimate. Knowledge of the storage dynamics, the rainfall distribution, and the crop response to irrigation are necessary for this exercise.

5.1 Rainfall and Water Storage

Water storage in the tank considered here exhibits a pattern consistent with the rainfall distribution, which is bimodal. The peak storage occurs in December, coinciding with the tail end of the major monsoon, which accounts for approximately 80% of the annual rainfall. The second rainfall season covering April and May leads to a small increment in storage. The water storage dynamics can be represented as a transfer function relating weekly rainfall and storage level, and estimated using time series methods (MAHENDRARAJAH, et al., 1982). The model estimated for a typical rainfall year is:

$$(3)\qquad \begin{aligned} \hat{x}_k &= 0.938\hat{x}_{k-1} + 0.687\, u_k \\ \hat{\varepsilon}_k &= 0.587\hat{\varepsilon}_{k-1} + \hat{e}_k \qquad\qquad \text{and } \hat{e}_k \sim N(0, 3.87) \\ y_k &= \hat{x}_k + \hat{\varepsilon}_k \end{aligned}$$

where y_k is the observed storage at the end of week k. Here, the observed storage is decomposed into a system component, x_k, and an error sequence, ε_k, generated by a white noise, e_k. Also, u_k represents the rainfall in k, modified to account for atmospheric and soil conditions in the catchment.

5.2 Simulation of Irrigation System

An irrigation system can be simulated within a soil-crop-atmosphere complex. This includes: soil moisture movements as influenced by irrigation, rainfall and other factors; and the associated crop growth and yield. The former is monitored daily with a soil-water-balance model given by the equation:

$$(4)\qquad M_t = M_{t-1} + RF_t + IR_t - ET_t - RD_t$$

where M_{t-1}, RF_t, and IR_t refer to the moisture level, incident rainfall and irrigation which constitute the gains, while the losses are accounted for by evapotranspiration (ET_t) and runoff (RD_t) on day t. Irrigation restores an appropriate depth of soil to saturation. Among irrigation agronomists, it is common practice to specify irrigation decisions in terms of terminal soil moisture, which can be defined as the moisture level at which the soil is allowed to dry before being given an irrigation. It is adopted here to capture the time and quantity of irrigation in the computer simulation model of the irrigation system.

The basic premise for growth is that for the crop to grow on any day, the potential evapotranspiration (ET) reflecting the atmospheric demand must be met by the moisture held in soil. If the actual ET rendered feasible by the prevailing soil moisture on a particular day is lower, the plant is stressed and does not grow. Furthermore, the contribution towards yield of stress-free days depends on the stage of the crop. The grain yield, Q, in terms of stress days at various stages is specified as a linear function in the equation below. This applies to either season.

$$(5) \qquad Q = Q_p - \Sigma F_m d_m, \qquad m = 1, ..., 13$$

where: Q_p is the maximum potential yield under stress-free conditions; F_m and d_m represent the loss in yield per stress day and the number of such days during week m. F_m values have been adapted from previous studies (DE DATTA, et al., 1973). Popular cultivars belong to the high-yielding 105-day age class with a 13-week irrigation season.

The water balance model and the crop growth model are used together to simulate the common pool water allocation practice. The irrigation rule amounts to irrigating whenever the soil moisture falls below saturation. The AR practices can be accommodated easily.

5.3 Optimization Under Single Ownership

For simulating the "hypothetical" single ownership, the water balance model and the crop growth program are incorporated as subroutines in a dynamic programming (DP) algorithm. Two DP models are used in sequence to accommodate the allocation problems in the wet and the dry seasons. For specified areas of the two crops, the optimum quantities of water and their distribution over the seasons are determined by the models and the optimum irrigation areas are found by search.

The DP models have thirteen weekly stages and two discrete state variables, viz., tank storage and soil moisture. An irrigation decision is considered each day after the state has been observed. The state and the decision taken on day *t* determine the state on the following day. The actual ET is estimated on the basis of soil moisture and potential ET, and the growth contribution, if any is recorded. A backward induction procedure determines the optimal sequence of decisions and the associated cumulative benefit. The maximum potential yield and the cost of production are assumed as 4 tons and Rs 6,175 per ha, respectively. The price of rice is taken as Rs 3,000 per ton.

5.4 Empirical Results

The allocation of storage and benefits under common property and single-ownership saturations are summarized in Table 2. Conforming to *a priori* expectations, the single ownership is associated with a lower allocation of water and a lower benefit in the wet season compared to the common property system. The trend is just the reverse in the dry season. Overall, the results suggest that the present institutional rules designed for the elimination of user conflicts account for the loss of a potential net benefit of Rs 14,733 or 8.8%. However, it must be noted that the results pertaining to single ownership are based on risk neutrality. Thus the figure also defines the upper bound of the efficiency cost of resolving the commonality problems by institutions. It also sets the upper limit for the permissible cost of any supplementary external enforcement.

Table 2. Allocation of land and water under two property regimes

Aspects	Common Property	Single Ownership
Wet Season [irrigation calendar from Oct. 14 to Jan. 12]		
Storage at the beginning (acre-ft)	8.5	8.5
Optimal area of rice (ha)	24.3	24.3
Net irrigation benefits (Rs)	133,652	131,138
Total Water Use (acre-ft)	50.4	33.3
Turn-around period: no irrigation from Jan. 13 to Feb. 16		
Dry Season [irrigation calendar from Feb. 17 to May 18]		
Storage at the beginning (acre-ft)	14.5	20.5
Optimal area of rice (ha)	3.4	8.1
Total water use (acre-ft)	11.2	15.0
Net irrigation benefits (Rs)	18,919	36,166
Storage at the end for *in situ* village uses (acre-ft)	10	10.3

Note: 1 acre-ft = 4.593 m^3

6. Conclusion

Common property externalities are inherent in flux water resources such as tank storages. The associated incentives for excessive extraction can lead to user-conflicts and to uncertainties in availability. However, conflicts have been eliminated by institutional rules founded upon voluntary cooperation in irrigation decisions. In common tanks, decisions of users are interdependent because of a fundamental non-separability of cost functions for crop production, where dominant strategies for the irrigators are infeasible. It is also manifested in the layout of irrigation infrastructures. The institutional rules evolved on the basis of interdependence and coordination of expectations and have the same structure as the assurance problem in game theory.

Collective restraints and priority rules in irrigation area obviate user conflicts in village tanks, yet they only mitigate the common property inefficiency. This cannot be eliminated completely in the absence of restraints on irrigation rates. However, relevant institutional rules for restraining rates do not exist. The present institutional rules appear to be only 91% efficient towards eliminating the commonality problems in a typical year, on the basis of the case study. However, the figure needs to be treated with caution as it is based on a single year's data, and its magnitude is sensitive to parameter values and rainfall variation. In principle, the inefficiencies in other tanks can be estimated, given the knowledge of storage dynamics, a simulation model of the irrigation system, and a DP optimization procedure. The efficiency cost will rise as the value of water rises with improvement in crop productivity, hence it cannot be ignored. Thus, there is much scope for public policy in seeding and promoting relevant institutional rules. The existing rules could be supplemented in the interim by external enforcement so long as the cost is not in excess of the inefficiency. However, outside enforcement is only a second-order solution and it cannot replace totally the present institutional rules. Under a cropping systems improvement program, a supplementary assistance has been implemented with great success in tanks in Sri Lanka since the mid-seventies, engaging the network of village level extension workers.

Where there are symmetric incentives for all users, reliance can be placed on the endogenous evolution of institutional rules in other small common pools such as shallow wells and rivulets. Rotational irrigation practice in common garden wells drawing from the storages in sedimentary limestone aquifers in Northern Sri Lanka provides a good example. Both group homogeneity and coherence fostered through marital and inheritance customs are conducive to voluntary cooperation and commitments, which are essential ingredients for assurance. Often, new small-scale water projects, even if constructed by the States, are eventually entrusted to the target groups as common property. An understanding of the evolution and limitations of institutional mechanisms in existing rural water resource systems are valuable in designing and promoting institutions in new projects.

In relatively larger systems, such as canals, payoffs are asymmetric for the upstream and downstream users, and voluntary agreements are seldom reached. The institutional rules are unstable and are not self-enforcing. Under such circumstances, dominant strategies for users are predominant and greater outside enforcement may be appropriate.

References

ABEYRATNE, E. F. L. (1956) "Dry land farming in Ceylon", Tropical Agriculturist, 62:191-229.

ARUMUGAM, S. (1959) Development of Village Irrigation Works, Government Press, Colombo.

DAVIS, O. A. and A. B. WHINSTON (1962) "Externalities, welfare, and the theory of games", Journal of Political Economy, 70:241-262.

DE DATTA, S. K., W. P. ABILAY, and G. N. KALWAR (1973) "Water stress effects in flooded tropical rice", In Water Management in Philippine Irrigation Systems: Research and Operations, IRRI ed., International Rice Research Institute, Los Baños, Philippines.

HARDIN, R. (1971) "Collective action as an agreeable N-prisoners dilemma", Behavioral Science, 16:472-481.

JODHA, N. S. (1985) "Population growth and the decline of common property resources in Rajasthan, India", Population and Development Review, 11(2):247-264.

LUCE, R. D. and H. RAIFFA (1957) Games and Decisions: Introduction and Critical Survey, John Wiley and Sons, New York.

MAHENDRARAJAH, S. (1978) "Resource characteristics and utilization in small tank settlements in the dry zone of Sri Lanka: a case study of the village Walagambahuwa", Mimeographed, Department of Agriculture, Maha Illuppallama, Sri Lanka, 108p.

MAHENDRARAJAH, S., P. YOUNG, and A. JAKEMAN (1982) "Stochastic time series analysis and the village dam management problems in Sri Lanka", In Optimal Allocation of Water Resources, Publ. No. 139, International Association of Hydrological Sciences, United Kingdom.

MILLIMAN, J. M. (1956) "Commonality, the price system and the use of water supplies", Southern Economic Journal, 22:426-437.

OLSON, M, Jr. (1965) The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard University Press, Cambridge, Massachusetts.

ROSENZWEIG, M. R. and K. I. WOLPIN (1985) "Specific experience, household structure and intergenerational transfers: Farm family land and labor arrangements in developing countries", Quarterly Journal of Economics, 100(suppl.):961-987.

SCHOTTER, A. (1981) The Economic Theory of Social Institutions, Cambridge University Press, New York.

SEN, A. K. (1967) "Isolation, assurance, and the social rate of discount", Quarterly Journal of Economics, 81:112-124.

SHAPLEY, L. S. and M. SHUBIK (1969) "On the core of an economic system with externalities", The American Economic Review, 59:678-684.

Multi-disciplinary Engineering: The Community Organization Method

Len J. Abrams
Executive Director
Rural Advice Center
Johannesburg, South Africa

Abstract

Our experience in the Rural Advice Center leads us to the conclusion that the level of technology which a community can support is related to the sophistication of the social structure of the community. In sophisticated urban environments sophisticated technology is sustainable and consulting engineers relate to expert clients. This convenience system is not available in marginalized rural communities where the engineer must deal directly with the end-user. The engineer is not usually equipped with the skills to interrelate with the community and hence a multi-disciplinary approach is needed.

1. Introduction

The discussion of development engineering which follows is written from the peculiar realities of South Africa at this time - the early 1990s. While the excesses of the apartheid system contribute to the distortion of most facets of life in South Africa, most of what follows is more broadly applicable to the development of rural communities in the South generally.

The following observations are drawn from the author's experience as director of the Rural Advice Center - a small professional NGO operating mainly in water supply projects with rural communities in South Africa. The paper is an attempt to provide a critique of the role of the engineer in the "empowerment" of rural people in a multi-disciplinary context.

Firstly, the concepts of transformation, empowerment and entrapment are discussed, which then leads to the question of the engineer's involvement in a multi-disciplinary environment. The debate between the conventional "community participation" model and the "community organizational" model is discussed to extend the thesis that "appropriate organization" is more important than "appropriate technology" in the sustainability of projects.

2. Transformation and Empowerment

2.1 Transformation

Transformation is more than a development theory. It encompasses all aspects of the society under consideration: social, political, physical, health and many other facets. A society is only transformed by its members, and this can only take place if the members are empowered with the means and will to act. This is only achieved as the community organizes itself. Any community requires cohesion in order to mobilize potential and develop organizational structures. Such cohesion is only possible when motivated by issues of common concern. Therefore, it must be seen clearly that the issue (say, lack of water in a rural or "squatter" village) is a means to an end, and not an end in itself. If the issue is perceived as an end in itself then the community is merely "making the cage more comfortable", and it is very likely that the technical solution will not be sustainable. A successful solution to the issue is nonetheless an important step in the transformation process because it endorses the process and encourages the people.

It has been our experience that the key to the process is to ensure that the community fully understands our approach. The community's expectations must be deflected from us back to themselves. We therefore have to continually reinforce our roles as facilitators only, with the community taking full responsibility for their own problems. To achieve this, specific professional skills are required in human relations and organization building, in addition to engineering.

2.2 Empowerment

Empowerment is the establishment of collective power for the fulfillment of the individual. It incorporates financial, community, and political leverage to gain increasing control of the people's resources and destiny.

Detailed attention must be paid to individual communities - grassroots communities are the building blocks of larger strategies but they must be served individually and at all times in their own interest. To the extent at which larger strategies are dependent upon the real empowerment of individual men and women in distinct communities, project work is an end in itself. However, real empowerment is not attainable in isolated communities because they lack political and financial leverage which can only be attained by the building of solidarity both through rural-rural linkages and rural-urban linkages.

2.3 Rural Entrapment

The main factors which contribute to rural entrapment (which is the opposite of empowerment) are as follows:

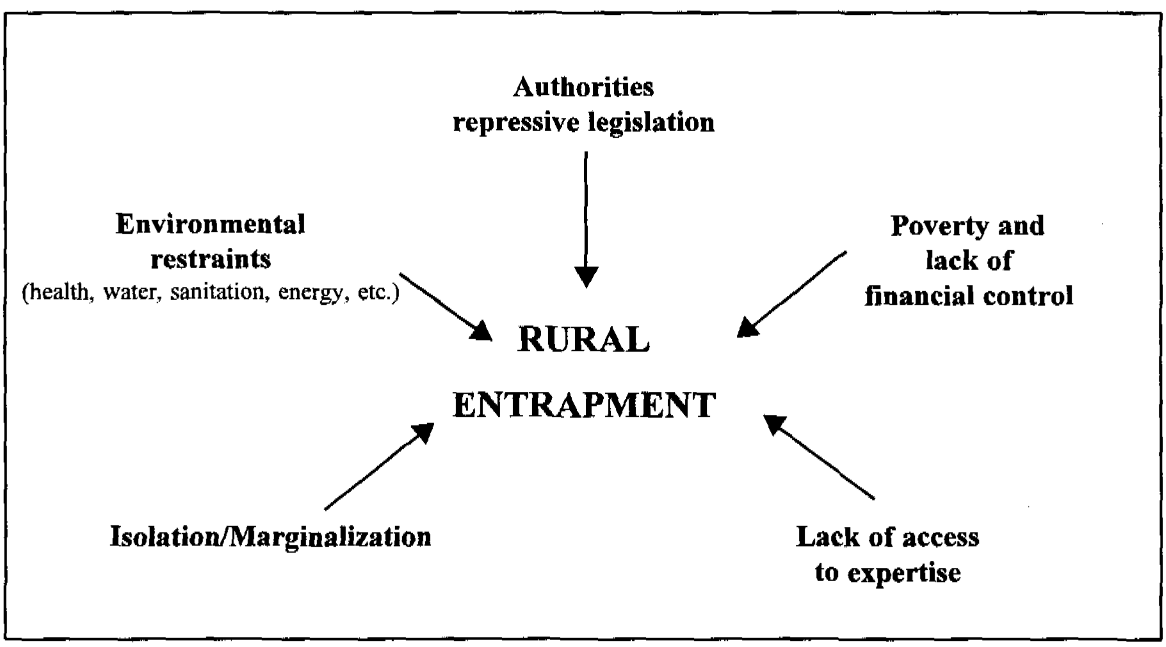


Fig. 1. Rural entrapment

2.3.1 *Authorities and Repressive Legislation*

"Homeland", "Independent State" and "Central" authorities in South Africa constitute a daunting edifice of officialdom to rural people. They are generally considered as unsympathetic and unaccountable. Local authorities are viewed differently depending upon their accessibility and their identification with the needs of the people. In the face of bureaucracy, corruption and inefficiency, authorities are usually considered as part of the problem rather than an agent of empowerment. An array of repressive legislation from the [1]Land Acts to the Squatters Act contribute to the legislative entrapment of rural people in South Africa.

2.3.2 *Poverty and Lack of Financial Power*

The grinding debilitation of poverty goes to the heart of rural life where the effects of a national economic system which relies heavily on a labor force of migrant workers determines the income of most families. Poverty ensures that individual and community potential can never be realized. Modern banking incorporates a mythology almost entirely unintelligible to the poor. It is viewed with suspicion and as a tool of entrapment. The small resources which rural people have depreciate continuously as a result of their not having real access to the wider financial world.

2.3.3 *Lack of Access to Expertise*

The productivity of indigenous rural wisdom is restricted by lack of access to expertise. Expertise is power in the hands of the expert and is more readily available in urban environments. Expertise provides communities with political and economic leverage. The key to unlocking this facet of entrapment is access to the expertise which already exists.

2.3.4 *Isolation and Marginalization*

Isolation is the geographical reality of most rural communities. Isolation creates an overwhelming sense of vulnerability for rural people because of their remoteness, the lack of communications and the poor transport infrastructure. Because of isolation, any activity with the outside world involves a host of logistical hurdles. Marginalization is the political side-lining of rural people. They play very little role in policy formation and cannot lobby for their own interests. Marginalization of rural people is practised in conservative and progressive circles in South Africa and is strengthened by the rural-urban divide of political, social, and economic priorities.

2.3.5 *Environmental Restraints*

Conventional "development" is restricted mainly to this facet of entrapment. The immense amount of time and energy expended daily in providing for domestic water and energy not only entraps rural people but is a major drain on potential productivity, costing the country a conservatively estimated 1,400 working years/day. If one adds to this the effects of illness and caring for the ill as a result of dirty and inadequate water supply, poor sanitation and insufficient fuel, the cost (even if only in terms of quality of life) is immense. Simply solving these restraints alone is not possible. Unless a holistic view is taken of empowerment, technical solutions alone are unsustainable.

---

1 *The 1913 and 1919 Land Acts deny black people, who comprise 75% of the population, access to all but 15% of the land of the country. The Squatters Act of 1989 allows for employed members of black families who have lived for generations on "white" farms to be proclaimed "squatters" and evicted, without compensation or appeal, or provision of alternative accommodation.*

2.4 Rural Solidarity

Because marginalized communities are unable to fulfill an empowerment process in isolation, it is necessary that they become informed of the wider process and that their experiences become part of that process. The major elements in the creation of rural solidarity are as follows:

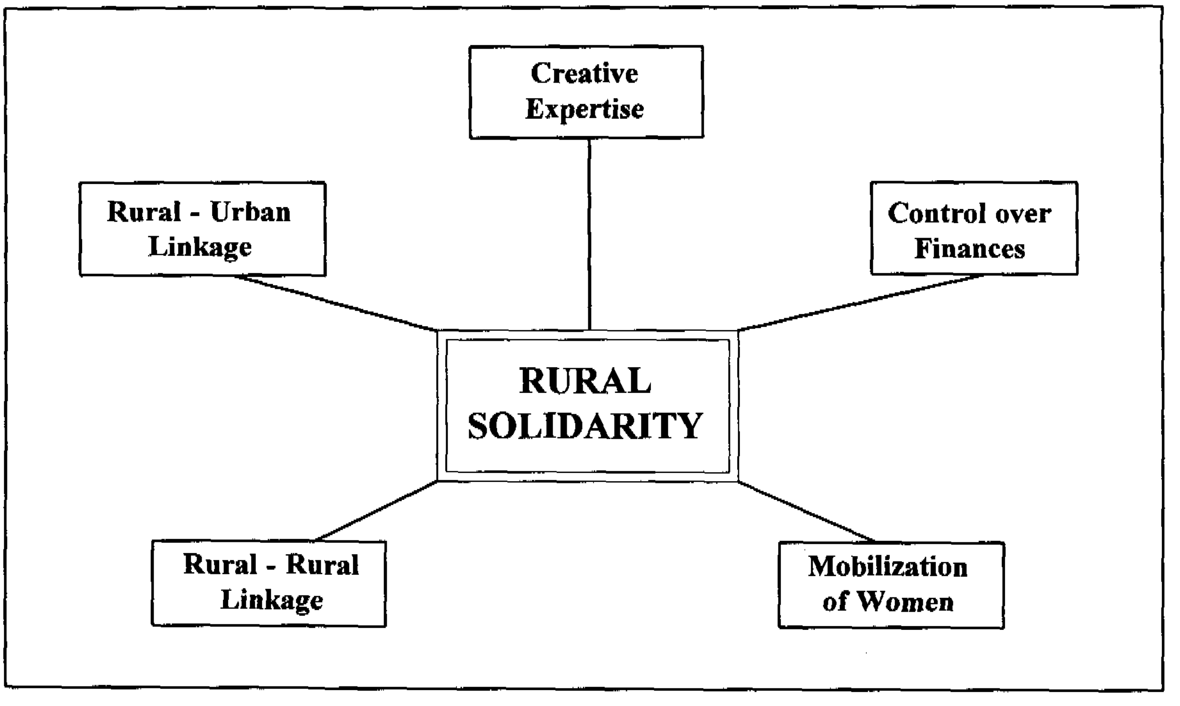


Fig. 2. Rural solidarity

2.4.1 Creative Expertise

Expertise unlocks and channels indigenous wisdom and ability, enabling rural people to follow their own processes. Expertise must, therefore, be professional and committed to avoiding dependency which perpetuates entrapment, however enlightened. Creative expertise in South Africa lies in an ad-hoc collection of unrelated and often competitive sources. Only through cooperation and planning will progressive and creative expertise be accessible to rural people. Access to expertise for rural people is an expensive component of any project because of isolation but is seldom budgeted for.

2.4.2 Control of Finances

Financial power needs to be built by communities with access to professional expertise to enable rural people to compete in a complex economy. Entrance into the marketplace needs to be through transparent and understandable systems at grassroots levels such as credit unions, to enable the community to collectively engage with the wider financial world. At present, in South Africa rural infrastructural financing is monopolized almost entirely by the state with a very thin layer of participation on the part of philanthropic endeavor. While the state must not be relieved of its obligations, it will only become accountable if there are sound alternatives. Sound alternatives must address the potential of loan financing, grass-roots affordability, risk and revolving finances.

2.4.3 Mobilization of Women

Denying women, who bear the weight of rural entrapment, access to decision making roles is often entrenched in order to protect an intransigent patriarchal incompetence. In mobilizing women a major resource is unlocked within the community which, experience has taught, is often the key to the empowerment process. The commitment of women to family, the land and the community ensures the sustainability of projects and makes them less susceptible to the effects of the migrant labor system in South Africa.

2.4.4 Rural-Rural Linkage

An invaluable component in the building of rural solidarity and the breaking down of isolation and vulnerability is the building of rural-rural linkages. More ground can be gained by the forging of links between ordinary struggling communities than the import of outside ideas and priorities. Creating these linkages and encouraging the organization of linkage structures, therefore, play a critically important role in empowerment.

2.4.5 Rural-Urban Linkage

In order to ensure that rural people increase their access to resources, expertise and power (both financial and political), it is important to create rural-urban linkages. This will begin to rectify the processes of marginalization and increase rural leverage. The need for the creation of "town committee" structures, rural-urban linkages and other strategies is important if rural people are going to make their unique and valuable contribution to national life.

Each of these five factors is a major subject in itself around which effective strategies must be developed. Each factor has direct application to projects at a practical grassroots level and provides a contribution itself to the struggle for wider democracy. All are needed for successful long term intervention.

3. The Role of the Engineer

The normal response of the engineer to the above is that it is all very well, but hardly the job of the civil engineer. The problem is that the training and most of the experiences of the civil engineer in South Africa is modeled on, and undertaken within a Western context. Within this context, there is an established system of convenience where the engineer is permitted the privilege of being a pure technologist. The engineer seldom has to relate to the end-user. The social structures are complex and sophisticated, in most cases employing expert advisors of their own. Human elements of problems are, therefore, seldom the concern of the engineer and the training the engineer receives usually ignores them, more or less completely.

If engineering is a profession, the engineer has a moral and ethical obligation to advise and provide for the marginalized and dispossessed communities of society. This is part of their professional responsibility and is not a retreat into the realms of charity or missionary endeavor. The question of who will pay the engineer is probably asked before the question of how to effectively undertake such work. The issue of remuneration goes to the root of why the communities find themselves dispossessed and marginalized in the first place, and therefore, does concern the engineer if only on this rather mercenary level.

The engineer is equipped to solve problems - that is his job. How is this accomplished in the context of rural and urban fringe transformation? Stripped of the convenience of the Western social structure, the job of the engineer changes from being able "to produce a technically adequate design" to being able "to produce a socially and technically sustainable solution". If the project is for the community to equip themselves with an irrigation scheme, then it is the engineer's job to ensure that this happens. If an otherwise technically adequate solution fails because the community does not have the organizational infrastructure to maintain it, or because a faction of the community sabotages it because they were not consulted, or for any other reason, the solution is not sustainable and the project has failed, the engineering objective has not been achieved and the engineer cannot deny responsibility.

"But" protests the engineer, "I am not trained for that and if I have to be involved at that level I cease to be an engineer". This is precisely the point - the engineer must remain the engineer but cannot remain a pure technologist. They must acknowledge their areas of expertise and where other disciplines have expertise which they do not have. This is the essence of professionalism. The rural transformation engineer must know his/her limitations and the strengths of other disciplines. They must have a social awareness and a local and national political critique, even if it is only an awareness of their own inadequacies. Within this framework the engineer can participate in innovative, creative engineering to provide sustainable solutions which will be part of the transformation process of the community.

Having established the multi-disciplinary context in which the rural transformation engineer pursues his/her career, it is important to emphasize that such engineers must avail themselves of all the tools available to provide the client community with the best professional service possible. These would include computers, sophisticated water testing equipment, mapping services, project management principles, and other resources and techniques; never forgetting that the solution must be sustainable and that the community makes the final decision.

4. The Community Organization Approach

"Development", as seen from the technocrats' position, has evolved through different phases but has, we submit, not changed its basic philosophy over the past 100 years - referring at least to colonized countries of the South (the "Third World"). At the risk of oversimplification the phases may be described as follows - through the initial periods of colonization and dispossession, development was a matter of doing what was in the "natives'" best interest. This phase moved to at least informing the "natives" of their fate prior to the start of development programs. As progress was made, the concept of "needs assessment" arose in order to tailor development to the needs of communities and avoid the high failure rates of projects. The solutions to the needs remained the prerogative of the experts. The latest approach has been broadly described as "community participation", and entails finding ways in which the community can participate in aspects of the projects, especially construction.

The basic philosophy, which has not changed (at least in South Africa), is that the expert knows best. In many countries where independence has been achieved the philosophy remains unchanged - development issues from the center of power, from an urban base, from the "top". Much has been written in recent years about the "bottom up - top down" debate but there remains a bewilderment as to how this is to be achieved. This arises from the fact that the change is more than adjusting the way in which projects are approached - what is needed is a different philosophy, a different world view, a paradigm shift. The basis of the philosophy lies in an understanding of *Rural Entrapment* and the keys which unlock it as described above. This can be summed up in the statement that development is a human process - not a technological one. This leads to the center of our argument: *If development is a human process, then the way in which humans organize themselves will determine how they develop - not the technology at their disposal.* How people organize themselves is commonly called "politics" which, as anyone who has worked at grassroots village level will know, is always present - be it family politics, village politics, or national politics.

The thesis that the level of technology which a community can sustain is closely related to the level of its organizational complexity is at present based on the observations in the field by the author. It as yet requires conclusive research. The emphasis must hence be moved from the technology to the organization of the community. This does not mean that technological or engineering excellence should be compromised - it means that the emphasis, the key, must be redefined. However simple, however "appropriate" the technology, if there is no sufficient organizational capacity it is unlikely to be sustainable. Much "appropriate" technology development has been aimed at devising solutions which can go into an organizational vacuum and still succeed.

4.1 Some Keys to the Organizational Approach

Community Initiative. One of the most important phases of a project is how it starts. The community must take the first step. The policy of the Rural Advice Center (RAC) is that even if the community is introduced to the RAC through a third party, we will only respond on direct requests (usually in writing) from the community. We don't go looking for work.

Ownership of the Problem. Whatever the problem - water, sanitation, etc., it must be emphasized that it is their problem, not the RAC's, the state's or anybody else's.

Strict Walk-away Policy. If the community is not prepared to organize around its problem and own it, the RAC will pull out and walk away from the project. Organization cannot be "done" to a community. Walking away is the best policy because the project is unlikely to succeed anyway.

Community-based. Careful discernment is needed to ensure that the "community" is represented by some form of democratic or collective basis. Often the "community" comprises no more than the local shop owner and his friends.

Conflict. This can either be divisive or cohesive. Divisive conflict originates within the community and can destroy a project. Cohesive conflict originates outside of the community and binds people together to work collectively against a common problem or enemy. Cohesive conflict should be sought for and enhanced to assist the project; divisive conflict should be avoided.

Self-interest. Very few villagers who are struggling to survive will act out of true altruism (the same applies to most people in most societies). Whether from religious, family, or community motives, people act primarily in order to advance their own cause or interest. This is not a value statement - it is a realistic one which can be a very powerful organizational and developmental motivation. A project which is aimed at meeting the greatest common self-interest is likely to succeed.

Technology Translators. The role of the engineer is an advisory one, with the community always making the decisions. It is a powerful role which must not be manipulative. The community will not choose an improved ventilated pit latrine if it does not know that the choice exists. While the community is not expected, for example, to understand the dynamics of open channel flow, the engineer must be able to translate the basic technology to the community to enable it to make an informed choice.

The "Snow Ball" Effect. The success of a project can often be tested by the extent to which community organization replicates itself within the community. We have seen organization around water issues spawn farmers' associations, brick-making, women's groups, and other bodies. Separate projects however should not be confused.

Financing and Money Matters. Money issues are often the cause of failure of organization-based projects. The RAC follows the following principles:

- The community must administer its own funds.
- The community should only do so once it has a constitutionally governed accounting/banking system.
- The community must raise its own finances to ensure ownership of the project. This is done with the full back-up and logistical support of the RAC.
- The community should be responsible for the ordering, purchasing, delivery, and storage of all materials with the advice of the RAC.
- The community should be responsible for the construction of the project, be it self-constructed or by contract, again with the advice of the RAC.

Live-in Approach. Community organization field workers and engineers live in the community during field trips and workshops.

Community as Client. This is perhaps the most important point. The RAC operates directly with the community as the client - not the government or any parastatal organization. This secures the moral and ethical relationship and is based on the initial written brief or invitation.

5. Conclusions

The Rural Advice Center will continue to operate and experiment with the Community Organization method with a critical approach to ascertain its effectiveness. Further research is required to test the hypothesis that the level of community organization is more important as the key to sustainability than the technology.

Community organization is, however, closely associated with the social and political struggles of rural people. It is, perhaps, for this reason that it is avoided by policy makers and engineers.

Small-scale Water Resources Development in Southern Africa: Effective Planning, Delivery and Management through an Integrated Rural Development Approach

John M. Erskine
Senior Research Fellow
Institute of Natural Resources
University of Natal, Pietermaritzburg
South Africa

Abstract

The inhabitants of less developed rural areas are experimental and adaptive - they cannot afford not to be. They need, it is now realized, not dictates but methods, not precepts but principles, not a single system but a range of options, not instructions on what to adopt, but ideas about what to try, and support for their trials and experimentation. With these basic tenets in mind, the Institute of Natural Resources has initiated a number of small-scale water resources development schemes in less developed rural areas of Southern Africa within the general framework of an integrated rural development approach. Important components of this approach include local institutional development, land capability analysis, and the formulation of policy and recommendations concerning regional development and the optimum form of land use for a particular area. Emphasis is placed on sustainability and economic upliftment with the primary objective of encouraging and providing opportunities for local people to move from subsistence agriculture into commercial farming and/or other rural-based income generating activities. Concurrent with the initial study phase, a number of small-scale precursor trials and demonstration units relating to agriculture, forestry, water and sanitation development, etc., are established with the help of the community and are run by local families or groups. These early trials afford the community and researchers an opportunity to assess the relative advantages and disadvantages of new systems, and lead directly to the formulation by the local development committees (assisted by the researchers) of realistic development proposals for the area. This paper describes a successful model for small-scale water resources development involving the adoption of an integrated approach to overall development in impoverished rural areas.

1. Introduction

Much of the water in less developed rural areas of Southern Africa is inaccessible or otherwise unavailable, and the remainder is unevenly distributed both from place to place and from season to season. In many of these rural areas, an adequate and reliable supply of water can be had only by active development and management of water resources. In order to meet the imperative demand of domestic consumption and the substantial demand of agriculture, water must be collected, stored, allocated, and distributed. An adequate supply depends on human intervention in the water cycle and the development of water resources not only on the surface but also underground. The water itself falls from the heavens and in that sense is free. But human intervention in the natural water cycle always entails some cost, and frequently the cost is high.

In many of the less developed rural areas of Southern Africa, the most urgent need is for safe drinking water and for waste disposal facilities; many people have no reasonable access to potable water of acceptable quality. The amount needed is not large compared with the demands of agriculture, but the per capita cost of distribution can be very high.

Where there is a demand for water that exceeds the maximum sustainable supply in arid areas or regions of high population density, the demand can be met by depleting accumulated reserves (such as groundwater), but overdrafts on a natural resource cannot continue indefinitely. It then becomes necessary to manage the demand as well as the supply so that the available water can be allocated to those who need it most and to those uses promising the greatest economic return (with reference to local, regional, and national needs).

Some of the successful initiatives of the Institute of Natural Resources relating to the development of small-scale water resources are summarized in this paper, with particular reference to the integrated rural development approach adopted by the Institute. This approach places emphasis on local institutional development, analysis and planned use of natural resources, technology evaluation and transfer, and local community support.

The systems and technologies discussed here should be seen as supplements to, rather than substitutes for, standard large-scale water supply and management methods. Their appeal lies in the fact that they may have immediate local value for small-scale water development and conservation, especially in remote rural areas. It is important to emphasize that they are not large-scale, formal types made small but, instead, a totally different concept. As such, a reversal of the traditional approach is required, that is, from the bottom up rather than from the top down.

2. Water Resources Development in KwaZulu

Years of drought, broken by devastating cyclones and further punctuated by outbreaks of cholera and typhoid - all these natural disasters have underscored the vulnerability of many people living in KwaZulu who are forced to rely on unprotected water resources and who have no toilets. People living in other less developed areas of Southern Africa face the same problems. A brief summary is presented below of some Institute of Natural Resources initiatives (a series of mutually supportive and integrated projects) with respect to water resources and sanitation development in KwaZulu.

2.1 Biyela Integrated Rural Development Project

In this project, integrated, concurrent, and comprehensive actions are being undertaken on a number of fronts (e.g. organizational, institutional, rural service center, agricultural, forestry, water resources and sanitation, and road development as well as the provision for services, education, and training). These various complementary activities of rural development are taking place within a coordinated framework and much attention is being directed towards facilitating local participation and control in the gradual process of creating a balanced organizational, institutional, and physical infrastructure in the area.

The Institute first became involved with development systems research in the 23,000 ha Biyela area of KwaZulu in 1981. The overall concern of the project has been the design, pilot-scale implementation, and evaluation of appropriate technologies and systems for development which enable optimum and sustainable land use and which maximize local participation, control, and organizational development. An initial intensive study of the area commenced in 1982 and this included a detailed assessment of the natural resources and socio-economic circumstances of the area as well as a land capability analysis. Concurrent with this study phase, a number of small-scale precursor trials and demonstration units were mounted in order to: (1) assess the technical, economic and, social acceptability of systems and technologies developed by the Institute in its technology research and development projects (described below); (2) minimize initial costs; and (3) evolve systems and provide training and opportunities for local participation in the development process. These early trials, which included various means of exploiting local water resources (for example, protected springs, boreholes, water pipelines, and small dams) and various types of toilets (for example, ventilated improved pit, dry system, and flush system), afforded the local community and researchers an opportunity to assess the relative advantages and disadvantages of new farm production, water resources and sanitation systems, and led directly to the formulation of development proposals for the area in 1985.

The main recommendations of the development proposals, formulated in conjunction with elected development committees and interested groups in the area, was that there was a need to commence implementation in the form of a pilot project and to continue research, monitoring, and evaluation.

After a slow start, occasioned by the need to gain the confidence of the local community, considerable progress has been made in the past two years. The establishment of a nucleus of a rural service center at a strategic location in the area has undoubtedly contributed greatly in this regard. The service center now plays a central role in the project as it provides a venue and organizational/coordination forum for the supply of services to 19 different local interest groups, including one concerned with water resources and sanitation development in the area. These interest groups presently have an active membership of 413, representing approximately 18% of the households in the 23,000 ha project area. The rapid increase in the number of households actively participating in the various aspects of the project over the past two years has exceeded initial expectations.

The primary objective of the pilot project is to facilitate the bringing together of the different components of the proposed developments (some of which were tested initially in isolation from each other in the precursor trials and demonstrations) on an integrated basis, and on a manageable scale which will facilitate maximum local participation and control, and lead to long term sustainability. The pilot project is, in essence, a rural laboratory in which further action research is being or will be conducted. In addition to on-going monitoring and evaluation of the initial demonstration and pilot project units, various Institute researchers are carrying out and will carry out other investigations in the area (for example, energy supplies, agroforestry, and social and environmental impact assessment).

The pilot project is beginning to serve as a core of development which is intended to be expanded in a gradual and orderly manner until overall development within the whole project area is achieved. This will include the development of adequate and sufficient local organizational and institutional capacity to control and direct the long-term development of the project. The development systems evolved and tested there are already being applied (with appropriate modification) in other projects in which the Institute is involved. Numerous requests for information and guidance from individuals, interest groups, non-government, and government organizations further afield also indicate that other long-term objectives of replicability and wider application are beginning to be achieved.

2.2 Development of Regional Policies for Water Resource Utilization in KwaZulu

A water resources policy for a less developed rural area should be the product of a process of decision making within a community, giving rise to a framework which facilitates equitable allocation of resources and adequate management of system infrastructure, and which accounts for future needs and further development. An additional requirement is that the policy should be flexible enough to allow for adoption at a local level, but sufficiently resilient to be a prototype for other regions.

In the Institute's water policy research project, a system for water resources planning and management is being examined for the Biyela area referred to previously. An appropriate policy relates to the evaluation, regulation, control, distribution, and optimum utilization of runoff and groundwater, with the emphasis being placed on maximizing human and economic development under sustainable systems. Thus, it is an integrated process involving not only the present supply and demand for potable and irrigation water, but a projected demand which must take cognizance of future development within the catchments under study. As demand increases, an assured water supply becomes less of a certainty and hence the necessity for catchment planning and water supply management which occurs within the context of integrated rural development.

One of the products of this study is the construction of a computer simulation model for catchment planning that can predict stream and groundwater flow. Because it can also account for abstraction, it can also be used in strategic planning. As an extension of the computer simulation model, a decision support ("expert") information system is being established to facilitate the rational development and allocation of water resources. It is the first time that such an approach has been undertaken for the development of rural water supply (domestic, agricultural and small-scale industrial use) in Southern Africa.

2.3 Preparation of Rural Area Water Plan for the Umgeni Catchment

The preparation of a rural area water plan for one of the major and most densely populated catchments in KwaZulu is being undertaken by the Institute in close collaboration with the regional planning authority. To prepare the plan by the end of 1990, the Institute aims to:

- Prepare a geographic information system as a decision support tool to guide key decisions concerning the supply of water to the rural areas of the region surrounding the Umgeni catchment.

- Interpret the policies of all development agencies active in the region insofar as their impact on the supply and demand for water in the rural area.

- Review the technologies available for water supply, as determined by the Institute in its water and sanitation technology transfer project, and evaluate their relative usefulness with respect to particular rural areas.

- Relate the data on demand for water to the supplies (determined from socio-economic and geohydrological surveys, respectively).

- Provide an understanding of how to manage community water schemes with particular emphasis on cost recovery.

- Identify the skills required by each scheme along with the prerequisites for learning such skills.

- Review the available approaches to funding rural water schemes and provide recommendations on the most appropriate approach for specific situations within the water supply region.

- Prepare a strategy for the implementation of the rural area water plan recognizing the crucial importance of involving communities in the process from the initial design through the construction and management.

- Recommend the most suitable information system for maintaining the plan up-to-date.

2.4 Rural Water and Sanitation Technology Transfer Project

This project consists of a number of sub-projects as follows:

Technology transfer (low technology)

Attention is being directed to the design, testing and demonstration of: (1) ultra slow sand filters; (2) galvanized rain water tank restoration; (3) spring water development; (4) improved ventilated pit toilets; (5) pit toilet additives (to dissolve solid material); and (6) low cost building methods (e.g. using the Lassack Easy Builder).

Technology transfer (high technology)

An evaluation is being made of: (1) hydraulic ram and solar-powered water pumps for use in small-scale irrigation schemes; (2) dry system toilets; (3) low-cost flush system toilets; (4) low-cost water reservoirs; and (5) water purification using flocculators and/or in-line chlorinators.

Mpumalanga community water resources development project

A rural community in KwaZulu is being assisted to test a wide range of pumping systems to take water from a river to community vegetable gardens so that the people can themselves determine which system best suits their needs.

Nsongeni water resources development project

The Nsongeni community in KwaZulu requested assistance in developing a nearby river as a source of water for domestic use (standpipes) and for a variety of agricultural and other undertakings. In close consultation with the local development committee, a small-scale water resources development plan is being drawn up for the area which includes a detailed cost/benefit analysis of the various options.

3. Guiding Principles for Small-scale Water Resources Development in Southern Africa

Based on the experience of the Institute of Natural Resources in its various water resources development projects, it is important to pose the question: "what works, how, and why?". Moreover, to transform the evaluation from a research exercise into a practical tool, a further question that needs to be asked is: "how can future work benefit from the answer?". Some of the lessons learnt from Institute projects have been used to formulate a number of guiding principles relating to small-scale water resources development as follows:

3.1 Planning

Integrated rural development is a systems concept - a multi-sectoral, multi-faceted planning approach to solving the problems of an area. Integration of the low-income elements of the population in the production process, coordination of different government departments and institution-building activities are all part of the concept. Rural development depends on many factors: health, education, agricultural development policies, water resources and sanitation development, nutrition, social stratification, ownership of means of production, access to production inputs, the industrialization process and policies, etc. Moreover, these factors themselves vary widely over time and from one country or area to another (UNITED NATIONS, 1979; MELICZEK, 1985; BEMBRIDGE, 1988). There is, therefore, no single feasible, optimal or politically desirable set of strategies and policies that can be prescribed as the best solution applicable to all or even most developing areas. However, an attempt can be made to identify the most fundamental factors that influence the style and pattern of rural development, and the main elements required for successful rural development, as follows:

- An improvement in the quality of life of rural people. This implies the involvement of the people in the development process and requires their participation in the decision-making process and the implementation of those decisions through village and district level organizations, interest groups and other forms of group organization.

- The mobilization of the energies and resources of the rural people themselves, to increase both their productivity and their self-reliance. Such mobilization requires the formation, adaptation and strengthening of community structures.

- The provision for basic services and infrastructure (in rural service centers) as a part of rural development programs; these can in fact be regarded as a starting point for them. The services provided include social (health, education, administration, legal and community); extension (agricultural and general) to encourage people to introduce technical changes in production and the development of water resources, sanitation, etc); and commercial (distribution of production inputs and marketing of produce). In addition, rural service centers can function as the main loci for the dissemination of external influences to the majority of the populace. In many parts of Southern Africa, such centers are important nodes in an otherwise dispersed population pattern and they provide important social, commercial and administrative functions for the rural population. Planners must be aware, however, that the distance-decay rates can be particularly sharp as most people are limited to travelling on foot, and that concentration on places rather than on the people within them can have unfortunate long term consequences (TAYLOR, 1972).

- A national policy and strategy for action on rural development, together with supporting national, regional, and local services and adequate financial support.

- A strong national level planning and development organization to facilitate coordination between departments, parastatal and other organizations.

- A decentralized effective administrative organization at the regional and local levels to coordinate the activities of departments, the private sector and other organizations operating in the various target areas.

- Introduction of rural development projects initially on a small-scale, with the idea of replication on a national scale.

- Human capital investment, particularly in the form of education which is so essential for building self-reliance, and creating and strengthening the capacity to participate in planning and making decisions.

The form of rural development institutions has to be adapted to both the social and economic requirements of rural communities. Organizations and institutions need to be viewed as a dynamic concept involving continuous decision making, planning and evaluation (KAHAN,1986). Success depends primarily upon rapid expansion of opportunities for productive employment both within and outside agriculture (JOHNSTON and KILBY, 1974) as well as provision for basic needs on a participatory basis.

At the more specific level of small-scale water resources, planning should include:

- Resource analysis
- Catchment planning
- Regional water resources policy formulation
- Financial planning, with emphasis being placed on the need to avoid hand-outs
- Reconciliation of the possible conflict between the need for increased use of groundwater and major construction programs utilizing on-site sanitation systems, particularly under certain hydrogeological conditions. Without an integrated approach, and without adequate design and construction, the extensive use of unsewered disposal systems may cause severe groundwater contamination. This may expose people to the risk of disease, and thus reduce the anticipated health benefits of providing water supply and sanitation facilities.

3.2 Delivery

What the people interested in improving their water resources really require from scientists and technologists are methods and equipment which are cheap enough so that they are accessible to virtually everyone, suitable for small-scale application, and compatible with man's need for creativity.

It is necessary to draw a distinction between technology and technique. Technique is that set of tools and knowledge that comprises the production possibilities of the individual and the collective. By way of contrast, technology is a combination of technique and of institutional arrangements. When we talk of "rice technology" in Asia, we are speaking not only of a set of machines, seeds, tools, and knowledge about how to combine labor, land, and water with these physical objects, we are also implying a particular set of institutional arrangements that defines land use patterns, water control practices, marketing opportunities, labor opportunities and obligations, and the diet of the people (BROMLEY, TAYLOR and PARKER,1980). This is technology.

Much of what is done in the name of development is a process of introducing *new techniques* - seeds, machinery, ditches, water pipelines - but not *new technology*; the hardware but not the software. It is apparent that new techniques are readily adopted if they fit into the existing institutional structure, and if the losses of important participants in the rural community are not severe. But it is the possibility of loss that creates a certain resistance at the local level in terms of the advantages and disadvantages that flow from the prevailing structure of choice sets. The prospects of a new configuration of advantages creates tension within the local setting.

3.3 Management

Coordination between government departments in concepts and actions is enormously complicated by sectoral functionalism. Non-government organizations appear to have the greatest success in establishing close ties with rural communities but there is often very little coordination between them. In theory, external cooperation should be coordinated by the government but in practice this goal is not easily achieved particularly because the agencies are frequently competing for grant money.

Rural development is most often viewed as a sectoral activity or agriculture "plus", and departments of agriculture are frequently treated as the primary agencies responsible for rural development, including water resources development. In view of the fact that increased output is a prerequisite for rural development, such a predominant role for these agencies is understandable. This should not lead, however, to the neglect of other aspects such as basic education, water resources development, rural health, housing, public works or small industry projects which are equally germane to rural development.

Many projects are implemented with only a superficial knowledge of the area and community concerned. Even such basic information as the land tenure system, farming system, local power structure, and local organizations is frequently absent. Projects often do not distinguish between the various social groupings and expected beneficiaries are most frequently identified as "the rural population", "villagers" or "farm families". Whilst knowledge of the local community is critical, the utilization of the talents and energies of the local population in managing any new developments is also important and may, in fact, open up income earning opportunities for some people.

As far as project performance is concerned (in terms of administrative, economic, and technical effectiveness at the level of the rural community), the local people are obviously in the best position to give an opinion on this aspect and should be involved in the evaluation process. Accordingly, a community monitoring component should be developed in the implementation phase.

4. Conclusions and Recommendations

The introduction of new **techniques** is sometimes blamed for project failures but this argument misses the point strongly emphasized in this paper: that it is the selection of the most suitable type of **technology** under the given conditions that is crucial. The term technology includes not only the particular technique (for example, water delivery through standpipes) but also the institutional organization (local, regional, and national) that ensures that the technique is the right one for the area, that the new system is effectively managed and monitored, and that the development is integrated and compatible with other essential elements of rural development.

This concept of rural development as a process has determined the scope and structure of this paper. Although one of the most urgent needs in the rural areas of many developing countries is for safe drinking water and for waste disposal facilities, no attempt has been made here to present detailed guidelines on specific interventions. Instead, a way of looking at *small-scale water resources development as one element of rural development*, which encompasses so many activities, is presented. The Institute of Natural Resources has found in its project work that this approach is the most effective means of ensuring the success of water development schemes.

It is unfortunate that, for planning purposes, rural life has been broken up into the sectors that form the basis for administrative compartmentalization and technical specializations. Whenever any activity or intervention for rural development is designed, the interlocking nature of these sectors should be considered in order to determine how the activity may be affected by conditions in other aspects of rural life (and which will, therefore, influence the design of the objectives, the plan of work, the resources to be used and the assumptions on which the validity and feasibility of the activity rest) and how the activity affects aspects of rural life to which it does not directly address itself.

In the project planning process, it is important to: (1) understand what rural dwellers really feel and want; (2) recognize that rural people will not spontaneously become experienced managers, accountants, mechanics, etc, without adequate and sustained training; (3) not assume a higher degree of training, motivation and managerial skills in the public service than actually exists (government services in most developing countries are weak due to the scarcity of experienced senior staff, low educational levels of intermediate staff and lack of revenue to pay salaries); and (4) realize that local people are often the only experts on the specific processes and problems affecting their areas.

Rural development is an integrated process because of the nature of the rural community: low levels of specialization; absence of separation between economic and non-economic interests; importance of group obligations and responsibilities; combination of vertical functions and horizontal stratification in the society; and, above all, the integration of problems imposed by poverty at the margins of survival, where even a small change brought about by a "sectoral" intervention may threaten the precarious balance. Also, the sectoral elements of rural development are mutually reinforcing. Our research findings confirm the close links between health, nutrition and fertility; between education, migration and settlement patterns; between technology, employment and their relationship with forms of agricultural and industrial development; between climate, natural resources, energy and environmental factors. Cutting through most of these sectoral considerations are patterns of wealth and income distribution and the effects of rising incomes, savings, and investment opportunities. It is not a question of recognizing abstract relationships between the sectoral aspects of rural development, however, but of understanding how these aspects in fact operate in any particular situation - how they affect the rural community and respond to its changing requirements. The introduction of a new technique or service will influence some elements of rural life more than others; it is essential, therefore, for the development process to consider all elements as an integrated whole.

References

BEMBRIDGE, T.J. (1988) "A proposed institutional framework for successful rural development in less developed rural areas of Southern Africa", Development Southern Africa, 5(1):23-39.

BROMLEY, D.W., D.C. TAYLOR, and D.E. PARKER (1980) "Water reform and economic development: institutional aspects of water management in the developing countries", Economic Development and Cultural Change, Vol. 28.

JOHNSTON, B.P. and P. KILBY (1974) "The design and implementation of strategies for agricultural development", Agricultural Administration, 21:165-197.

KAHAN, D. (1986) "Institutional development: some lessons from the experience of Israeli technical assistance in the setting up of Moshav multipurpose co-operations", Agricultural Administration, 21:135-146.

MELICZEK, H. (1985) "Issues and trends in rural development", In Land Reform, Land Settlement and Cooperation, Food and Agriculture Organization of the United Nations, Rome.

QUINN, N. (1989) "Biyela water policy", Institute of Natural Resources, Pietermaritzburg.

TAYLOR, D.R.F. (1972) "The role of the smaller urban place in development: A case study from Kenya", African Urban Notes, 6:7-23.

UNITED NATIONS (1979) Rural Development, United Nations Development Programme, New York.

Community Participation in Water Supply and Sanitation Programs: South African Experiences over the Decade

Safira B. Mogane
Project Leader
Division of Water Technology
CSIR
Pretoria, Republic of South Africa

Abstract

This paper describes four participatory approaches adopted by organizations in South Africa to improve water supplies in developing areas. However, emphasis will be laid on the author's approach based on her involvement with a research organization as exemplified by a recent community water supply project in Ndwedwe, a village near Durban. The four approaches are briefly thus:

Government departments mainly employ the labor-intensive participatory approach to water supply development projects. Although local people benefit both in terms of employment and potable water, they have minimal say as far as the choice, planning, and decision-making are concerned. The rhetoric of community participation is described.

Parastatal organizations, unlike government departments with maximum bureaucracy, are more flexible in their participatory approach. An example of how parastatal organizations manage to involve communities in water supply projects through tribal authorities and villagers is discussed.

Non-governmental organizations (NGOs) are most effective in implementing small-scale water supply and sanitation schemes in this country. Through their direct involvement with communities, they manage to plan, establish development committees and implement projects with reasonable success. However, efforts of these organizations are often hampered by lack of sufficient funds to cover larger geographical areas. A critical analysis of one NGO's approach is outlined.

Research organization: A socio-technical approach to improve village water supply and sanitation schemes is described. An analysis of the community's response to project proposals, obstacles and deficiencies encountered throughout the project phases including institutional aspects, voluntary labor, funding and training of maintenance officers is made. Lastly, the "ingenious" way that the community came up with solutions to problems encountered is also highlighted.

1. Introduction

In recent years there has been a shift in emphasis on the development of water supply and sanitation programs. Since the devastating drought and subsequent cholera outbreak of the early eighties, the human factor has rapidly gained momentum among development agencies in South Africa. An essential premise of this shift is the realization that a lot of project failures have hampered development programs which lacked social information. In the past, emphasis was laid on both the technical and financial aspects, and less often on social considerations of water supply programs.

In this paper, four participatory approaches adopted by organizations in South Africa to improve water supplies in the rural areas are outlined. However, more emphasis will be laid on the author's approach based on a community water supply project in Ndwedwe near Durban.

2. Approaches of South African Organizations towards the Improvement of Water Supplies

2.1 Government Organizations

Prior to the International Drinking Water Supply and Sanitation Decade (1981 -1990), rural water supply has been the sole responsibility of the Department of Agriculture and Forestry throughout the country. Through this department, the Government has been providing boreholes and windmills in communities where surface water is limited or absent. However, some states in the country have been given autonomy in the management of their administrative affairs. This has led to the creation of several Departments of Water Affairs and Agriculture which are now responsible for the provision of water in these states. Except for the installation of boreholes, no further water supply improvements were made in the rural areas. Studies undertaken countrywide during the course of the decade indicated that approximately 60% of boreholes installed in these areas are defunct and some are under-utilized. Clearly, the major concern of planners/government was coverage rather than continued functioning and utilization of facilities (CHANDLER, 1986). Planners were basically concerned with quantity of boreholes supplied for an area and cared less about the people who were to benefit from these projects. Therefore, the imposition of predetermined ideas and programs characterized the kind of assistance offered to rural communities. As a result, people tended to distance themselves from projects they regarded as the Government's and not theirs. In some areas this case still holds (MOGANE, 1987).

Ever since the inception of the water decade, all development organizations began to recognize the fact that in the development process, people should come first. The acute unemployment rate and the devastating drought of the early eighties left most rural communities poverty stricken. Therefore, the Government allocated special funds for job creation. Through the labor-intensive approach, people in the villages where facilities are to be installed are being employed to do some menial work in order to earn a living. The current trend in most national states is of implementing the regional water supply schemes that involve transporting bulk water to the edge of the village. In this case, people in the village are being employed to provide labor to dig trenches for the pipelines. The advantage of this approach is that money that is being injected into the community results in the improvement of living standards. Therefore, short-term benefits are being derived from the labor-intensive projects. However, the fact that it provides a one-off construction job may be disruptive to the community.

Due to the bureaucratic nature of the Government and the fact that it is responsible for larger-scale water supply schemes, genuine community participation in the choice, planning and design of projects is often impossible. However, most Government authorities are trying to move more and more in this direction. Moreover, the Development Bank of Southern Africa, emphasizes the need to involve user communities in projects that are aimed at improving their own lives. It is, therefore, hoped that with time, the participatory approach will improve.

2.2 Parastatal Organizations

There are only two parastatal organizations involved in integrated rural development in the independent states of South Africa. An increasing interest of these organizations in rural development has helped to reduce poverty in most communities in developing areas.

Unlike Government organizations with maximum bureaucracy, parastatals are more flexible in their participatory approaches. For example, the Thusano Foundation (Drought Relief) was established in 1984 and is responsible for the creation of job opportunities, providing water where necessary as well as other relief services. The Thusano's approach is based on a broad spectrum development, but as it operates in Bophuthatswana which is the dry area of the country, the provision of improved water supplies forms an important part of its development strategy. This organization is tapping a huge reservoir of informal skills at the local level to build water storage tanks, pit latrines, schools, clinics, community halls and tribal offices as well as to establish food gardens. In addition, it drills new boreholes, repairs defective ones, and constructs small water reticulation systems.

The Thusano believes in the active participation of communities in choosing, planning, and implementing projects. The organization enjoys a sound cooperation of the tribal authorities. Through supervisors employed and trained by the Thusano, the communities are able to identify their needs, prioritize these needs and help implement them.

The only disadvantage with this organization is the fact that local people are not being trained to maintain their water schemes. As a result, communities have to wait for weeks before their defective boreholes could be repaired. Delays in repairing the boreholes are partly due to the lack of transport, particularly to remote areas, as well as the busy work schedules of the maintenance team. However, concerted efforts are being made to establish maintenance teams throughout the Thusano's area of operation.

The Transkei Appropriate Technology Unit (TATU) is also involved in integrated rural development. This unit started in 1982 with the objective of promoting appropriate technology in fields such as housing, agriculture and water supply. Transkei is blessed with small water sources like springs and perennial streams from aquifers which are easily harnessed for domestic water supply and small-scale irrigation. Through financial assistance from the Department of Agriculture and Forestry, TATU pursued the Rural Initiative Water Program (RIWP) that mainly involved:

- spring or stream fed village water supply
- garden irrigation schemes
- boreholes with handpumps
- hydraulic ram pump and windmill applications
- stock pond for animal use.

TATU initially advertised the use of protected springs for small gravity-fed rural water supply schemes by constructing a number of these schemes in various parts of Transkei with little contribution from the communities. Having established the viability and created the awareness, the TATU then responded to applications and requests for such schemes from communities. Through RIWP, communities provided cash, labor, maintenance responsibilities, and their hospitality, to provide themselves with water. The program has interacted with over 140 communities or wards within the three years of its existence. By the end of May 1987, 127 projects had been registered and a lot more projects were underway. Through the RIWP many people in the rural Transkei have access to potable water (WULINGMINGA, 1987).

2.3 Non-governmental Organizations

Over the past decade, there has been a rapid growth in non-governmental organizations' (NGOs) involvement in the development of rural communities in South Africa. The appalling social conditions characterized by malnutrition, endemic diseases, high infant mortality rate, and low life expectancy were the main reasons for the NGOs' increasing interest in rural development. In contrast to the "top-down" blueprint approach, the NGOs use the "bottom-up" approach. The NGOs believe that the poor know what they want and are capable of taking appropriate action towards the solution of their problems. These organizations encourage dialogue, mutual consultation with user communities at all stages, democratic decision-making and local control over project activities (MIDGELEY, 1986). As a result of this approach, the NGOs' projects are self-sustaining. In most cases, the user communities tend to develop a sense of ownership, responsibility and pride for the projects.

There are several NGOs involved in the improvement of water supplies in South Africa, such as World Vision, the Valley Trust, Springs Ministries, Africa Co-operative Action Trust, among others. Although their approaches are not identical, they follow similar lines. A brief description of the Valley Trust's approach is given below.

The Valley Trust was started in 1951 and its main objective is to promote health among the Zulu people living in the Valley of a Thousand Hills near Durban. The approach of this organization is based on a broad spectrum philosophy of primary health care which emphasizes the link between health, nutrition, water and sanitation. One of the Trust's objectives concerning water and sanitation is to help the rural people to improve their democratic organizational skills to enable them to manage their own basic needs infrastructure. The Valley Trust believes in appropriate technology for development, and it has designed a triple purpose, reusable mold made of corrugated iron and used to build ferrocement roof tanks, a spring protection reservoir and the superstructure for pit latrines (MANN, 1985). In 1980, Dr. Friedman, the director of the Valley Trust, initiated the idea of spring protection with a view to improve the quality and quantity of water supplies for household and agricultural purposes.

Initially, because of inexperience, the Trust did not involve the community in the spring protection project. As a consequence, they experienced difficulties from the lack of cooperation and sense of ownership of the protected springs by the households concerned. In order to stop this imposition of projects on the intended beneficiaries, the Trust encouraged the formation of spring associations. A technician from the Valley Trust will first assess the potential for spring protection by inquiring from identified reliable members of the community using the particular spring whether it is perennial or whether it dries up in the dry season. Should the latter situation prevail, then spring protection is not done. If the spring is perennial, then the technician will indicate the willingness of the Valley Trust to help in protecting it. However, this is done on condition that the people around the spring are willing to organize themselves and form a spring association, elect a committee, appoint a maintenance officer, adopt a constitution and open a savings account to deposit a nominal fee for the maintenance of the spring. The spring association must invite the technician back if they wish the Trust to help in protecting the spring, otherwise, the Trust will not involve itself. As a result of this approach, no vandalism has been reported.

The Valley Trust also assists communities in the establishment and monitoring of Village Development Committees. These committees are responsible for bigger development projects such as piped water, electricity, roads, rainwater tanks and ventilated improved pit (VIP) latrines. The development committees are elected by the local people and their constitutions approved by their tribal authorities. The tribal authorities retain the right to veto decisions, but do not involve themselves directly in the committee's functions.

Through the development committees, the communities identify their needs as well as prioritize them. In order to build rainwater tanks and VIP latrines for individual households, each development committee employs a two-man team which is trained at the Valley Trust to do the job. The

Committee owns two molds, the necessary tools and also administers the rotating credit fund. If a member of the community needs a tank or VIP latrine, an application is made to the Committee and a R50.00 deposit is paid. The tank or toilet is then constructed and the construction team is paid for their labor by the Committee. The applicant pays the balance of the construction costs to the Committee in installments.

However, it has to be recognized that with all their apparent advantages, the impact of the Valley Trust and other NGOs is geographically limited because they operate on a small scale.

2.4 Research Organization: A Socio-technical Approach

2.4.1 Introduction

In his message to all South Africans involved in rural development, SWANEPOEL (1988) warned: "Make do with what you have. That does not mean that we should leave the rural people in the lurch, but it means that our scarce resources should be applied with wisdom and foresight; that we should stop building bureaucratic structures and start addressing the real problems; that we should control our grandiose ideas, stop spending money on projects with high political visibility and rather get our priorities right; and that we should stop the terrible waste through duplication". In short, this is the prevailing situation as far as rural development (including water supply) in South Africa is concerned.

In a bid to develop appropriate guidelines for improvement of water supply and sanitation programs throughout the developing areas of South Africa, the Appropriate Technology Program of the Division of Water Technology has set up an objective of undertaking pilot projects to demonstrate the intrinsic value of appropriate technologies as well as the people-oriented approach to rural development. Our approach is based on the current international trends on water supply which have been successful in other developing countries. The social wing of our team maintains contact with the community and relays findings to the technical design team so that the final product is adapted to the requirements of the particular community. It is on this point that I now turn to the brief discussion of a case study which uses a socio-technical approach to water supply in the KwaHlophe rural ward, Ndwedwe near Durban.

2.4.2 The Study Area

KwaHlophe is a small rural settlement which lies about 80 km northeast of Durban. It is located in a high rainfall area of the Ndwedwe district in KwaZulu, Natal. The ward has a mean annual rainfall ranging from 850 and 1,300 mm and mean annual temperatures of 17.5 - 20°C. Much of the land is at an altitude of 450 - 900 m and falls within bioclimatic group 2, which is coastal hinterland.

The topography of the study area is generally steep and rugged with the flatter terrain largely confined to the crests of hills and the valley bottoms. Rivers and springs abound although irrigable land is, in general, scarce. Soils are extremely variable and erosion is an ever-present hazard especially on the sloping areas. The range of possible land uses is wide with potential for expansion into forestry, pastures, vegetable gardens, etc.

The community is culturally homogeneous and is predominantly composed of the Hlophe and Cebekhulu clans. The ward is settled by 2,065 people (Population Census, 1985) with an annual growth of approximately 3%. The major sources of potable water are the unprotected springs in summer and rivers during the dry season.

Based on the topography of the area and for ease of reference, it was decided that the area be divided into four regions A, B, C and D with each one representing a watershed.

2.4.3 Background and Events Leading to Implementation

Towards the end of 1988, the Ndwedwe Development Council initiated a project involving both the Umgeni Water Board and the Division of Water Technology. The Ndwedwe Development Council is responsible for the coordination of all developmental activities in the tribal district known as Ndwedwe. The two main objectives of the project were:

- To upgrade the water supply and sanitation situation in the KwaHlophe ward and,
- To draw up guidelines which could be translated for use in other areas of the region.

In January 1989, a chain of events started when contacts with the tribal authority and other community leaders were made to negotiate as well as establish their interest in a project of this nature. Both the tribal authority and leaders were unanimously in favor of the project. Therefore, the team was given the green light to go ahead with the socio-technical feasibility study. Meanwhile, the chief agreed to inform all his councilors and the community about the proposed project so they would cooperate with the research team in undertaking the survey.

A socio-technical feasibility study was undertaken to assess the potential for the community to become involved and accept responsibility for upgrading their own living conditions on a community basis, as well as to assess the water resources available locally. Using an interview schedule, a sample of just over 30% of 500 households, primarily adult women were interviewed. Interviews were carried out by the author with the assistance of four local agricultural extension workers and one public health worker who were trained nominally in social science techniques of gathering data.

Subsequently, a community meeting was held wherein the proposed project was formally introduced for discussion. The community's response to the project proposal was quite optimistic and encouraging. As a result, a representative water committee was elected. The research team promised to report back the findings of the feasibility study in another formal meeting.

The socio-technical feasibility study revealed that the community lacks access to safe and convenient water supply and sanitation. Therefore, the community expressed an interest in working together and contributing towards improving their situation. Either of three methods could be used to achieve this objective. In the first option, 16 springs could be protected. A gravity-feed reticulation system was designed for 12 of these to cover the entire area. In the second option, regions A, B and C would still rely on spring protection systems as in option 1, however, a small dam needs to be built in region D. The water would be pumped to two reservoirs from which it would then be gravity-fed through two respective networks to supply the whole region. The third option is similar to the second but the only difference is that the source would be boreholes from which water could be pumped into the reservoirs.

In May 1989, the results were presented to Umgeni Water Board, which was the main sponsor for the discussion. The viability of the third option was discussed but was decided against as no one was sure if there would be enough underground water. Therefore, in the subsequent meetings with the Water Committee and the community, the first two options and their financial implications were presented. The unanimous response of the community was in favor of the second option. Arrangements were made for the initial payment of R30.00 per family in three monthly installments to the Water Committee. The community was enthusiastic to the extent that some families started paying at the meeting. The people who would be trained on-site to maintain the system were selected and it was agreed that implementation should start at the beginning of August.

As planned, project implementation started at the beginning of August with the spring protection in region C. The problems that arose at this stage were the lack of male laborers or selected maintenance officers. Only women and children from region C turned up to provide voluntary labor. Another major problem was that the Water Committee seemed to be non-existent or defunct. However, the women in region C were quite enthusiastic and construction continued.

In the light of new developments that emerged on the project, intervention became necessary. Therefore, the team decided to convene a community meeting with the general aims of:

- reorganizing and negotiating an appropriate strategy and getting the community to suggest solutions to pertinent problems;
- clearly defining the roles and responsibilities of different groups involved in the project.

Prior to the meeting, informal discussions were held with the various community groups to gauge their feelings about the whole project. This was done as it had been felt that opinions gathered in meetings might not be truly representative because some people are not able, for one reason or another, to speak in public. The response from the interview of four groups of women and a few men were almost identical. Everyone agreed it was a good and commendable project. The lack of male labor, particularly during the week was due to migrant labor. The women had no problems about providing labor but they felt that it would be impossible for them to dig deep trenches. Therefore, men would have to be present for that chore.

A meeting was also held with the Water Committee to discuss all pertinent problems and the roles of all participating groups in the project. It was established that two members of the Committee found jobs elsewhere, and therefore, needed to be replaced. The problems pertaining to the project that needed to be addressed in the community meeting included:

- slow payment
- low labor turnout
- maintenance officers
- general perceptions.

At the community meeting, it was unanimously agreed that women be elected as maintenance officers since they are the people available throughout the process of spring protection, they have shown the most interest, they are the ones who would constantly use it. The remarkable development was the ingenious way the community came up with a solution to the labor problem. Young male members of the community who are migrant workers suggested that they should have access to the tools over the weekend and be allocated some work so they would be able to honor their obligation. Despite the fact that payment is still slow, the project is progressing fairly well at the moment.

3. Conclusion

Undoubtedly, progress has been made on beneficiary participation in rural development, particularly by the NGOs. This concept has become a bandwagon among Government authorities throughout the developing areas of South Africa. The main obstacles to achieving success in community participation is the lack of a national policy, central planning and programming of water supply and sanitation schemes. Rondinelli and Ruddle (SWANEPOEL, 1985) stated that national planning must indicate a centralized direction and course for the realization of national policy objectives, at the same time permitting a considerable degree of decentralized policy. However, decentralization needs to take into account local potential and constraints and the need for central control to foster national integration (SWANEPOEL, 1988). Therefore, there is a great need for an integrated approach among the national and independent states as well as the South African Government. In addition, there is also a need for political commitment to increase greater beneficiary involvement at all stages of water supply and sanitation projects.

References

CHANDLER, C. (1986) "Achieving success in community water supply and sanitation projects", Waterlines, 5(2):2-6.

MANN, C. (1985) "Water and sanitation projects", The Valley Trust, South Africa.

MIDGLEY, J., A. HALL, M. HARDIMAN, and N. DHANDAUL (1986) Community Participation - Social Development and the State, Methuens & Co., New York.

MOGANE, S.B. (1987) "Rural water supplies in S.A. - sociological implications", Journal for Housing in Southern Africa, June.

SWANEPOEL, H. (1988) "Rural development - the path to a better quality of life for rural people", International Conference of Population Development in Southern Africa, Department of Health and Population Development, Johannesburg.

Acknowledgements

I wish to acknowledge the opportunity afforded me by the Divisional Director, Dr. B. M. Van Vliet and the Appropriate Technology Program Manager, Mr. I. A. Pearson for the encouragement and valuable criticism of my lengthy paper. A special word of gratitude is due to my research team for the support.

Towards Sustainability: The Application of a "Resources Coverage" Approach to Community Water Supply and Sanitation in Southern Africa

Fabiano Kwaule
Water Coordinator
Ministry of Works
Republic of Malawi

M. Seager
Program Officer
IRC International Water and
Sanitation Center

Abstract

This paper describes some first applications of a draft set of international guidelines on resources coverage/cost recovery for community water supply and sanitation.

It first summarizes what the international guidelines are all about, how they were developed and the approach to sustainability they describe. A summary is given on how the guidelines were first used in the Southern Africa sub-region in a three-country activity in Western Province, Zambia.

The main part of the paper goes on to describe how Malawi has taken a lead in organizing a series of activities around this approach. These include a National Workshop and a series of field studies, recently completed, supported by funding from the Netherlands Government. In carrying out the field studies, a multi-disciplinary team from several national agencies worked with local staff and user communities to study four existing projects from the viewpoint of sustainability. Using a questionnaire developed from the guideline approach, the team came up with some interesting conclusions about the potential for long life, use and impact of the various schemes, and how this potential could be strengthened. Particular emphasis, which the paper reflects, was put on the required resources for sustainability, and implications for the balanced input of resources by both user and agency partners.

The paper ends with plea for further international information sharing and joint work on the different ways of maximizing impact and success of small-scale water supply and sanitation improvements.

1. Introduction

The main objective of this paper is to highlight an ongoing effort by several countries in Southern Africa to promote sustainability through the development and application of the process of "resources coverage".

This approach acknowledges that sustainability is not the result of any one activity. It depends, instead, on the presence and adequate resourcing of a number of essential elements at each stage of the project. Alongside this, the crucial importance of a partnership approach is recognized, where agencies, communities, and households agree on and carry through their responsibilities. All partners need to work together and supply the necessary resources if water and sanitation facilities are to continue to work, be used, and give long-lasting impact.

The country-level work described by the paper has been stimulated by recent international development work on the subject. A number of developing countries and international agencies have come together in recent years, under the auspices of WHO and assisted by IRC, to look at resources coverage and cost recovery issues, as part of an effort to support institutional strengthening.

An approach framework for resources coverage has been produced from this work. It is in the form of guidelines, for further development and adaptation at country level. This paper is essentially an account of such onward work in two countries of the region, Malawi and Zambia.

2. The Draft Resources Coverage Guidelines

2.1 How the Guidelines Developed

Over the past few years, a series of four consultations (IRC INTERNATIONAL WATER AND SANITATION CENTER, 1988/1989) on institutional development have been held under the auspices of the Community Water Supply and Sanitation (CWS) Unit of WHO. The first consultation took up institutional development issues generally, whilst the following consultations focused more specifically on cost recovery. Participants in the four consultations included senior government officials from developing countries, consultants, representatives from a number of international lending, donor and non-governmental agencies, as well as WHO and IRC staff.

During these consultations, work on draft guidelines for cost recovery in community-based projects has progressed. The document "Principles and Models to Achieve Sustainable Community Water Supply and to Extend Household Sanitation" (WHO, 1989) resulted from the Fourth Consultation, held in Geneva in November 1988.

2.2 Objectives

Earlier IRC work had focused on cataloging and giving guidance on fund-raising mechanisms for communities and the agencies who support them (IRC INTERNATIONAL WATER AND SANITATION CENTER, 1987). Rather than concentrating on the financial and economic aspects of fund-raising and cost recovery, the new guidelines, therefore, attempted to describe a broader framework to maximize sustainability and coverage. This would allow fund-raising, cost recovery and related issues to be addressed in context, particularly in situations where the community's inputs can include in-kind contributions as well as cash, and where the agency has an important balancing, supportive role.

The guidelines are intended to be used in the context of rural/peri-urban water supply and sanitation in developing countries. They specifically apply to situations where communities assume partial or full responsibilities for ownership, management, operation and maintenance of completed facilities.

The draft guidelines aim to help find answers to some fundamental questions related to Cost Recovery:

- What should be recovered?
- Why?
- From whom?
- When?
- How?

2.3 Brief Description

The guidelines place major emphasis on the concepts of:

Resources Coverage:	a process by which all inputs and resources required for successful project implementation and its working life are identified, sourced and timed;
Cost Recovery:	where the agency recovers part of or all of its project-related costs from the community;
Cash-Raising:	where the community raises cash from its members to meet financial obligations to the agency and for direct purchases.

These concepts are discussed within a larger framework that stresses **sustainability** and **long-term development**. Fig. 1 (taken from the guidelines) illustrates these concepts and their important inter-relationships.

A fundamental concept set forth in the guidelines is that for both sustainable water supply and extended household sanitation, a number of **key elements** must be in place. These elements relate to both technical and non-technical aspects of a project, and reflect important strengths and qualities that a project must have if it is to be sustainable and extendable in the long term. The "key elements" for both water and sanitation as proposed in the guidelines are presented in Tables 1 and 2.

The important point to note is that each of these key elements have important **resource requirements**, not only during project preparation and implementation, but for many of them, throughout the project's full operational life as well. Moreover, these resources, i.e. cash, labor, skills and materials, must all be found somehow. The process of working out the resource needs of a project, deciding and agreeing how, when, and from whom these are to be secured, is the essence of the "resources coverage" process that the guidelines describe.

2.4 Potential Uses

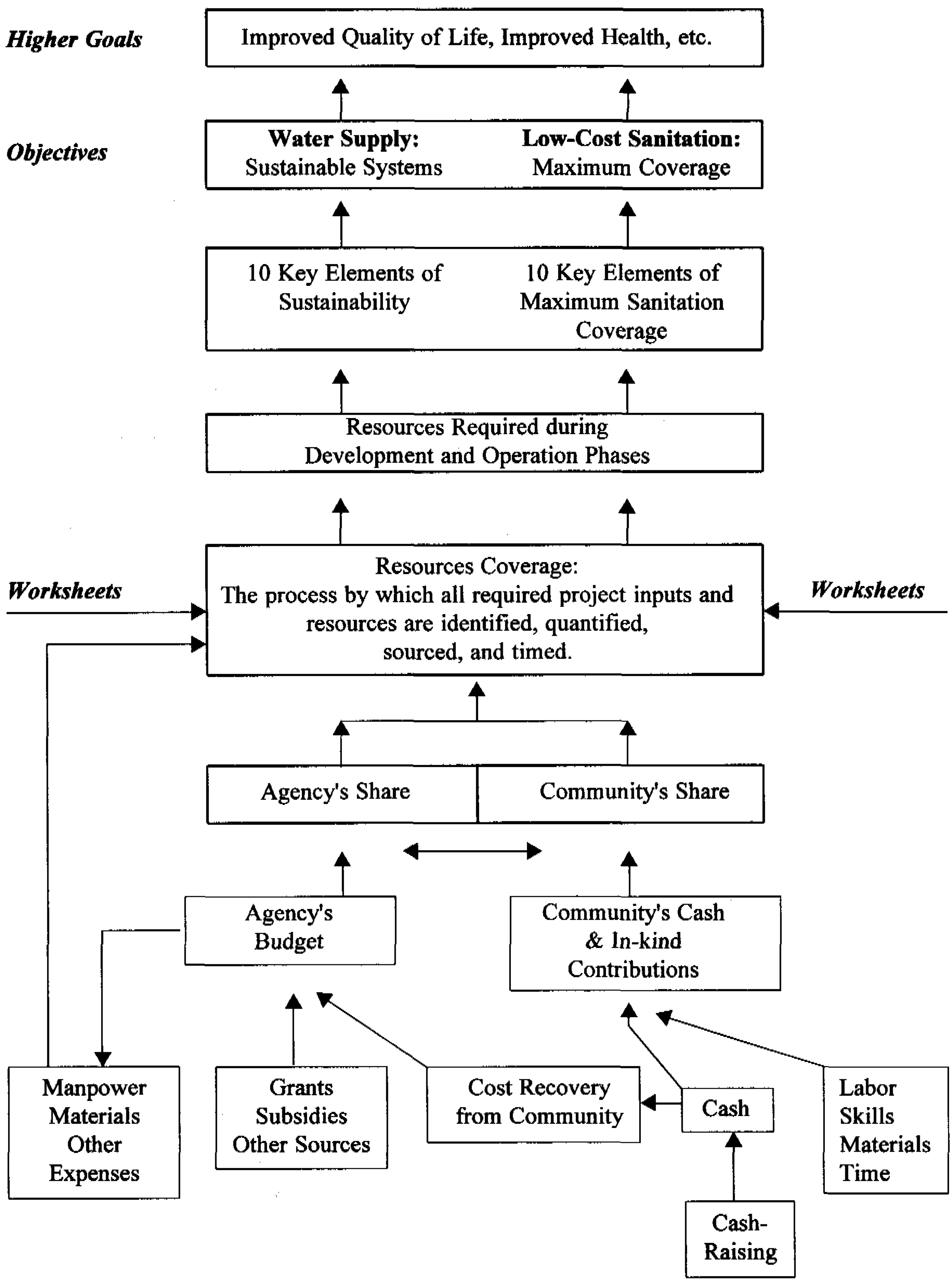
The guidelines aim to provide project planners, implementors and evaluators with some initial tools. These are intended to help them to identify and quantify the major inputs and resources required for successful community-managed water supply and sanitation projects.

The guidelines put forward:

- some basic guiding principles;
- concepts and processes related to the attainment of resources coverage, as a step towards the achievement of community water supply and sanitation development goals;
- worksheets that can be used as planning, monitoring and evaluation tools, in a preliminary or detailed fashion, or simply as checklists.

Possible applications of the guidelines include:

Project Planning -	to identify and allocate the resources and responsibilities necessary to achieve sustainability and extension of facilities.
Project Appraisal -	to check the soundness of project design, specifically to ensure that the resources and responsibilities required for the achievement of sustainability or extension of facilities have been adequately considered.



Acknowledgements: WHO-led Task Force on Cost Recovery
WHO/CWS/89.6

Fig. 1. Sustainability, resources coverage, and cost recovery

Table 1. Key elements of water supply sustainability

KEY ELEMENTS OF WATER SUPPLY SUSTAINABILITY
No. 1 ***Community Institutions*** Strong community institutions and administrative mechanisms - community water/health committees, women's groups, functioning accounts, and financial management systems, etc. No. 2 ***Developed Skills*** All technical and non-technical Community/Agency skills required to successfully implement community-based management and resources coverage. No. 3 ***Supportive Attitudes*** General human attitudes essential for successful achievement of sustainability and resources coverage - understanding, motivation, choice, willingness to assume ownership, management, and maintenance responsibilities, etc. No. 4 ***Community Extension Services*** Important activities - community organization, mobilization and participation, health education (both initial and ongoing), ongoing support, etc. - initiated mainly by the Agency and outsiders. No. 5 ***Accepted Service Levels*** Community understanding, acceptance, and agreement of levels of service and costs associated with water supply facilities being constructed - continuity and reliability of supply, maintenance requirements, ongoing costs, willingness to pay, etc. No. 6 ***Appropriate Technology*** Water supply technology suitable to the given situation. Along with other technical/non-technical factors, willingness to pay should help determine technology choices. No. 7 ***Operational Phase Inputs*** All required operational phase cash/in-kind inputs connected with provision of water supply at agreed-to service levels. No. 8 ***O&M-Related Supportive Systems and Services*** Backup systems and services provided on a timely basis by others outside the community - spare parts, special equipment, technical expertise to carry out major repairs, etc. This element includes Agency monitoring of actual system functioning and performance. No. 9 ***Allocation of Responsibilities*** Formal decisions and allocation of responsibilities for Elements 1 through 8 between the Agency and the Community at the start of the project. A clear joint understanding, acceptance and agreement as to who is responsible for what, when. No. 10 ***Execution of Responsibilities*** Timely execution of development and operational phase responsibilities as agreed to in Element No. 9.

Acknowledgements: WHO-led Task Force on Cost Recovery
WHO/CWS/89.6

Table 2. Key elements of extended low-cost sanitation coverage

KEY ELEMENTS OF LOW-COST SANITATION COVERAGE
No. 1 ***Support from Community Institutions and Local Leaders*** Strong support for health improvement actions by recognized formal and informal community leaders which motivates community members to take action.
No. 2 ***Created Awareness*** Awareness and reinforcement of beliefs amongst individuals and households concerning the benefits of, and the needs for better hygiene and sanitation.
No. 3 ***Involvement of Women*** Communication with and meaningful involvement of women who should be recognized as the prime movers and family-unit opinion-formers for better hygiene and sanitation.
No. 4 ***Household Priority*** Genuine individual/household attitude and desire to construct and use latrines. Priority implies willingness to contribute required cash and/or in-kind contributions.
No. 5 ***Examples of Low-Cost Sanitation Successes*** Positive promotional effects gained by having successful latrine projects to refer to, visit, and learn from.
No. 6 ***Developed Skills*** All technical and non-technical skills required to successfully support financially, implement, and sustain household sanitation schemes.
No. 7 ***Appropriate Technology*** On-site sanitation technology suitable to the technical and socio-cultural conditions of the area. Affordability, acceptability, availability of materials, local soil conditions, locally-known construction techniques, etc. should be amongst the criteria that influence technology choice.
No. 8 ***Community Extension Services*** Health-related activities like health education, monitoring, support, etc., that are initiated, implemented, and followed-up by public sector institutions.
No. 9 ***Allocation of Responsibilities*** Formal decisions and allocation of responsibilities for Elements 1 through 8 between the Agency and the Community at the start of the project. A clear joint understanding, acceptance and agreement as to who is responsible for what, when.
No. 10 ***Execution of Responsibilities*** Timely execution of development and operational phase responsibilities as agreed to in Element No. 9.

Acknowledgements: WHO-led Task Force on Cost Recovery
WHO/CWS/89.6

Project Review - to determine what is going right or wrong during project implementation, as well as to identify the required corrective actions and associated costs.

Project Evaluation - to evaluate project success and performance.

3. Southern Africa Sub-Regional Involvement

3.1 Mongu Working Group Meeting

An Action Plan calling for pre-testing of the draft guidelines to determine their validity for future onward development was one of the outcomes of the 1988 meeting. In response to this, the Southern Africa Sub-Regional Working Group Meeting on Cost Recovery and Resources Coverage was held from January 30 to February 6, 1989 in Mongu, Zambia (GOVERNMENT OF THE REPUBLIC OF ZAMBIA, 1989).

Financial support and resource persons came from NORAD, IRC and GTZ. Participants in the meeting included five representatives from Zimbabwe, three from Malawi, seven from Zambia and three resource persons who had participated in earlier discussions in Geneva 1988.

Mongu in the Western Province was selected as an appropriate venue for the meeting so that the government's WASHE (Water Supply, Sanitation, and Health Education) program, being implemented with NORAD support in Western Province, could be used for small-scale field-testing purposes.

The objectives of the Mongu Sub-regional Working Group Meeting in Zambia were:

- to field test the draft guidelines on a preliminary basis and develop recommendations for further development/improvement of the approach and the worksheets;

- to plan country and sub-regional level follow-up action for:

    - further use/development of the guidelines
    - related cost recovery and resources coverage activities.

3.2 Working Group Meeting Conclusions

Among the conclusions of the Sub-Regional Working Group Meeting was that Cost Recovery can only be viable when the "environment" is right. In other words, there must be political will and genuine government commitment to make cost recovery work within a framework of achieving sustainable coverage.

The meeting observed that work on the issue of Cost Recovery and Resources Coverage was particularly timely, since it was of increasing concern in all three participating countries.

The validity of the concepts contained in the draft guidelines was fully endorsed by all. The guidelines, participants observed, provided a structure and systematic approach to looking at cost recovery and resources coverage issues and concepts. Moreover, they had potential use in a variety of planning and appraisal situations. Participants concluded that efforts to develop, refine, test, and apply the work further should continue.

It was also concluded that the Guidelines on Cost Recovery and Resources Coverage would greatly help in raising consciousness on cost recovery issues in the sub-region and that the guidelines provided useful background and guidance for policy discussions at national and regional level.

Among the recommendations of the Mongu meeting was that the draft guidelines needed to be field tested further at the individual country level. Tentative follow-up activities were thus identified and target dates were indicated by representatives from each of the participating countries.

4. Malawi's Initial Follow-Up Activities

4.1 Action Plan

The follow-up action plans for Malawi drafted at the sub-regional meeting included:

- Sectoral planning meetings to introduce the guidelines;
- Submission/clearing of guidelines to the government;
- Preparation of a project proposal to source the necessary funds;
- National workshop to discuss guideline concepts;
- Field testing of the guidelines;
- Multi-sectoral professional meeting to present field report;
- Report to the government, support agencies, WHO, and IRC.

4.2 National Workshop

The workshop, held with financial assistance from the Netherlands Government provided through IRC, took place at Liwonde, Machinga District in Malawi from August 21 to 26, 1989 (REPUBLIC OF MALAWI, 1989). It was attended by participants from Ministry of Works (Water Department), Ministry of Health, Center for Social Research of the University of Malawi, Ministry of Community Services, and Ministry of Local Government. It was facilitated by two resource persons who had participated in earlier consultations, one from the IRC International Water and Sanitation Center, and one from Zambia. The objectives of the Cost Recovery and Resources Coverage Workshop in Malawi were:

- to introduce the draft guidelines to a multi-sectoral group drawn from institutions which are directly or indirectly concerned with community water supply and sanitation;
- to increase awareness of the Cost Recovery and Resources Coverage issues raised by the draft guidelines;
- to acquaint participants with the practical field use of the guidelines by carrying out small field exercises;
- to get views and comments from participants on the applicability of the guidelines to the local situation and adaptation needs; and
- to prepare for the main field trials by:
  - producing detailed plans on how the field trials would be carried out;
  - producing adapted worksheets; and
  - developing relevant questionnaires which would be used for collecting information on each of the "key elements".

4.3 Workshop Output and Conclusions

The output and achievements of the Malawi National Workshop included:

- the expansion of "Key Elements" to include the characteristics, which have to be present to ensure that each element is strong. This was developed by participants in the group discussion;
- the development of preliminary questions which were to be used in collecting data for use in assessing individual key elements;
- constituting a multi-sectoral team to carry out the field trials;
- selection and discussion of projects which were to be used for field trials; and
- development and endorsement of a program for the field trials.

Amongst its conclusions, the workshop found the general principles presented in the draft guidelines to be relevant and promising. It also endorsed the view that the guideline framework should be considered as a tool that can be adapted to local needs and requirements at hand.

Echoing the Mongu (Zambia) recommendations, the Malawi Workshop confirmed the need to carry out full field trials in order to assess the applicability of the guidelines and relevance to the Malawi situation to be taken up as a further stage.

5. Field Trials in Malawi

5.1 Background

The field trials ("pilot survey") were carried out between December 7 and 19, 1989 again with funds from the Netherlands Government (REPUBLIC OF MALAWI, 1990). Four community project areas were selected: Zomba East Gravity Piped Water Project; Liwonde Sanitation Project; Livulezi Integrated Groundwater Project; and Salima Piped Supplies for Small Communities Project.

The trials were carried out by a multi-sectoral team of seven officials drawn from Water Department, Center for Social Research of the University of Malawi, Ministry of Local Government, Ministry of Health and Ministry of Community Services, using questionnaires that were developed earlier.

The pilot survey had two major objectives:

- to field test the guidelines which were developed under the umbrella of WHO and determine their applicability and relevance to Malawi; and
- to use the data collected during the pilot survey to determine the extent at which the four projects covered were sustainable.

More specifically, the pilot survey tried to find out whether:

- the guidelines were useful in gaining insights on whether the projects were likely to be sustainable or appropriate for maximum extension;
- the guidelines could be improved or adapted to better meet Malawi's needs;
- the application of the Guidelines to gain information on existing projects indicated any potential for future use in planning, appraisal, full case study work, and evaluation or monitoring.

For each of the four projects included in the study, the pilot survey also sought to find out:

- whether the key elements were in place or not, as well as their strength;
- what necessary resources would be needed (cash, skills, time, materials) to ensure that each element was adequately strong to sustain the projects;
- whether the elements have, and would continue to have, adequate resources to meet the needs;
- whether the distribution of responsibility for providing the resources had been, and would continue to be, fairly and realistically divided between the agency and the community.

5.2 Summary of Findings

The study found that the guidelines are comprehensive, useful and relevant. They can assist project planners and project implementors in identifying and allocating inputs and resources required for successful community water supply and sanitation projects.

The ten key elements for both water supply sustainability and extended low-cost sanitation are particularly useful, especially when key characteristics of each element are identified and properly defined.

By using the guidelines (key elements), the study team was able to collect data which has proved valuable in getting insights into:

- resource inputs which have gone into the projects during both the development phase and the operational phase;
- resources which were in short supply or lacking in order for the projects to be sustainable;
- the level of partnership in sharing resource inputs between the agency and communities;
- the pinpointing of gaps in resources coverage.

One of the conclusions was that the originally agreed upon sharing of responsibilities between the agency and communities was unfavorable, with the agency having taken on too many responsibilities - most of which were not effectively executed, thus, leaving the communities with very little to do.

If the projects were to be sustainable, the scheme needs to be changed to give the communities more responsibility. This need was also felt by the communities in areas where there were problems with the water supply. They felt that given the necessary training and support, they could sustain the system themselves without having to wait for long periods for agency inputs as at present.

Using the guidelines, it has been possible to recommend more and better balanced resource inputs into each of the four projects that were studied. This should help ensure the sustainability of the water schemes and the expansion of the sanitation projects concerned.

The study's conclusion was that the use of the guidelines in the field enabled: (1) an analysis of individual resource inputs, and; (2) determining how responsibilities for such inputs ought to be shared between the agency and community. This in-depth experience indicated that the guidelines should have a good potential in Malawi for:

- Project Planning
- Project Appraisal
- Project Reviews
- Project Evaluation

6. Conclusions

- Financial realism is one of the keys to wider future coverage and adequate operation and maintenance, use and impact of both existing and planned water supplies and sanitation improvements.

- Based on this, the need to address the overall and continuing resource requirements of a project, and to reach early and binding agreement on who will provide them, cannot be over emphasized. Sustainability must be the immediate goal, and a "resources coverage" approach has been shown to be a valuable tool in reaching it.

- Because of the wide interest in the achievement of lasting water and sanitation improvements, the work described may prove to be of interest for adaptation and use in other countries in Southern Africa and also perhaps countries in other regions. It is hoped, therefore, that the work initiated by WHO in partnership with IRC and a number of developing countries will be further shared through enhanced international and in-country information exchange.

- Further joint efforts on the different ways of maximizing the sustainability, coverage, and impact of small-scale water and sanitation improvements is essential. The Southern Africa work should be looked upon as one contribution to this global effort towards more effective sector development.

References

GOVERNMENT OF THE REPUBLIC OF ZAMBIA (1989) "Working Group Report", Sub-Regional Working Group Meeting on Cost Recovery and Resources Coverage, Mongu, Zambia, January 30 - 3 February 3, 1989.

IRC INTERNATIONAL WATER AND SANITATION CENTER (1988/1989) Newsletter Nos. 177 and 185, The Hague, The Netherlands.

REPUBLIC OF MALAWI (1989) Workshop on Cost Recovery and Resources Coverage for Water Supply Sustainability and Extended Low Cost Sanitation Coverage. Draft Report, Liwonde, Malawi.

REPUBLIC OF MALAWI (1990) "Cost recovery and resources coverage pilot survey", Draft Report on Field Trials, Lilongwe, Malawi.

WIJK-SIJBESMA, C.VAN (1987) "What price water? User participation in paying for community-based water supply", IRC International Water and Sanitation Center, The Hague, The Netherlands.

WORLD HEALTH ORGANIZATION (1989) "Principles and models to achieve sustainable community water supply and to extend household sanitation", Report of the Fourth Consultation on Institutional Development/Working Group on Cost Recovery Volume II, Geneva, November 21 - 25, 1988.

Acknowledgements

The agreement of the Malawi Government and the IRC International Water and Sanitation Center to the authors jointly preparing this paper has been appreciated. Similarly the support of Carl Duisberg Gesellschaft in sponsoring the principal author to present the paper in Thailand is gratefully acknowledged. Due recognition is also made to the World Health Organization, whose continuing efforts in raising awareness of the cost recovery and resources coverage issues, gave rise to the Southern Africa initiatives described in the paper.

Planning and Development of Small-scale Water Resources

J. Hari Krishna
Director
Water Resources Research Center
University of the Virgin Islands
St. Thomas, VI 00802
U.S.A.

Abstract

In the development of small-scale water resources, careful attention should be given to many aspects such as ease of operation and maintenance, staff training, and provision of funds for annual repairs and upkeep. Water supplies from various sources such as surface water, groundwater, and where feasible, municipal water should be pooled and used conjunctively. The water collection and distribution system at the University of the Virgin Islands is discussed as a good example of a multi-source water supply system. Other techniques discussed include collecting surface runoff in small tanks (ponds) and the use of membranes for agricultural purposes.

1. Introduction

Small-scale water resources are becoming increasingly important in many parts of the world because of a number of factors. The capital costs and operating costs of these facilities are lower than those needed by large projects; in many cases, the technology required for the development of small-scale water resources is easily available and the time required for creating such facilities is much less compared with large water projects. Also, smaller projects can be designed to suit the needs of individuals and communities better than large projects.

This paper will discuss some general strategies for planning small-scale water projects and provide examples of small-scale water resources from two tropical regions: the U.S. Virgin Islands in the Caribbean and India.

2. Planning Strategies

Small-scale water resources will be valuable only when planned and executed properly. In general, if some water projects have already been created but are not performing at optimum levels, it might be desirable to provide the required maintenance and/or rehabilitation to reactivate and fully utilize these projects before investing large sums of money on entirely new ventures (KRISHNA, 1983). This strategy of course assumes that the original project was well-conceived and will produce the desired results.

When new small-scale water projects are designed in developing areas, it is important that the operation and maintenance procedures be such that they can be easily handled by the local staff and facilities. Responsibilities for operation and maintenance must be clearly identified from the very beginning. In several cases, facilities have been observed to deteriorate because of inadequate maintenance. Regular review and supervision is essential to ensure that a project is performing according to expectations. Timely repairs will help in avoiding major problems at a later time. Training programs for users and operators must be included in overall planning strategies for water resource projects. In many cases, project repairs can be identified, but due to lack of funds, the needed maintenance is not performed. Based upon experience, a certain amount of money must be encumbered in each project for annual maintenance and repairs even after the project is completed.

Wherever feasible, water user groups should be established and encouraged to provide a feedback for the governmental and other agencies who are involved in the construction and operation of the water projects (KRISHNA, 1982). The facilities can be managed better through an exchange of ideas and information with the users; the feedback will also assist planners in designing other projects more efficiently in the future

3. Innovative Techniques

Small-scale water resources in rural areas can be either community-oriented or specifically designed for individual households. Community or multi-user water supplies will be discussed first, followed by individual household needs.

3.1 Community Water Resources

Community or multi-user water supplies can be provided from a single source such as a small tank/ reservoir or from a combination of sources. The water supply system at the St. Thomas campus of the University of the Virgin Islands shown in Fig. 1 is a good example of a multi-source small-scale water resource facility. A two-hectare hillside catchment (made of corrugated metal sheets supported on a wooden frame structure), and a number of rooftop catchments (from campus buildings) provide surface water during the rainy season to intermediate cisterns from where water is pumped to a central storage tank of 4 million liter capacity. Groundwater is also pumped to this tank from a series of wells on campus, when the water table rises in the wet season. During extended dry periods, municipal water is used to supply the central storage tank. This tank provides a buffer from which water is pumped to an elevated gravity feed tank of 250,00 liter capacity. The water is supplied by gravity from this tank to several buildings on campus. The campus buildings shown in Fig. 1 can be visualized as individual users in a multi-source multi-user water harvesting, storage and distribution network.

In the area of agricultural water management, a system of collecting rainfall excess, storing it, and re-applying the water as supplemental irrigation could be promising. At the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) in India, several small tanks (ponds) were excavated to collect runoff from the catchments above. The runoff collected in a 4,000 cu m tank during the monsoon season was used to apply supplemental irrigation on the 6.5 ha catchment later in the season. The storage capacity was tentatively calculated based on a runoff volume of 10 to 15% of the seasonal rainfall (KAMPEN and KRISHNA, 1978). Conceptually, the catchment could belong to more than one farmer and the water collected in the tank could be shared mutually by them. Since their construction in the early 1970s, the tanks at ICRISAT have collected valuable runoff in most years, which would have otherwise been lost.

3.2 Individual Water Supplies

In the U.S. Virgin Islands, every building is required by law to have a cistern for water storage. Rooftop runoff is led into the cisterns which are usually constructed underground. Most cisterns are constructed of reinforced concrete. However, some fiberglass cisterns are being used for

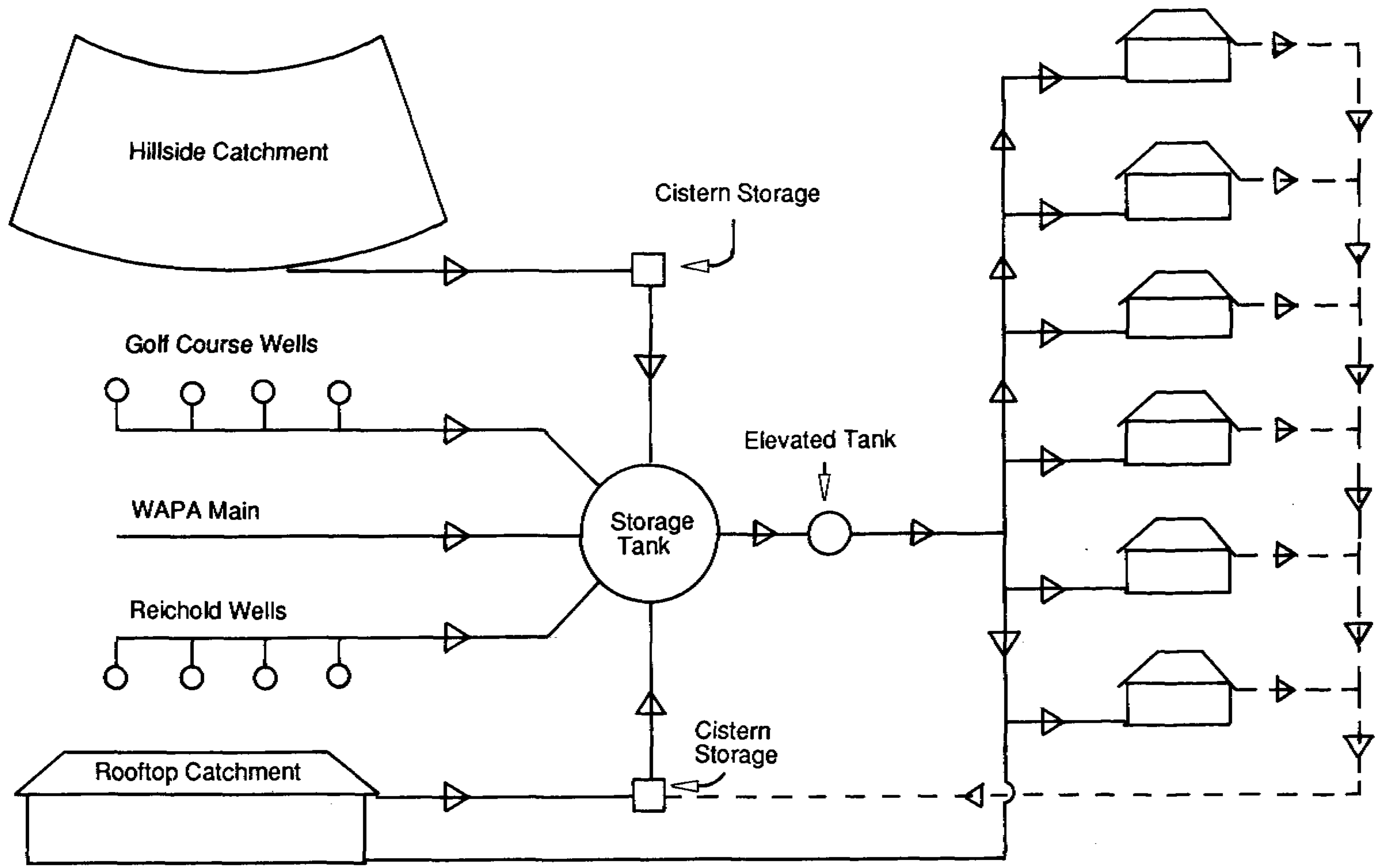


Fig. 1. Schematic of the UVI water supply and distribution system

temporary facilities, and where large quantities of runoff water are not expected. The water in the cisterns is pumped up to the house on demand. As the water is being utilized, more rooftop runoff during the year enters the cistern for later use.

The Virgin Islands receive approximately 1,000 mm of rainfall annually, distributed throughout the year, with peaks usually in May and September. Most storms are high-intensity short duration events, so there is a high percentage (70-80%) of rainfall that can be collected as rooftop runoff.

In tropical regions, rooftop runoff should be collected to provide domestic water supplies. It appears that this is becoming popular in Thailand and should be encouraged further. However, care must be taken to protect the quality of the water collected, particularly if it is used for drinking purposes. Chlorination is very effective for disinfection and may be practised in consultation with local health authorities.

Another approach in capturing rainwater involves the use of membrane catchments that yield water even after the smallest showers. A 0.2 ha vinyl tarpaulin was installed at the Agricultural Experiment Station, St. Croix campus, University of the Virgin Islands (RAKOCY, 1989). This tarpaulin supplied rainwater to a series of fiberglass tanks for intensive aquaculture and hydroponics. Research has shown that the annual water yield from this small catchment is approximately 1.6 million liters, which is enough water to raise 20,000 kg of fish and considerably large amounts of fresh vegetables.

4. Conclusion

In planning the development of small-scale water resources, careful consideration must be given to all aspects of the project, such as ease of operation and maintenance, training and clear delineation of responsibilities for staff members, and provision for adequate funds for annual maintenance and repairs even after the project is completed. Periodic review and feedback from water users should be encouraged to improve the effectiveness of any water project.

Water supplies can be increased by pooling a number of sources such as surface water, groundwater, and whenever feasible, municipal supplies. The water supply at the St. Thomas campus of the University of the Virgin Islands is a good example of using runoff from a hillside catchment, rooftop runoff, combined with groundwater and municipal supplies to provide the needed requirements. Domestic cisterns are commonly used in the Virgin Islands to collect rooftop runoff for providing household water supplies.

In the agricultural sector, water supplies can be generated through runoff into small tanks or ponds, or by membrane catchment techniques. Research has shown that the water collected can be used for a number of purposes such as crop production, growing vegetables, or for fish production. Small-scale water resources will become increasingly important in the future to meet the needs of the rural population in many parts of the world.

References

KAMPEN, J. H. and J. R. KRISHNA (1978) "Resource conservation, management, and use in the semi-arid tropics", Technical Paper No. 78-2072, American Society of Agricultural Engineers.

KRISHNA, J. H. (1982) "The development, management, and utilization of small-scale water resources in Thailand through small farmers' production groups", Consultancy Report, Food and Agriculture Organization of the United Nations, Bangkok, Thailand.

KRISHNA, J.H. (1983) "Water resources development in Thailand", Water International, Vol. 8:154-157.

RAKOCY, J. (1989) "Aquaculture production systems", Proceedings of the Virgin Islands Water Resources Conference, University of the Virgin Islands, pp. 41-46.

Acknowledgements

The author wishes to acknowledge the cooperation and assistance of the U.S. Department of the Interior Geological Survey, the University of the Virgin Islands, and the sponsors of the International Symposium, particularly CDG, in enabling his participation at this symposium. The views expressed in this paper are those of the author, and do not necessarily represent those of his employer or sponsors.

Part 3:

Technologies, Tools, and Training

Developments in Rainwater Catchment Systems: Technology and Implementation Strategies in the 1980s and Lessons for the 1990s

John E. Gould
Acting Honorary Secretary
International Rainwater Catchment Systems Association
United Kingdom

Abstract

Despite the failure of the IDWSS decade to even approach its targets during the 1980s, rainwater catchment systems (RWCS) flourished and spread rapidly throughout the decade. Although this ancient and simple technology has a history of scattered use around the world stretching back for centuries, even millennia in some places, its widespread adoption as a serious water supply alternative in regions suffering from water shortages is a recent phenomenon. Two trends are responsible for the recent success of this technology: the transition from thatched to corrugated iron or tiled roofing in the rural areas of many developing countries; and the development of cheap, simple and effective ferrocement tank designs.

This paper examines the development of the hardware aspects (the design and construction) of RWCS from a number of projects in both East Africa and Southeast Asia. It also considers the software aspects (i.e., the community organization and participation, the financing, and the management) of these projects. A variety of successful implementation strategies based on case studies from Kenya, Thailand, and the Philippines are cited and common elements discussed. In particular, techniques for income generation and fund raising to help finance projects are examined.

Some of the lessons learned from the past, such as the failure of initially promising designs, like the interlocking brick and bamboo reinforced tanks, and problems of contamination are examined. Difficulties associated with the uncontrolled and very rapid spread of RWCS as in some parts of Thailand are also considered. General guidelines designed to foster successful project implementation are presented.

Finally, the role of international agencies, international associations, NGOs, and other institutions in promoting the future development of this technology is examined.

1. Introduction

The 1980s will probably be remembered as the lost decade in the field of small-scale water resource development due to the failure of the international community to even come close to meeting the lofty goals of the IDWSS Decade. Despite this, there were some notable successes during the decade in particular regions, e.g. Thailand, and with particular technologies, e.g. rainwater catchment systems (RWCS).

RWCS have been used for at least 4,000 years and evidence of roof catchment systems date back to early Roman times. In the Negev desert in Israel, cisterns for storing runoff from hillsides for both domestic and agricultural purposes have allowed habitation and cultivation in areas with as little as 100 mm of rain per year since 2000 B.C. or earlier (EVENARI, et al., 1981). It is only in the last 20 years, however, that RWCS technology has started to spread rapidly from isolated pockets to many areas worldwide. There are a number of reasons for this. Before 1970, RWCS were mainly limited to areas lacking any alternative forms of supply, such as coral islands and remote arid locations such as the U.S. Virgin Islands and parts of the Australian outback, respectively. This was due to the absence of suitable surface or groundwater sources in such localities. From the 1970s onwards, however, a number of preconditions led to the introduction of RWCS into the rural areas of many developing regions suffering water shortages. These preconditions include:

- an increased emphasis on rural development in an attempt to stop rapidly growing populations flooding into the new urban slums.

- increasing pressure on rural water supplies due to population growth, and the trend towards settlement by nomadic people and their livestock.

- problems with ground and surface water supplies such as salinity, agricultural practices, and deforestation.

- the rapid spread of impervious roofing materials such as tiles and corrugated iron, replacing the traditional grass and palm thatch in many regions.

- the development of effective, low-cost tank designs based on ferrocement technology.

The early success of RWCS technology led to accelerated implementation in some regions in the 1980s, with Kenya and Thailand leading the way in their respective continents. Apart from a rapid increase in the number of systems with around 10 million roof catchment tanks having been constructed in Thailand by the end of the decade, the quality of both the design and construction techniques and the effectiveness of implementation strategies also improved. The successes in Thailand and Kenya provide a useful demonstration of the potential of roof catchment technology for domestic water supplies in areas lacking clean, reliable alternative sources. Some of the advantages and disadvantages of roof catchment systems are outlined in Table 1.

The potential of RWCS technology to provide water for crops and livestock in semi-arid areas through the construction of large sub-surface tanks and bunds for runoff farming have yet to be demonstrated on a large scale. The potential for this technology to help in the reduction of soil erosion makes it a technique worthy of much more research and development in the 1990s.

2. The Importance of Both Sound Hardware and Software

In the 1970s and early 1980s a great deal of research and applied experimentation was directed towards the development of a cheap, robust and, easy-to-build rainwater tank design. Unfortunately, this pre-occupation with the hardware side (design and construction) of RWCS projects led in many cases to insufficient attention being paid to the software side of project implementation. These software aspects involve the promotion of individual and community awareness, motivation, organization skills, and resource generation (GOULD, 1989). Although a sound, affordable, and easy to construct tank design is essential to the success of many projects, excellent hardware alone is not sufficient to ensure a clean, reliable, well maintained, and long-term water supply.

The perils of ignoring the software aspects of project implementation were well illustrated by the difficulties experienced by those involved with a ferrocement roof tank project near Kilifi in the

Table 1. Advantages and disadvantages of rainwater catchment systems for domestic supply

Advantages	Disadvantages
Convenience provides a supply at the point of consumption. **Good Maintenance** since the operation and maintenance of household roof catchment sytems are under the sole control of the tank owner and family. **Low Running Costs** these are almost negligible. **Good Water Quality** much better than that from traditional unimproved sources. **Low Environmental Impact** rainwater is a renewable resource and no damage is done either to the environment or to future water supplies through its introduction. **Ubiquitous Supply** rainwater collection is always a water supply alternative wherever rain falls. **Simple Construction** the construction of rainwater catchment systems is simple and local people can easily be trained to build these by themselves, thus reducing costs. **Flexible Technology** the systems can be built to almost any requirement and poor households can start with a single small tank and add more when they can afford them.	**High Initial Cost** the cost per liter of water supplied is high compared with some other methods. **Supply is Limited** both by the amount of rainfall and by the size of available catchment area. **Expensive** when compared with alternative water sources in some areas. **Unattractive to Bureaucrats and Policy Makers** compared with large-scale water supply projects involving the construction of a single multi-million dollar dam, the funding and administration of rainwater tank construction in scattered and often remote locations presents the administrators with more work for less tangible returns.

Coast Province of Kenya during the early 1980s. Due to the failure of an earlier project in the area in which 35 cement jar roof catchment tanks had cracked due to technical problems related to poor workmanship and the effect of the sea air on the cement, it was decided to contract out the construction of the tanks in the new project. The result was the production of high-cost, high quality ferrocement tanks made at a central privately owned factory (Ferrocraft). Although technically sound, being able not only to withstand transportation from the factory but also the impact of a coconut falling from 30 m, the cost of the tank was well beyond what most farming families in the area could afford.

Community involvement and participation in the scheme was limited to participants being assisted with loan applications to cover the cost of transporting and installing a tank. The loan which had to be repayed over 10 years following a two-year grace period was subject to a 6.5% interest rate. A few farmers in the area did not understand the difference between a grant and a loan, since the repayment of loans for the earlier project had been waived when the tanks had cracked.

Since the community was not involved with the planning, design, construction or implementation of the project, few understood how the, albeit, simple RWCS technology worked. Little information was provided on how to operate and maintain the system and, as a result, following the installation of the tanks many families failed to erect the necessary guttering and downpipes effectively, thus losing a large amount of their roof runoff. Few understood the concept of rationing supplies and, in many cases, the system only provided a small fraction of their potential.

Disillusioned with the apparent failure of the rainwater tanks to provide an abundant year-round water supply and with the high cost of loan repayments, defaulting was commonplace. The loan scheme soon became unwieldy and expensive to administer and since the provision of future loans was dependent on the revenue collected, the whole project was quickly put in jeopardy (McPHERSON, et al., 1984).

Fortunately, the failure of the Kilifi RWCS project to address the software aspects of project implementation can be balanced with many other examples of projects in Kenya where community involvement at every stage was central to the introduction of rainwater tanks. Two notable examples are the Mutomo Soil and Water Conservation Project and the Catholic Diocese of Machakos Project. Both of these projects included major components involving the implementation of rainwater tanks using well-tried and tested hardware. However, they differed from the Kilifi project in placing an equal emphasis on the software aspects of project implementation. This involved liaison and discussions with the recipient communities right from the outset, and the active participation of the community at every stage of the project from planning, to design, construction, operation and maintenance. In the case of the large roof catchment tank construction project in the Diocese of Machakos, villagers were invited to establish revolving fund groups to help individual group members to acquire subsidized rainwater tanks one at a time. Due to the fact that the communities were responsible for the provision of most of the resources and ideas for these projects, both have grown steadily and have resulted in replication in the surrounding regions.

3. Recent Developments in Low-Cost Rainwater Tank Designs

During the 1980s a variety of new tank designs, such as the bamboo reinforced and interlocking brick designs, were developed and field-tested as alternatives to expensive metal, reinforced concrete, and brick tanks. Due to problems with some of these new designs, however, just one general tank design type, the ferrocement, was left leading the field in terms of its low cost, ease of construction, durability, and popularity by the end of the decade. Although all ferrocement tank designs have a number of common elements - a reinforced base and thin cement walls reinforced with wire or weldmesh - there are numerous variations on this theme. These range from cement jars of less than one m^3 for domestic supplies to tanks of more than 100 m^3 for communal supplies.

4. Case Studies

4.1 The Thai Jar Program

The Thai jar program is the largest RWCS implementation project in the world and resulted in the construction of around 10 million 2-m^3 tanks between 1985 and 1990. The cement jar is made using either basket work or cement block reusable mold, 2.5 bags of cement, sand, and a few meters of fencing wire reinforcement. When complete, a final layer of cement slurry is applied, followed by a coat of a traditional non-toxic red paint. A galvanized cover and brass tap are now included in the construction of most jars.

The most impressive features of this program are the way the cost of the jars has been kept very low at around US$ 25 without generally sacrificing their quality, and the extent to which every tier of society, from the Ministry of the Interior to individual village households, has been mobilized to insure the success of the scheme. Researchers from Khon Kaen University, who provided support and advice on both technical and strategic aspects of the program, consider that the implementation strategy used was critical to the success of the project (WIROJANAGUD and VANVAROTHORN, 1990). Specifically, they noted the importance of villagers' involvement in both the financial management and all stages of construction of the project. The significance of revolving funds and the contributions of villagers in terms of both labor and the cost of materials was also fundamental. This was, however, balanced by the government's role in providing tools, training and small cash injections to help establish revolving funds.

In practice, the rapid development of the program meant that the suggested procedures were not always followed. In many regions, small jar-making factories sprang up to meet the growing demand for the tanks. It is a credit to the local official administering the projects at the grassroots level that, through adopting a flexible approach, they were able to incorporate these small-scale business enterprises into the overall program. The speed of implementation and the uncontrolled growth of private contractors willing to provide jars at low costs has, nevertheless, led to a number of problems. The quality of the jars has, in some instances, suffered and due to the lack of community involvement, the level of effective use and maintenance of the tanks has suffered. For example, the rationing of supplies has not always been adopted, leading families to return to contaminated traditional sources when the tank is empty (TUNYAVANICH and HEWISON, 1989).

4.2 The Diocese of Machakos Concrete Ring Rainwater Tank Project, Kenya

The Diocese of Machakos rainwater tank project is one of more than a hundred projects that sprung up in Kenya during the 1980s. It has been instrumental in encouraging the construction of several thousand tanks of ferrocement type (DE VREES, 1987). The project was also one of the first in Kenya to establish revolving funds as a method of assisting groups of householders with the cost of the tanks.

The concrete ring tank design is particularly suitable for medium sized tanks up to 6 m^3, although larger tanks than this can be built. This design is an attractive option in areas where aggregate and hardcore are cheap, widely available, and where wiremesh and steel reinforcing bars needed for standard ferrocement designs are expensive.

The construction procedure basically involves using two concentric ring molds, each made from two corrugated iron sheets bolted together and having diameters of 1.9 m and 1.65 m, respectively. These are placed on a 2.5 m hardcore foundation. Concrete (1:3:3 cement, sand, hardcore) is then poured into the void between the rings and barbed wire wrapped around it 12 times as reinforcement, the concrete being poured between each turn of the wire. The following day, the mold can be unbolted and placed on top of the first concrete ring and a second ring is cast in the same way. The next day, a third ring can be added, and on subsequent days, the tank should first be plastered inside twice (once with a 1:2 cement, waterproof sand mix), then a roof is added using fixed shuttering, and finally plastered outside. The tank should be cured for a week and the shuttering removed before use. A 5-m^3 tank requires about 12 bags of cement, 200 m of barbed wire and 14 man-days of labor (7 skilled). The molds can be reused up to 25 times.

4.3 The Capiz Wire Framed Ferrocement Tank Project, Philippines

This design was developed with the assistance of IDRC and to date, more than 500 tanks have been constructed (APPAN, VILLAREAL, and WING, 1989). Although more expensive than the cement jar, this design is robust, durable, and particularly suitable for tanks with capacities between 2 and 10 m^3 and can be used for tanks up to 16 m^3. Unlike the commercially available metal tanks widely used throughout the country, the wire framed ferrocement tanks do not rust and corrode easily in the saline coastal air.

The construction of these tanks consists of making a frame out of steel reinforcing bars and wire mesh. This is then placed on a sturdy reinforced foundation and plastered from both inside and outside simultaneously. The materials required for a 10 m^3 tank include 22 bags of cement, 40 steel reinforcing bars (9.15 m x 9 mm), 30 m x 0.9 m of 12 mm welded wire mesh, and 3 m^3 of sand.

One novel feature of the implementation strategy used for this project was that loans provided for covering the cost of the tanks included a component for covering the cost of an associated income generating venture. A common example of this was pig-rearing. Project participants take a loan of around US$ 300 repayable over 3 years and covering the cost not only of the tank but also of one or more piglets costing around US$ 25 each. Once mature, the pigs can fetch up to US$ 90 each, thus generating revenue to help meet the repayment of the initial loan.

5. Lessons Learned

5.1 Lessons Learned Regarding RWCS Design and Construction

During the 1980s a great deal of experience and expertise were developed regarding the hardware (design and construction) aspects of RWCS, and a number of initially promising new designs were developed. Many of these, however, failed to stand up to extensive field testing where flaws were revealed. For instance, attempts to develop cheap locally available substitutes for wire reinforcement ran into problems. In Thailand and Indonesia, where tens of thousands of bamboo reinforced tanks were built, a number of failures have been reported. The causes for these were fungal, bacterial, and termite attack on the bamboo. Similar problems were associated with the Ghala basket rainwater tank design in Kenya. Unfortunately, a great deal of literature promoting these designs is still in circulation, which could potentially result in new projects springing up using these obsolete and discredited designs. Another design still undergoing field tests is the interlocking brick tank, which showed initial promise but is now clouded in doubt following leakage problems.

Most ferrocement tank designs appear to have survived the scrutiny of widespread field testing in the 1980s very well, and where levels of workmanship have been high and proper curing procedures followed, problems have been few. The general lesson learned in relation to promising new RWCS hardware in the 1980s has been that new designs need very thorough field testing over a long period of time before wider scale replication could be encouraged.

5.2 Lessons Learned from Experience with RWCS Project Implementation

- Most successful projects have started small and grown slowly, developing and modifying both design and implementation strategies all the time.
- Projects which have been predominantly run by local people have had a much higher success rate than those run by people foreign to the area.
- Projects which involve the local community from the outset in the planning, implementation, and maintenance of systems have the best chance of enduring and expanding.
- Successful projects are generally associated with communities where a real 'felt need' for water has been expressed and where this need figures prominently on the communities' development priorities.
- Projects where the local community has contributed funds, labor, and ideas have a greater record of success than those externally planned and funded.
- Successful projects have generally been those which have been subjected to constant appraisal, evaluation, and modification to overcome problems as they arise.

5.3 Lessons Learned Regarding RWCS Water Quality

- Rainwater is susceptible to contamination by heavy metals such as lead used in some paints, roofing material, and pipes and these should be avoided at all costs.
- Contamination of stored rainwater from bird and animal droppings and other organic materials is a potential health hazard and should be avoided by removing overhanging trees above roof catchments and employing foul flush and coarse filter systems when possible.
- Water collected from ground catchment systems and stored in sub-surface tanks is generally not potable and is unsuitable for human consumption.

6. Guidelines

(1) All rainwater tank designs should include as minimum requirement:

- A solid secure cover,
- A coarse inlet filter,
- An overflow pipe,
- A manhole, sump, and drain for cleaning,
- An extraction system that does not contaminate the water, e.g. tap/pump, and
- A soakway to prevent spilled water from forming puddles near the tank.

Additional features might include:

- A device to indicate the amount of water in the tank,
- A sediment trap, tipping bucket, or other foul flush mechanism,
- A lock on the tap, or
- A second sub-surface overflow tank to provide water for livestock, etc.

(2) The following questions need to be considered in areas where RWCS project is being considered, to establish whether or not rainwater catchment warrants further investigation:

- Is there a real need for an improved water supply?
- Are present water supplies either distant or contaminated, or both?
- Do suitable roofs and/or other catchment surfaces exist in the community?
- Does rainfall exceed 400 mm per year?
- Does an improved water supply figure prominently in the community's list of development priorities?

If the answer to these five questions is YES, it is a clear indication that rainwater collection might be one feasible water supply option. Further questions, however, also need to be considered.

- What alternative water sources are available in the community and how do these compare with rainwater catchment?
- What are the economic, social, and environmental implications of the various water supply alternatives (e.g. ability of a community to pay, potential in the community for income generating activities; does the project threaten any community members' livelihood, such as water vendors)?
- What efforts have been made either by the community or an outside agency to implement an improved water supply in the past? Lessons may be learned from previous projects, although if these failed, it may be difficult to gain the community's support for future projects.

(3) All catchment surfaces must be made of non-toxic material. Painted surfaces should be avoided, if possible, and used only if the paint is non-toxic (e.g. not lead-based). Overhanging vegetation should be avoided.

7. Conclusions

The 1980s witnessed the rebirth and rapid spread of the ancient art of rainwater collection. During the decade, great improvements were achieved both in refining the design of RWCS 'hardware' and with innovative new 'software' for project implementation strategies. As RWCS technology matures and continues to spread during the 1990s, it is essential that the lessons learned so far are both disseminated and applied.

International organizations such as UNICEF, WASH, ITDG, IDRC, IRC, and IRCSA (International Rainwater Catchment Systems Association, Appendix 1) will need to take the lead in encouraging both research and the widespread exchange of information regarding all aspects of RWCS technology and its implementation. In particular, the dissemination of information relating to the quality of rain water and the cause and effect of possible sources of contamination need to be given priority.

Governments and major international donors should be encouraged to support major RWCS programs, particularly in Africa, so that the success seen in Thailand in the 1980s might be repeated elsewhere during the 1990s. Although rural RWCS projects are only likely to succeed if they stem from grassroots involvement, support and encouragement from above can both speed up and smoothen the implementation process considerably.

Due to the small scale of many community RWCS projects, NGOs both from the North and South can play a crucial role in assisting communities with the initial training, tools, resources, and organizational support required to initiate a RWCS project. Many of the numerous RWCS projects in Kenya have been established by communities working in tandem with NGOs, and there is enormous potential for greatly extending these types of cooperative ventures in the 1990s.

References

APPAN, A., C. VILLAREAL, and L. WING (1989) "The planning, development and implementation of a typical RWCS system: a case study in the province of Capiz," Proc. of the 4th Int. Rainwater Cistern Systems Conf., August 1989, Manila, C3 pp. 1-12.

DE VREES, L. (1987) "Machakos Diocese rainwater tank program", Development Office, Diocese of Machakos, P.O. Box 640, Machakos, Kenya, 15p.

EVENARI, M., L. SHANAN, N. TADMOR, and Y. AHARONI (1961) "Ancient agriculture in the Negev", Science, 133:966-976.

GOULD, J. E. (1989) "Strategies for overcoming the obstacles associated with 'software' aspects of rain water catchment systems implementation", Proc. of the 4th Int. Rainwater Cistern Systems Conf., Manila, B3 pp. 1-16.

McPHERSON, H. M. McGARRY, J. GOULD, and B. LATHAM (1984) "Low cost appropriate water and sanitation technologies for Kenya", GTZ Report to the Min. of Water Development, Maji House, Nairobi, 257p.

TUNYAVANICH, N. and K. HEWISON (1989) "Water supply and water use behavior: The use of cement rainwater jars in Northeastern Thailand", Proc. 4th Int. Rainwater Cistern Systems Conf., Manila, C2 pp. 1-23.

WIROJANAGUD, P. and V. VANVAROTHORN (1990) "Jars and tanks for rainwater storage in rural Thailand", Waterlines 8(3):29-32.

Appendix 1

The International Rainwater Catchment Systems Association

The International Rainwater Catchment Systems Association (IRCSA) was born out of a proposal by Dr. Adhityan Appan and discussions held at the Fourth International Rainwater Cistern Systems Conference in Manila, Philippines in August 1989. At this meeting, Prof. Yu Si Fok was elected president of IRCSA and was asked to draw up a constitution. It was agreed that work to establish the association should begin so that by the Fifth International RWCS Conference to be held in Keelung, Taiwan, IRCSA could be formally established and a committee formally elected.

The main objectives of IRCSA will be:

(1) To promote RWCS technology and to encourage the dissemination of information about this technology.

(2) To attempt to link all those working in this field so that information and experiences can be shared.

(3) To draw up a set of international guidelines regarding the use of RWCS technology.

(4) To support the continuation of the series of International Conferences on Rain Water Catchment Systems.

For further information about IRCSA, please write to Prof. Yu Si Fok, Department of Civil Engineering, 2540 Dole St., University of Hawaii, Honolulu, Hawaii 96822.

For information about the Fifth International RWCS Conference, August 4-10, 1991, write to: Mr. Show Chyuan Chu, Department of River and Harbor Engineering, National Taiwan Ocean University, Keelung, Taiwan 20224.

Appendix 2

Recommended Background Reading on Rainwater Catchment Systems

FERROCEMENT WATER TANKS by S.B. Watt, (1978) I.T. Publications, 103-105, Southampton Row, London, WC1B 4HH.

RAINWATER HARVESTING by A. Pacey and A. Cullis, (1986) I.T. Publications, 103-105, Southampton Row, London WC1B 4HH.

RAINWATER CATCHMENT AND RURAL WATER SUPPLY IN RURAL AFRICA: A MANUAL. E. Nissen-Petersen (1982), Hodder and Stoughton, London.

The Proceedings of the 1st, 2nd, 3rd, and 4th International Conferences on Rainwater Cistern Systems are useful sources of background work. Copies of the proceedings of the 4th conference are available from KABALIKAT, MCPO Box 189, Makati 1299, Philippines.

WATER FOR THE WORLD, Technical Notes: RWS 1.C.4, RWS 1.D.4, RWS 1.P.5, USAID Development Information Center, Washington D.C. 20523.

WATERLINES: Journal of Appropriate Water Supply and Sanitation Technologies. Volumes 1.2, 2.4, 3.2, 3.3, 4.4, 5.2, 5.4, 6.1, 6.2. (1962-1990) I.T. Publications, 103-105, Southampton Row, London WC1B 4HH.

WATERLINES TECHNICAL BRIEF No. 1 (1984), No. 11 and No. 14 (1987) I.T. Publications, 103-105, Southampton Row, London WC1B 4HH.

Contact Institutions

Approtech Asia, P.S.D.C., Magallanes Cor. Real St., Intramuros, Manila 1002, Philippines.

I.R.C.S.A.: The International Rainwater Catchment System Association, c/o Prof. Fok, Department of Civil Engineering, 2540 Dole St., Honolulu, Hawaii 96822.

I.D.R.C., Box 8500, Ottawa, Canada K1G 3H9.

International Reference Centre, P.O. Box 13190, 2509 AD, The Hague, The Netherlands.

The Botswana Technology Centre, P/Bag 0082, Gaborone, Botswana.

The Mutomo Soil and Water Conservation Project, P.O. Box 125, Mutomo via Kitale, Kenya.

The Capiz Development Foundation, P.O. Box 57, Roxas City, Philippines.

The Faculty of Engineering, Khon Kaen University, 40002, Thailand.

UNICEF, Technology Support Unit, P.O. Box 44145, Nairobi, Kenya.

W.A.S.H., 1611 N. Kent Street, Room 1002, Arlington, Virginia 22209, USA.

WaterAid, 1, Queen Anne's Gate, London SW1H 9BT. Tel 01-222 8111.

Tools for Small Water Resources Implementation and Management in Rural Thailand

Prakob Wirojanagud
Associate Professor and Director
Water Resources and Environment Institute
Faculty of Engineering
Khon Kaen University
Khon Kaen, Thailand

Vason Vanvarothorn
Head
Rural Development Section
Provincial Administration Division
Department of Local Administration
Bangkok, Thailand

Prinya Chindaprasirt
Associate Professor and Dean
Faculty of Engineering,
Khon Kaen University
Khon Kaen, Thailand

Abstract

Four management tools have been identified for effective and sustainable development of small water resources in rural Thailand. These are: appropriate technology, decentralized development system, district watershed development planning, and geographic and management information system. The authors have been providing technical and managerial support to the Department of Local Administration of the Ministry of the Interior since 1985, with the objective of incorporating these management tools into government development system.

Through water resource projects such as the Thai-New Zealand Small Watershed Development Project and the Thai-German Self-Help Training Project on Small Water Resource Development in Rural Areas, Khon Kaen University has been successfully introducing these management tools to the Thai government. However, more efforts have to be pursued in training for self-help water resources development, district watershed planning, and information system.

1. Small-scale Water Resources Development

Just about 10 years ago, in 1979, the Royal Thai Government clearly stated its policy of small-scale water resources development in the rural areas. The policy was made following recommendations given in a 1978 investigation report, '*Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources*', prepared by the Asian Institute of Technology. The situation was clearly defined in the report, showing that all the large dam and irrigation schemes the Thai Government had commissioned in the past, even when fully operational, contributed to the needs of only a very small portion of the rural population. Eighty percent of the rural population living in areas that can never be served with water from large irrigation schemes and major rivers, could only look toward the development of small water resources scattered in the villages.

The distinction between large and small-scale development projects is in the nature of their implementation and management. In large-scale projects which are highly technical, the government can afford to hire technical personnel to be fully responsible because they are limited in number and economically justified to do so. For small-scale projects, the number of projects are tremendous and locations are scattered. This makes these projects economically infeasible to be supervised and operated by centralized means. It is, therefore, necessary that users must bear the responsibility of management. Social and economic feasibility is, therefore, a very significant factor for the success of a small-scale project.

The development of small-scale water resources during the first 5 years from 1979 to 1985 had been very inefficient. There were 16 government agencies and 17 committees involved in the implementation, but they were very much into experimenting on the appropriate design of water resource facilities and seeking ways and means for successful project implementation. Problems of water shortage for drinking and domestic use had not been effectively alleviated. For agricultural water, only about 20% of the small-scale irrigation projects were actually utilized by farmers for irrigation purposes. The majority of these projects also faced operational and maintenance problems. ***Efforts had to be made to develop better implementing procedures for a higher degree of success.***

Researchers at Khon Kaen University (KKU) have been among those actively involved in developing appropriate technology and implementing procedures for successful small-scale water resources development since 1979. Findings from research and experience with the implementation of water resource projects in Northeast Thailand over the past 10 years have identified four major tools for small water resource implementation and management:

- Appropriate Technology
- Decentralized Development System
- District Watershed Development Planning
- Geographic and Management Information System

During the past 6 years beginning 1985, the authors have been providing consultancy services to the Department of Local Administration of the Ministry of Interior with the objective of incorporating these management tools into the government development system. The emphasis was on *decentralized development management at the district level with the integration of the four management tools into the government development system in such a way that a project is planned and coordinated by the district, managed by local organizations with support on the use of appropriate technology, and with villagers' participation.* As a result, the water resource development and management in rural areas of Thailand have become more efficient with better operation, maintenance, and water utilization. The following section explains how these tools were applied in Thailand.

2. Appropriate Technology

Problems of inefficient small water resource development can be lessened with the use of development technologies appropriate to local geographic and socio-economic conditions of the rural community. One of the reasons for many unsuccessful projects in the past is that the water resource facilities and technologies used were too complicated for the villagers to operate and maintain. In many cases, the design was not appropriate for the needs of the rural community and local conditions, thus, making the facilities unsafe, uneconomical, and difficult to construct, operate and maintain.

One example of inappropriate technology applied to the rural community was the development of village piped water supply system. When a surface water source was chosen, the system would require a water treatment plant which is too complicated for the villagers to operate and maintain by themselves.

For small villages, the system was not self-sufficient due to the high fixed costs for operation and maintenance. Since the government agency which built them could not afford the subsidy, these systems failed within one year without financial and technical support from the government. People in these villages had to revert to their traditional way of getting water supply: drinking water by roof runoff collection and domestic water from shallow wells or ponds.

Another example of inappropriate technology applied in small water resources development is the adoption of the 'catchment yield design' (a procedure normally used for reservoir spillway design) for use in the design of small diversion weirs. As a result, the design procedure is unnecessarily complicated and the designed weirs were always too big and uneconomical. The inflexibility of the design procedure, together with the fixed height of weir crest, makes them unsuitable to local conditions and farmers are unable to regulate the water levels as they normally desire to do.

Researchers at Khon Kaen University have played an important role in developing appropriate technologies for small water resources development in rural areas and passing them on to the government agencies. In order to provide water supply efficiently, the need for water was classified into three categories: drinking, domestic uses, and agriculture. Since the need for water for each purpose is different both in terms of quantity and quality, the classification of water needs according to the specific use has given clear direction to the research and development of appropriate technology in resolving water problems.

For drinking water, the construction of rain water storage facilities, such as jars and tanks for storing rainwater from roof runoff was found to be an effective and economical solution. Consequently, KKU carried out research on roof runoff collection systems, water quality of rain and roof runoff, construction techniques for rainwater jars and tanks, and water utilization behavior of village households. Manuals for the construction of jars and low-cost rainwater tanks were published and disseminated for use through the nationwide "Jar and Rainwater Tank Construction Project".

Appropriate types of small water resources for domestic uses are shallow dug wells, tube wells and natural or dug ponds. Studies on appropriate technology related to the development of these water resource facilities have concentrated on dug ponds and tube wells. A study to investigate and improve the groundwater well drilling system for the self-help program was set up at KKU which involved three areas: development of appropriate drilling rigs that can be locally made and repaired, improved well design and construction techniques, and development of a suitable hand pump for a wide range of water depth. Two types of small drilling rigs were developed so far, a small hand drilling rig and an engine-driven rotary rig. The small hand drilling rig is appropriate for village drillers with low investment. The engine-driven rotary rig (having a registered name of Thai Rig 60 or TR 60) was accepted as standard drilling rig for the nationwide self-help program for groundwater development, the "People's Well Drilling Project".

As for agricultural water supply, weir construction across a stream has been the traditional method that farmers use to divert water into the rice fields during periods of streamflow, pass flood flows during the peak, and store as much water as possible for the dry season when the streams stop flowing, for domestic, livestock and fishing purposes. KKU with the support of the New Zealand Government had developed an appropriate design of weir which is safe, durable, economical, simple in design and which can be constructed, operated and maintained by villagers.

The basic hydraulic concept of this simple "KKU-NZ Weir Design Method" lies on the fact that at the sites where farmers need a diversion weir, unrestricted berm flow naturally occurred during flood events. Construction of a weir in the stream merely increases the quantities of berm flow to some extent. If the weir is designed to pass the natural channel capacity, then the effect of the weir on increased berm flow is insignificant. Based on this berm flow concept, a weir is designed to pass the natural channel flow capacity rather than the flow based on the watershed runoff estimation. During flood events, the flow in excess of the weir flow capacity will become berm flow onto the rice fields on both sides of the stream as it did previously before weir construction. This concept of "channel capacity design" not only simplifies the weir design procedure but also reduces weir sizes from the typical "catchment yield design" procedure generally used by Thai government agencies, thereby reducing the cost of water resources development investments. Most importantly, the simplified concept enables villagers to conduct survey, size the design, and construct the weir themselves with some advice from trained technicians. This weir design concept together with the weir construction approach using voluntary labor, provided the basis for the nationwide "People's Volunteer Weir Project".

3. Decentralized Development System

Rural development in Thailand is administered under the National Rural Development System. This system is centralized in the sense that planning, decision making and implementation is "top down". Under this system, local organizations such as village committees and sub-district councils do not take part in the planning and development process at all, but submit project requests selected from projects being offered by the agencies. After the project has been approved by the Government, the agency will carry out the work. Villagers or local organizations do not have any opportunity to make decisions or conduct the work in response to their own need. They often do not have the chance to gain experience in project management nor to decide how village water resources should best be managed.

Another existing development program is called the Rural Job Creation Program which has delegated the administrative power to sub-district councils. However, this program should still place more emphasis on the villagers' participation in planning and acting together. The government needs to strengthen the planning and management capability of the sub-district council, as well as improve the technical quality of the work.

For effective implementation and management of small water resources, decision making and implementation should be decentralized to the local people and decisions must reflect the local environment. Researchers from Khon Kaen University have studied water resources development systems which emphasize villagers' participation and the use of technology appropriate for local conditions. Development in the form of people volunteering their labor conform with the policy of the Ministry of the Interior. For this reason, the Department of Local Administration (DOLA) of the Ministry of the Interior, in cooperation with KKU, decided to implement the *"People's Volunteer Weir Project" (PVWP) and the "People's Well Drilling Project" (PWDP) in order to solve problems of inadequate water in rural areas through self-help approach and to lay the foundation for villagers' participation in water resources development.*

The development of small water resources using the voluntary labor approach integrates the philosophy of farmers' participation and self-reliance in accordance with the government's objectives for rural development. Under the PVWP, the villagers are responsible for site selection and construction, with the District Office providing the construction materials and technical advice. The cost of a volunteer-constructed weir is approximately one-fifth of the cost of an agency-built weir. Also, under the PVWP, the farmers are responsible for managing the project themselves, which means that they make use of local resources such as labor, expertise, and information.

The PWDP is another example where appropriate technology is used in rural development with an emphasis on farmer participation. Most groundwater development programs currently conducted by government agencies use very large and expensive drilling rigs; they are too expensive for individual farmers to fund, so that most of these wells are for community drinking and domestic water supplies. In order to reduce the cost and solve this problem, KKU has developed two small rigs, one hand-operated and the other motorized. Drilling and construction techniques have been studied and manuals have been published. The PWDP has been adopted also by DOLA and is being used to promote agricultural activities in areas remote from surface water resources. KKU staff train district and village technicians to enable them to use and maintain the equipment. Farmers requiring wells can request assistance from the district DOLA office and must pay for the materials, technician labor, and operational cost such as fuel. Total cost of wells are approximately one-fifth of the agency-constructed well costs.

The following figure gives a summary of the self-help water resources development projects implemented by DOLA. KKU is assisting DOLA to start the "People's Water Use Promotion Project" to enhance agricultural production once the water is available from these constructed water resources.

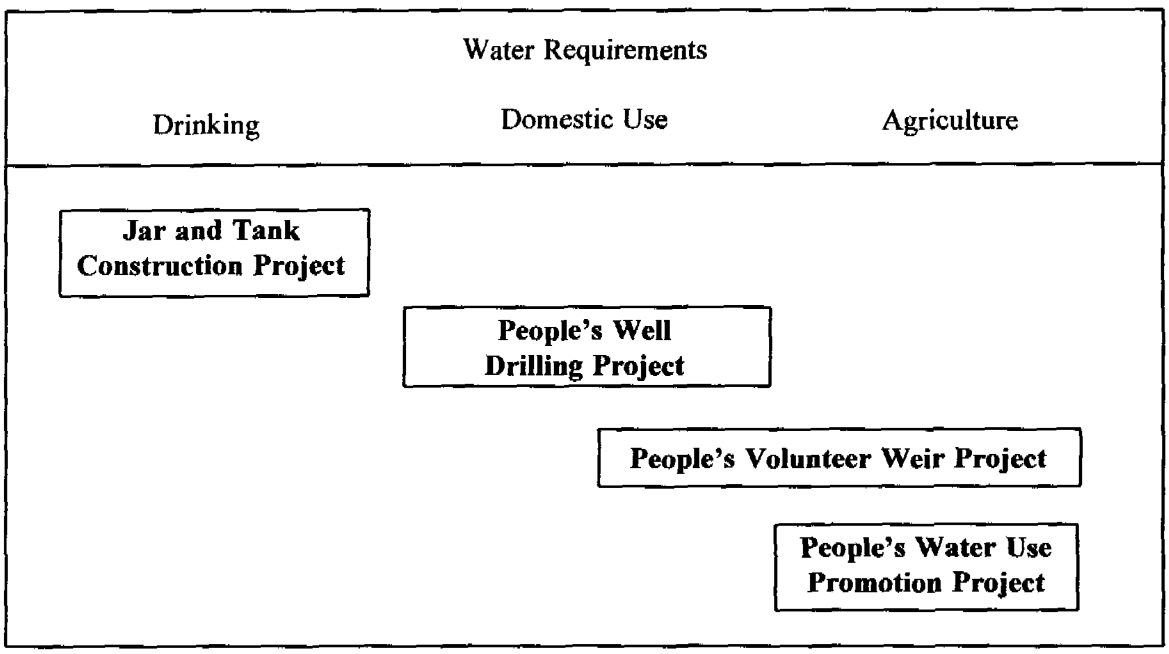


Fig. 1. Self-help water resources development projects

Khon Kaen University has been able to assist DOLA with these nationwide projects through the implementation of bilateral aid projects such as the Thai-New Zealand Small Watershed Development Project and the Thai-German Self-Help Training Project on Small Water Resources Development in Rural Areas.

4. District Watershed Development Planning

A district watershed development plan enables the district to coordinate the activities of other agencies as well as to specify the activities of the self-help water resource projects which are in their direct responsibility. The development of the larger watersheds with larger rivers should be the responsibility of the national construction agencies such as the Public Works Department, the Office of Accelerated Rural Development, and the Royal Irrigation Department. The district can integrate their watershed plans with the overall district and provincial plans.

The approach of water resources development according to watershed zoning, as given in Table 1 can be used as a guideline for small watershed planning.

Table 1. Development approach according to watershed zoning

Watershed Zone	Development Approach
Areas near reservoir	Irrigation system from reservoir Water use promotion and crop marketing
Areas near large stream	Pumping from river with distribution system
Lowland near small stream	Small weir or reservoir Stream dredging Groundwater well
Upland and rolling hills	Groundwater well Farm pond
Forest brushland, range land, and land subject to inundation	Forest plantation and conservation of water resources Erosion protection and drainage

The specifics of each small watershed plan varies according to the individual local environment and community development need. The district might start the plan with limited information and review it annually as more information becomes available and as implementation proceeds, or confidently plan five years in advance. In general, the content of a district watershed development plan should at least have the following components:

1. Natural conditions of water resources
2. Existing water resources development
3. Policies and goals of development
4. Development plan and budget
5. Plan for implementation and monitoring

5. Geographic and Management Information System

The major constraint in planning faced by government agencies is the lack of information or, if available, the information is not in a readily usable form. For this reason, there is a need for a planning information system. The established system has two parts: a management information system (MIS) at each provincial office, and a geographic information system (GIS) at the regional data centers, e.g. at KKU.

The MIS consists of the village data gathered from the National Rural Development, and other surveys. The GIS currently being developed for the Northeast displays the data in map form.

The computer-based information system enables planners to evaluate the existing water resources, current water usage, and the needs and potential for development.

The contents of the two components of the information system are outlined below:

Geographic Information System	**Management Information System**
- District map with streams, village locations, locations of existing water resources	- Village Information
- Stream inventory, properties, and flow characteristics	- Existing water resources facilities
- Crop suitability soil map	- Potential water utilization
- Topographic map	- Existing water utilization
- Land-use map	- Potential for water resources development

The two components will be updated and maintained, with revisions to the stored data as necessary. For example, current research on hydrology will give us guidelines as to the quantities of water in the watershed, the reliability and the development potential. Marketing research will help farmers plan their crops more confidently.

Khon Kaen University is assisting in the dissemination of the information along with the guidelines for its uses as the information systems are being developed. KKU is coordinating with central DOLA, the provinces, and districts for the whole of the Northeast in this task.

6. Conclusion

Improved water resources management will be achieved when the responsibility for rural development is decentralized to local organizations. This will result in decisions reflecting the needs of the individual rural communities, prompting a better standard of living, and conserving the balance of nature. Farmers must play a greater role in planning development, with guidance from the district office. Good local information and appropriate technologies must be used. Finally, the government must give recognition to the needs of the rural community in proportion to the country's rural population.

For successful and efficient management of small water resources in rural Thailand, more efforts will have to be pursued in training for self-help development, district watershed planning, and information system development.

References

ARBHABHIRAMA, A., et al. (1978) "Water for the Northeast: A strategy for the development of small water resources", Asian Institute of Technology, Bangkok, Thailand.

BOONYAKANJANA, P., et al. (1984) "Use of public standposts water supply in Thailand", First International Meeting on Public Standpost Water Supply, Thailand, IRC The Netherlands, 14p.

CHINDAPRASIRT, P. and P. WIROJANAGUD (1985) "Testing of mortar jar", Research Report, Water Resources and Environmental Institute, Faculty of Engineering, KKU, 13p.

CHINDAPRASIRT, P. and P. WIROJANAGUD (1985) "Wire reinforced mortar tank", Third Conference on Technology for Rural Development, Khon Kaen University, pp. 2:107-2:118 (in Thai).

SETHAPUTRA, S., P. WIROJANAGUD, and P. CHINDAPRASIRT (1985) "Small-scale water resources development in the Northeast: strategy and problems", The Third Conference on Technology for Rural Development, Khon Kaen University, pp. 6:203-6:216 (in Thai).

SRIBOONLUE, V., et al. (1987) "Village well drilling method of the Northeast", Thai Agricultural Engineering Journal, Jan-Apr (in Thai).

THAI-AUSTRALIAN VILLAGE WATER SUPPLY PROJECT and OFFICE OF WATER RESOURCES DEVELOPMENT, FACULTY OF ENGINEERING, KKU (1984) "Jar construction program for drinking water in rural areas", Promotion document, October 1984, 28 p. (in Thai).

WIROJANAGUD, P. (1990) "The people's volunteer program: A three-way collaboration in irrigation", Waterlines, 8(3):24-26.

WIROJANAGUD, P. and K. SMITH (1990) "Small watershed management in Thailand", Waterlines, 8(3):2-5.

WIROJANAGUD, P., et al. (1982) "People's Volunteer Weir Program: An appropriate approach to the development of water resources in rural areas", The Fourth Conference on Technology for Rural Development, Khon Kaen, pp. 6:111-6:121 (in Thai).

Natural Coagulants for Small-scale Water Treatment: Potential Applications

G. K. Folkard
Lecturer
Department of Engineering
University of Leicester
United Kingdom

J.P. Sutherland
Research Associate
Department of Engineering
University of Leicester
United Kingdom

W. D. Grant
Senior Lecturer
Department of Microbiology
University of Leicester
United Kingdom

Abstract

Polymers derived from natural materials perform effectively as primary coagulant aids in the clarification of turbid raw water. Of principal interest are seeds of the tree *Moringa oleifera.* Technical, economic and environmental advantages are claimed by using such natural coagulants in preference to aluminum sulphate and proprietary polyelectrolytes for many developing countries. Their application is considered across a wide scale from individual household level to community water treatment works. The work of the Environmental Engineering Group at the University of Leicester is briefly reviewed and future development plans outlined.

1. Introduction

The World Health Organization estimates that 1,130 million people are currently without access to safe drinking water. Of this total, 80% live in relatively small rural communities, often relying on rivers as their only source of water (WHO, 1988). Irrespective of season, such sources can, on occasion, exhibit bacterial concentrations that would be normally associated with weak, raw sewage (FEACHEM, 1980). For such communities, household treatment and low capacity treatment works can make a significant impact on drinking water quality and, consequently, on the general health and well-being of the people.

Chemical treatment of surface waters using, for example, aluminum sulphate (alum) and/or synthetic polyelectrolytes is generally not feasible due to high cost, absence of suitable infrastructure necessary for supply and distribution and lack of skills required for treatment application. The use of coagulants derived from indigenous plant materials is a viable alternative which offers significant technical, economic, and environmental advantages.

Seed kernel material of the tree *Moringa oleifera* Lam. [1](*M. oleifera*) is widely accepted as the most effective of the plant coagulants. The seeds have been shown to be non-toxic (BARTH et al., 1982) and the tree itself has a high growth rate and yield (JAHN, 1986) and is indigenous to many countries in the developing world. The effectiveness of the seeds have been demonstrated in a number of studies (JAHN, 1981; FOLKARD and GRANT, 1989; and SUTHERLAND, 1989). At high initial raw water turbidities, *M. oleifera* seed application gives results comparable to those obtained using alum.

The work of an inter-disciplinary Environmental Engineering Group at the University of Leicester is briefly reviewed.

M. oleifera applications are reviewed over a range of operation capacities: from 40 liter batch treatment in clay vessels intended for individual treatment to rural treatment works level.

One of the main objectives of this paper is to stimulate interest in tropical and sub-tropical developing countries in the application of natural polymers to water treatment.

2. *Moringa oleifera* Seeds as a Naturally Derived Coagulant

2.1 Laboratory Work

The tree *M. oleifera* is a native of the sub-Himalayan regions of northwest India and indigenous to many parts of Africa, South America and Asia. In addition to the provision of coagulating material, the trees are cultivated in many areas for a variety of other purposes. For example, the leaves, green pods, flowers and seeds are used as vegetables; the seeds for oil; all plant organs for various medicinal purposes; and the trees themselves as live fences and land stabilizers. However, traditional usage of the seeds as coagulants has been limited to remote areas of the Sudan.

Laboratory studies in the United Kingdom have established seed efficiency using model clay, clay/bacteria and dilute sewage suspensions. Results have demonstrated the seed to be most effective at removing suspended material from water exhibiting relatively high initial turbidities. Reductions in bacterial numbers in the range of 90 to 99.9% have been achieved. The limited regrowth potential was established to be due to the nutrients naturally present in the water.

Investigations into the removal of viruses have been carried out using bacteriophage (bacterial viruses). An important finding is that not only are the seeds capable of removing bacteriophage, but they appear to have an inhibitory effect preventing replication of the bacteriophage. Work on animal viruses is planned.

2.2 Field Work

Field studies carried out in Malawi in the period October 1988 to February 1989 provided further evidence as to the efficiency of the seeds. Three contrasting river sources were examined over the transition period from the dry to the wet season. *M. oleifera* seeds, harvested in Malawi, were applied to these water sources.

Compared to alum addition, seed application gave equivalent, and in some cases superior clarification of highly turbid waters. However, as for model suspensions, the results do indicate a limit to

[1] Authors' note:

Specimen of *M. oleifera* noted growing in Thailand at Chiangmai, Kanchanaburi, Bangkok, and Petchaburi (VERDCOURT, 1986).

Vernacular names in Thailand given variously as Kaanaeng-doeng, Phak echuem, Phak eehum, Phak-nuea-kai, Se-cho-ya, Ma khonkom (Northern) and Ma rum (Central/Peninsular) (JAHN, 1981).

the effectiveness of seed addition alone for the treatment of low turbidity waters. Another approach was adopted whereby approximately equal quantities of alum and whole seed were mixed and then applied as "co-coagulants". Dramatic improvements in floc quality and settling were apparent using this dosing regime even at low initial turbidities. As Table 1 below indicates, alum savings in the range of 60-75% are possible.

Table 1. Field data for Thylo raw water; comparison of alum as primary coagulant to alum as "co-coagulant" with *M. oleifera* seed

Initial Turbidity (NTU)	Alum (mg/L)	Residual Turbidity (NTU)	Alum (A)+ *M. oleifera* (MO) (mg/L)	Residual Turbidity (NTU)	Percentage Reduction in Alum
18	50	1.0	A 15 + MO 10	2.3	70.0
22	40	2.0	A 15 + MO 10	2.4	62.5
25	50	1.0	A 15 + MO 15	1.9	70.0
30	40	2.6	A 15 + MO 15	3.6	62.5
150	40	7.6	A 10 + MO 50	6.3	75.0
900	80	5.4	A 40 + MO 50	5.5	50.0
1450	80	6.6	A 20 + MO 60	7.0	75.0

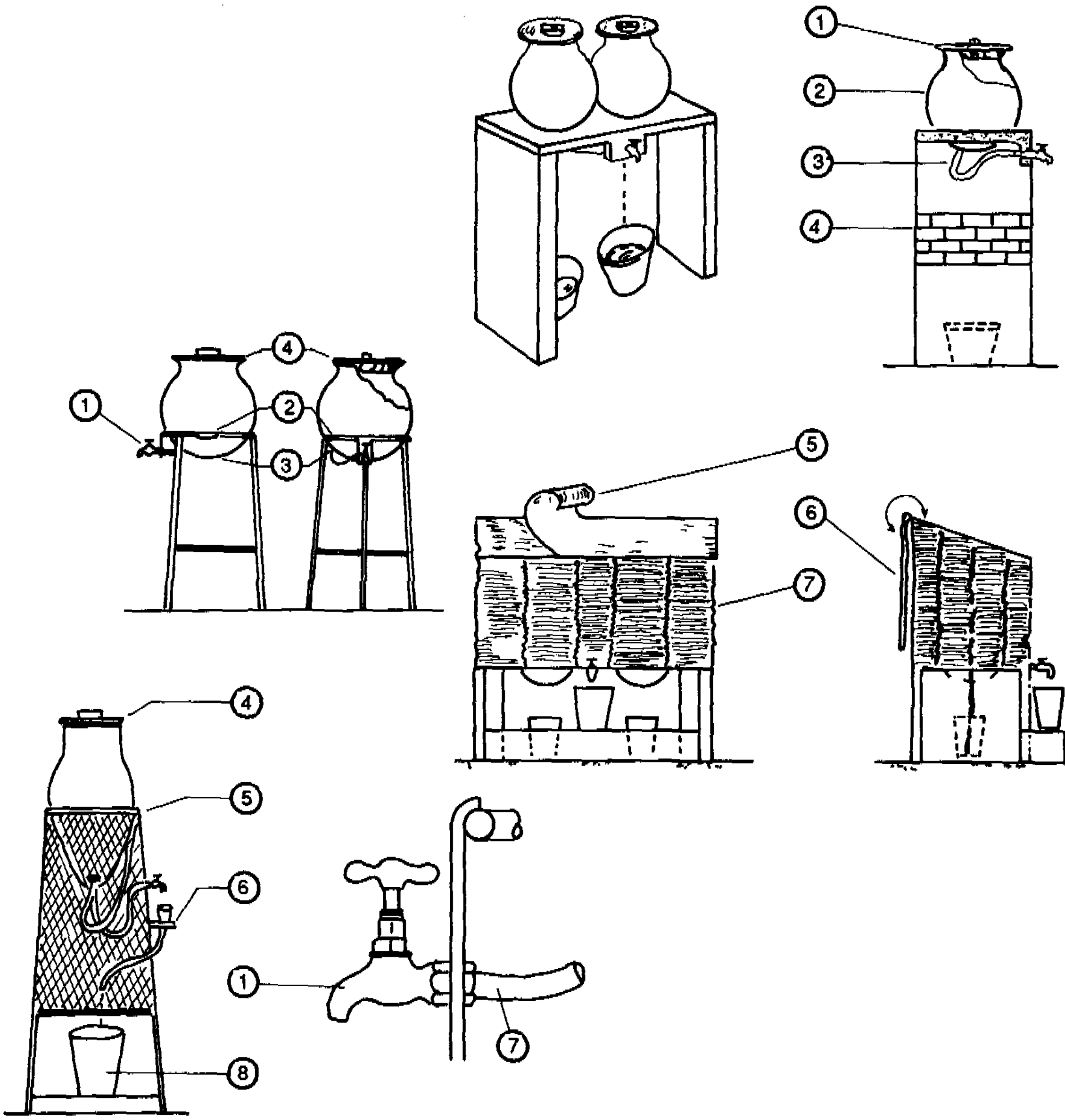
At initial turbidity of 1,450 NTU, *M. oleifera* at 120 mg/L outperformed alum, giving a residual turbidity of 4.1 NTU.

3. Potential Applications of Natural Coagulants

3.1 Individual Household Level

The simplest form of treatment in batch mode is through the use of traditional or modified clay jars as shown in JAHN (1986). Fig. 1 shows examples of simple improvements and protections employed.

The introduction of this treatment process to areas outside those of current traditional usage has been limited. In Indonesia, a program aimed at introducing the seeds at the village level has so far proved very successful. Following a period of educating the villagers to the risks of untreated water, 180 families were supplied with clay jars by the Indonesian NGO Yayasan Dian Desa. The NGO also supplied seeds from its own plantations, encouraged the villagers to grow their own trees, and provided a full time member of the staff to continue the education of the villagers and to monitor the success of the program. Despite some setbacks with the supply of seeds, at the end of the first year all 180 families, plus six others who had requested that they become part of the program, were still treating their daily drinking water with the seeds. Clarified water for consumption is subsequently boiled to improve the bacteriological quality still further.



Improved traditional clay jar on simple holders

1. Tap mounted on iron plate
2. Slit hose to protect jar when mounted
3. Outlet above sludge level
4. Tight fitting lid
5. Drainage pipe
6. Recycling of spilt water
7. Hose connection for jar
8. Collection of evaporation water and other losses

Jar holders of brick and concrete with protection

1. Tight fitting lid
2. Traditional clay jar
3. Outlet hose to tap
4. Brick side walls
5. Water-tight roofing mat
6. Removable bamboo lattices
7. Front view of installation

Fig. 1. Improvements possible for household treatment units
(from JAHN, 1986)

3.2 Community Level

As a contribution to the International Drinking Water Supply and Sanitation Decade, the Institute of Human Settlements Agency in Indonesia developed the system shown in Fig. 2. The two stage system employs sand filtration as a second treatment phase and can operate with raw water tanks up to 200 liters in capacity. Construction costs for the model illustrated were estimated at US$ 18 in July 1987.

3.3 Treatment Works Level

One study has been carried out in Burundi where small works (continuous flow) were constructed and operated for a period of a year using the seeds as the coagulant (KASER, 1989). The works were constructed taking into account the fact that it should be simple to build, operate, and maintain. In addition, the plant has to be economic in terms of initial capital and operating costs and consideration had to be given to the possibility of the rural population undertaking self-help activities. The works were designed for a capacity of 2.5 m^3 per day and consisted of a sand trap, *M. oleifera* seed dosing unit, flocculator channel, settling basins, filtration unit (comprising of pre-filter and two successive slow sand filters), and storage tank (Fig. 3). The plant was capable of producing treated waters with 97% turbidity removals, accompanied by reductions in fecal coliform numbers in the order of 99.0%. *M. oleifera* seed dosages were in the range of 50-100 mg/L. The quality of the treated water considerably reduces the risks from waterborne disease. However, a residual disinfection stage may be necessary for any future designs.

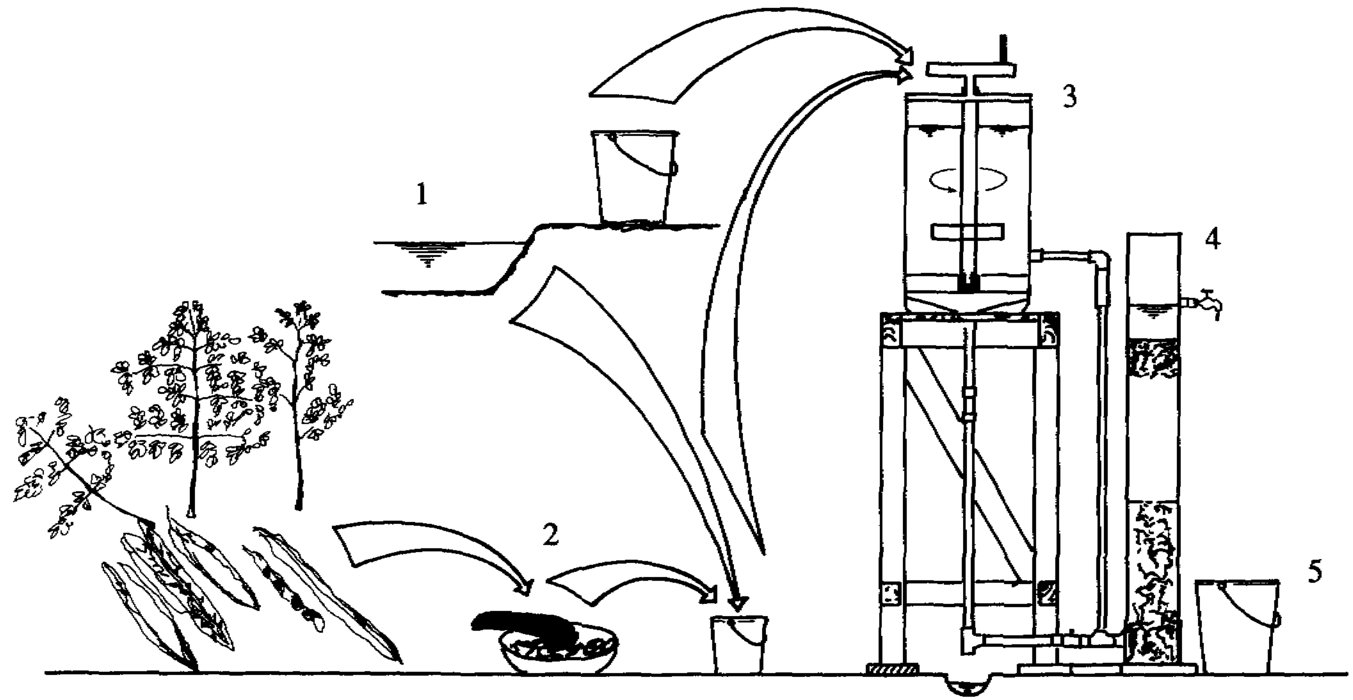
The use of *M. oleifera* for large scale treatment of surface-derived raw waters is currently being evaluated by the Environmental Engineering Group at the University of Leicester.

A rural treatment system with a flow capacity of 150 m^3 per day using alum as coagulant has been identified in southern Malawi, being operated by the Ministry of Works and Supplies. In 1991, a field study is planned during which the alum dosing will be replaced by *M. oleifera* seed dosing. Seeds for this large-scale trial will come from a plantation specifically established for this purpose.

Aspects of seed propagation, cultivation, harvesting, processing and storage are currently under investigation in collaboration with the Forestry Research Institute of Malawi. Table 2 provides estimates of the area of plantation required (hectares) over a range of nominal works flow capacities for a full year of operation. The figures are based on a tree spacing of 2 m, an average kernel weight of 150 mg, and an average tree yield of 10,000 seeds per year.

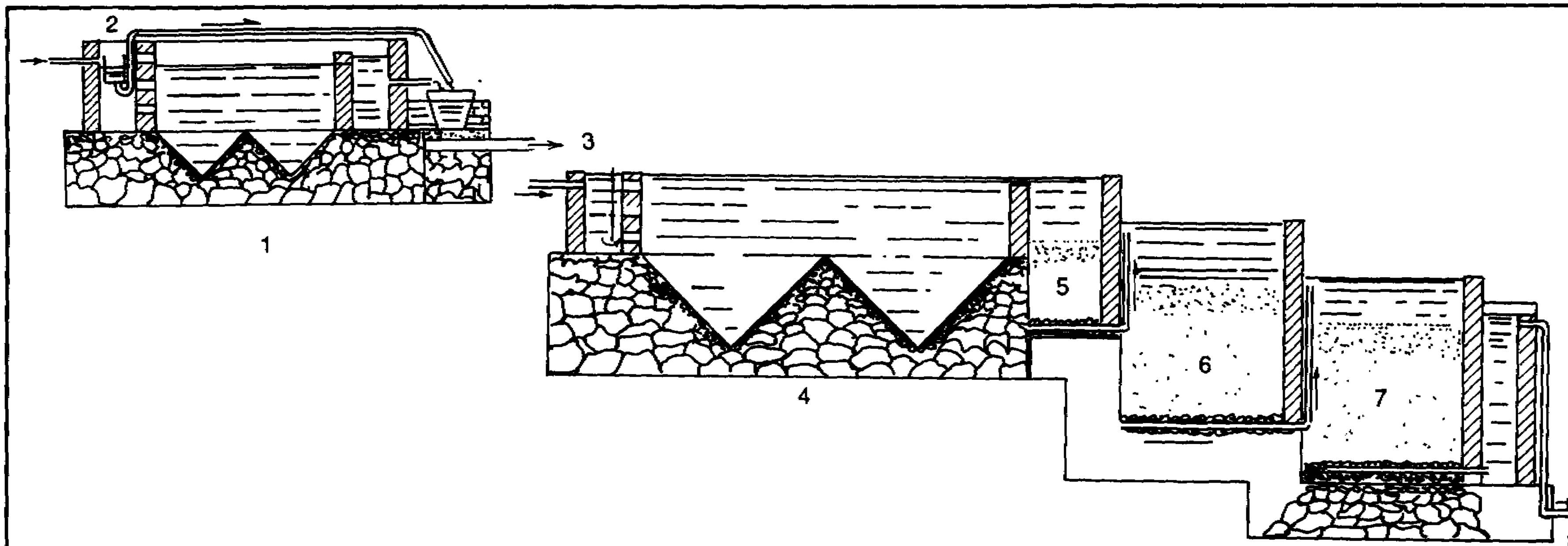
Table 2. Area of *M. oleifera* plantation required (ha) for a full year of operation at stated flow rates and seed dosages

Moringa oleifera Dose (mg/L)	Nominal Works Flow Rate (m^3/d)			
	5	20	40	400
25	0.012	0.048	0.096	0.960
50	0.024	0.096	0.192	1.920
75	0.036	0.144	0.288	2.880
100	0.048	0.192	0.384	3.840



1 Raw water from river source
2 *M. oleifera* seeds crushed and added to small quantity of water
3 Coagulation-flocculation-sedimentation vessel with mechanical stirrer
4. Upflow sand filter
5. Treated water collection

Fig. 2. Community treatment unit developed in Indonesia (from IHS, Indonesia, 1987)



1	GRIT CHAMBER	-	settling basin with inverted pyramidal base; sludge draw-off pipes from apex not shown; dentated outlet weir.
2	COAGULANT DOSING UNIT	-	controlled by water level fluctuation.
3	HYDRAULIC FLOCCULATION	-	within 15 m long interconnecting bamboo channel of 1.6 m overall drop.
4	PRE-FILTER	-	0.8 m deep sand bed with mean grain diameter of 0.6 mm on 3 mm diameter gravel support bed.
6,7	SLOW SAND FILTER	-	0.8 m deep sand bed with mean grain diameter of 0.6 mm on 3 mm diameter gravel support bed.
8	TREATED WATER STORAGE TANK	-	with 2.3 cubic meter capacity.

Fig. 3. Schematic diagram of 2.5 m^3/day treatment works in Burundi

4. Conclusions

- The *Moringa oleifera* tree is hardy, drought-resistant, fast-growing and yields high quantities of seeds.

- Promotion as a renewable natural resource and cultivation as a 'coagulant crop' may arrest deforestation in sensitive areas. The tree itself provides other useful materials.

- The seeds are non-toxic and effective as coagulants to remove turbidity and bacteria from water; as cost-effective replacement of imported chemicals.

- Application is viable from household treatment to rural treatment works level.

References

BARTH, W.H., M. HABS, R. KLUTE, S. MULLER, and B. TAUSCHER (1982) "Trinkwasseraufbereitung mit Samen von *Moringa oleifera* Lam", Chemiker Zeitung, 106:75-78.

FEACHEM (1980) "Bacterial standards for drinking water quality in developing countries", Lancet, pp. 255-256.

FOLKARD, G. K. and W. D. GRANT (1989) "The introduction of natural coagulants to water treatment practices in Malawi - Laboratory Studies", Paper presented at Int. Seminar on The Use of Natural Coagulants in Water Treatment, Yogyakarta, Indonesia, 2-7 October.

INSTITUTE OF HUMAN SETTLEMENTS, INDONESIA (1987) "Low-cost installation for clean water treatment using Kelor seeds (*Moringa oleifera*)", Agency for Research and Development, Ministry of Public Works, Indonesia.

JAHN, S. A. A. (1981) "Traditional water purification in developing countries - existing methods and potential application," Manual No. 116, Pub. GTZ, Eschborn, West Germany.

JAHN, S.A.A. (1986) "The tree that purifies water," Unasylva, 38:23-28.

JAHN, S.A.A. (1986) "Proper use of African natural coagulants for rural water supplies: research in the Sudan and a guide for new projects", Manual No. 191, Pub. GTZ, Eschborn, West Germany.

KASER, F. (1989) "Small rural treatment plant - studies with *Moringa* seed as flocculant", Paper presented at Int. Seminar on The Use of Natural Coagulants in Water Treatment, Yogyakarta, Indonesia, 2-7 October.

SUTHERLAND, J. P. (1989) "The introduction of natural coagulants to water treatment practices in Malawi - field studies", Paper presented at Int. Seminar on The Use of Natural Coagulants in Water Treatment, Yogyakarta, Indonesia, 2-7 October.

VERDCOURT, R. (1986) "A synopsis of the Moringaceae", Kew Bulletin, 40:(1)1-34.

WORLD HEALTH ORGANIZATION (1988) "Review of progress of the International Water Supply and Sanitation Decade, 1981-1990; Eight years of implementation", Report by the Director-General to the Executive Board, 83rd Session, Item 5, October 25, 1988, World Health Organization, Geneva.

Acknowledgements

The authors gratefully acknowledge the financial support provided by the Overseas Development Administration of the British Government. The authors also take this opportunity to thank [2]Dr. Jahn, for her inspiration, support and guidance over the past five years. She is, and remains, the leading advocate of the use of natural coagulants.

[2] Project Leader and Special Advisor on Traditional Water Purification, Section for Water Supply and Sanitation, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Fed. Rep. of Germany

An Integrated Summary of Evaluation Studies on Several Community Potable Water Supply Projects in the Philippines

Carmelo M. Gendrano
Research Officer
Tulungan sa Tubigan Foundation
Philippines

Marieto M. Perez
Operations Manager
Tulungan sa Tubigan Foundation
Philippines

Abstract

In 1989, *Tulungan sa Tubigan Foundation, Inc.* undertook evaluative surveys of several completed community water supply projects (CWSPs) in which it participated.

The surveys focused on the following areas of inquiry:

- Comparison of project targets and accomplishments (costs, infrastructures and extent of serviceability);
- Functionality of installations and reasons for nonfunctionality; and
- Beneficiary profiles, logistics of system operation and maintenance; and political interventions.

Aside from the information gathered on these areas, the surveys resulted in direct and indirect benefits to the projects which have more than paid for survey costs.

1. Background

The *Tulungan sa Tubigan* (Cooperation for Water) *Foundation, Inc.*, or TSTF is a non-government, non-profit volunteer organization extending technical and financial assistance to depressed and mostly rural communities by providing facilities for potable water supply. It also undertakes research and training on potable water technologies and management.

Aside from being the funding donor, the TSTF works with a proponent organization and the beneficiaries themselves in the planning and implementation of a CWSP. A proponent (a local government unit, area-based NGO or church group working for the economic, social, or even spiritual upliftment of a specific disadvantaged beneficiary group), in consultation with the beneficiaries, first works out a project proposal for submission to the TSTF. This proposal, which identifies water problems in the project area, the technical solutions envisioned, and the scope and costs involved, is then checked by the TSTF against actual field conditions and its own budget limitations. After suitable modifications, the Foundation then disburses the required amount to the proponent as a grant.

Prior to or immediately after the start of the project, the concerned staff of the proponent (and often, the beneficiaries or at least its most active members) undergo short, TSTF-administered courses on community organization, project management, community sanitation, and operation and maintenance of water supply systems.

The choice of technology depends on the most economical source of adequate and potable water to be tapped. TSTF usually utilizes the modes shown in Table 1.

Table 1. Rule of thumb costs

System	Rule of Thumb Per Capita Cost Allotment ($)
1. Shallow hand pump wells	6-7
2. Deep hand pump wells	7-9
3. Spring-fed gravity pipe system serving public faucets	18
4. Roof runoff catchment and storage systems	0.06/liter

Whatever the technology used, the required materials and skills are derived from local sources as much as possible.

During the project implementation, the TSTF provides overall policy direction and technical consultancy, while the proponent is responsible for on-site technical, material procurement, administrative, accounting and coordinating staff services. The beneficiaries, meanwhile, are expected to provide the bulk of labor inputs and, where locally available, some materials (e.g., aggregates and formwork lumber). More importantly, they are expected to care for or expand their respective completed systems with little or no further support from both the TSTF and the proponent.

For its operating funds, the TSTF is dependent on contributions from the general public, the business community, and the Government as well as project-specific grants from local and foreign institutions.

2. How the Studies were Conducted

The surveys were done intermittently between January and October 1989 in completed projects in Nueva Ecija, Rizal, Laguna, Camarines Sur, Antique, Cebu, and Northern and Eastern Samar. They covered 211 shallow wells, 8 deepwells, 2 spring-fed piped systems and 25 rain water tanks.

A TSTF research officer went to each of these sites guided by proponent staff. Hydrology conditions were noted, the status of each system was determined and interviews with some of the beneficiaries were done (in one project, questionnaire forms were accomplished). Additional data were gathered from involved TSTF and proponent officers and existing project documents.

The evaluation team also carried along tools and spare parts for repairing dilapidated or unserviceable systems. Inspection instruments such as well depth plumbs, pump valve lifters, and borehole periscopes were fabricated in the field.

3. Results

3.1 Project Targets vs. Accomplishments

3.1.1 Infrastructure (Table 2)

Table 2. Infrastructure targets and accomplishments

Type of System	Number of Units	
	Targeted	Actual
Shallow wells	92	233
Deepwells	59	15
Spring-fed piped	2	2
Rainwater tanks	186	154

The low-cost technologies used in excavating shallow wells (jetting and manual digging; adoption of uncased borehole designs as shown in Fig. 1) and conscientious fund management by most proponents enabled more shallow wells to be constructed for the same or less amounts of money.

The lack of hard-rock drilling equipment in many areas forced the scrapping of deepwell installation in these sites. In many instances, funds intended for the latter were rechanneled instead to shallow well construction.

The shortfall in rainwater tank construction was mainly due to the failure of 30 of the smaller, unreinforced mortar jars soon after fabrication. This problem was eliminated by incorporating GI wire reinforcement in subsequent units constructed.

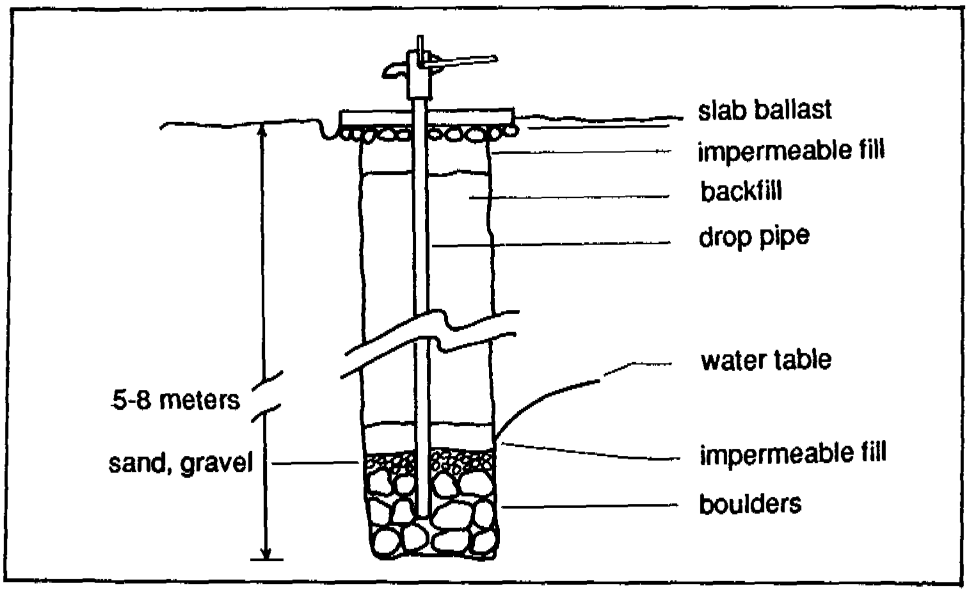


Fig. 1. An uncased, hand-dug well

3.1.2 Costs (Table 3)

Table 3. Actual costs

Type of System	Typical Cash Cost (US$)	
	per system	per capita
Shallow well pump, uncased borehole (6-8 m depth)	200	1-4
Deepwell pump, cased (18-30 m depth)	1,000	3
Spring-fed piped system	2,000	7.50
400-liter mortar jar	5	0.80
12,000-liter interlocking block tank	400	28

Only one of the projects exceeded its budget. This was basically a research endeavor where a new type of handpump (developed by the International Development Research of Canada or IDRC and Universiti Malaya) featuring plastic below-ground components was being field-tested. Monitoring and training as well as importation and inflation expenses increased per capita cash costs for this project to over US $20.

Actual per capita costs were below TSTF rule-of-thumb figures. Overhead, including training typically accounted for 10-20% of cash costs.

3.1.3 Number of Beneficiaries Served and Extent of Service (Table 4)

Table 4. Targets and accomplishments for beneficiaries served

Area/Project	Target	Actual	Explanation for Variance
Camarines Sur, Rizal, Laguna, Negros (IDRC Pump)	-	-	No set targets
Antique	24,000 families	974 families	Unrealistic targets (it would have meant that every pump will service 2,880 persons)
Cebu (Bantayan) rainwater tanks	1,700 families	230 families	Unforeseen hauling costs costs reduced infrastructure accomplishment
Northern Samar	502 households	750 households	More actual users per system than planned
Eastern Samar	10 communities	45 communities	More systems were installed and more users than planned
Nueva Ecija	450 households, 2 schools	267 households, 3 schools	Erroneous target estimates, unoptimized system siting, breakdown of some systems

Of 62 functioning pump wells, 43 were providing their users enough water for all household needs. Drawing water for bathing and/or washing were prohibited from seven others due to insufficient well yield, while well water from 12 units were deemed unsuitable for drinking.

The two spring-fed systems also suffered from inadequate yield, and were restricted for drinking purposes.

The estimated 230 families using rainwater tanks were getting only about 12% of household water requirement from these. This was due to insufficient tank and catchment sizes (averaging only 400 liters and 7 m^2, respectively, for each 6-member family). As these installations were in small coral limestone islands, beneficiaries, used to calcareous well water, found rainwater strange-tasting. This, and the fact that runoff from thatched roofs were discolored, restricted the use of tank water for drinking purposes.

3.2 Functionality of Installations

3.2.1 Pumps

Four makes of pumps were used in the surveyed projects (Fig. 2):

a) IDRC-UM pumps

These pumps feature a PVC cylinder with pistons and footvalves of the same material. Polyethylene seals are used in the pistons while rubber is used in the footvalves. Rubber flaps are also used and acetal bolts hold the piston and footvalve assemblies together. The pumprod is either PVC or GI pipe or steel bar. The drop pipe is also of PVC. The stand is mainly of commercial ungalvanized steel pipe length (with some galvanized sections). In the Mark II and lift versions, the leverage is a combination of GI bars, oil-soaked wood and GI bolts to serve as hinges. In the Mark III model, the steel bars and a GI pipe handle replaced the wooden components. The intention was to produce a VLOM design out of off-the-shelf materials.

After four years of operation, beneficiaries rated the pumps highly in terms of above ground sturdiness, ergonomics of operation, and ease of assembly and disassembly. However, they had some marked weaknesses. Of the 85 units installed, 6 broke down due to sand (sand particles were imbedded on the polyethylene seals and wore out the PVC cylinder), 2 due to pump stand corrosion, 2 (all lift pumps) due to failure of substandard PVC pump rods, and 4 (all Mark IIs) due to a design oversight in the leverage linkage (which had only 3 instead of the 4 necessary hinges). Five more pumpwells were not operational due to borehole-related problems (borehole collapse, inadequate yield and water quality).

The rubber parts tended to swell and crack with chemically aggressive water, plastic bolts failed due to entrapped air in their material, and pins and bushings wore out quickly.

Since most parts had to be imported and the local supply network for them was weak, 5 additional pumps were left unrepaired by users. Nevertheless, perhaps due to intensive user training for these research project pumps, the users exhibited resourcefulness in repairing the rest of the units: bolts were procured from local hardware stores, electric-arc welding and GI wire were used to repair connectors, wood parts were fabricated by village carpenters, and users even tried to make seals out of discarded rubber sandals. (IDRC and UM have since developed a vastly improved series of similar pumps, and the TSTF is currently involved in their manufacture and marketing in the Philippines.)

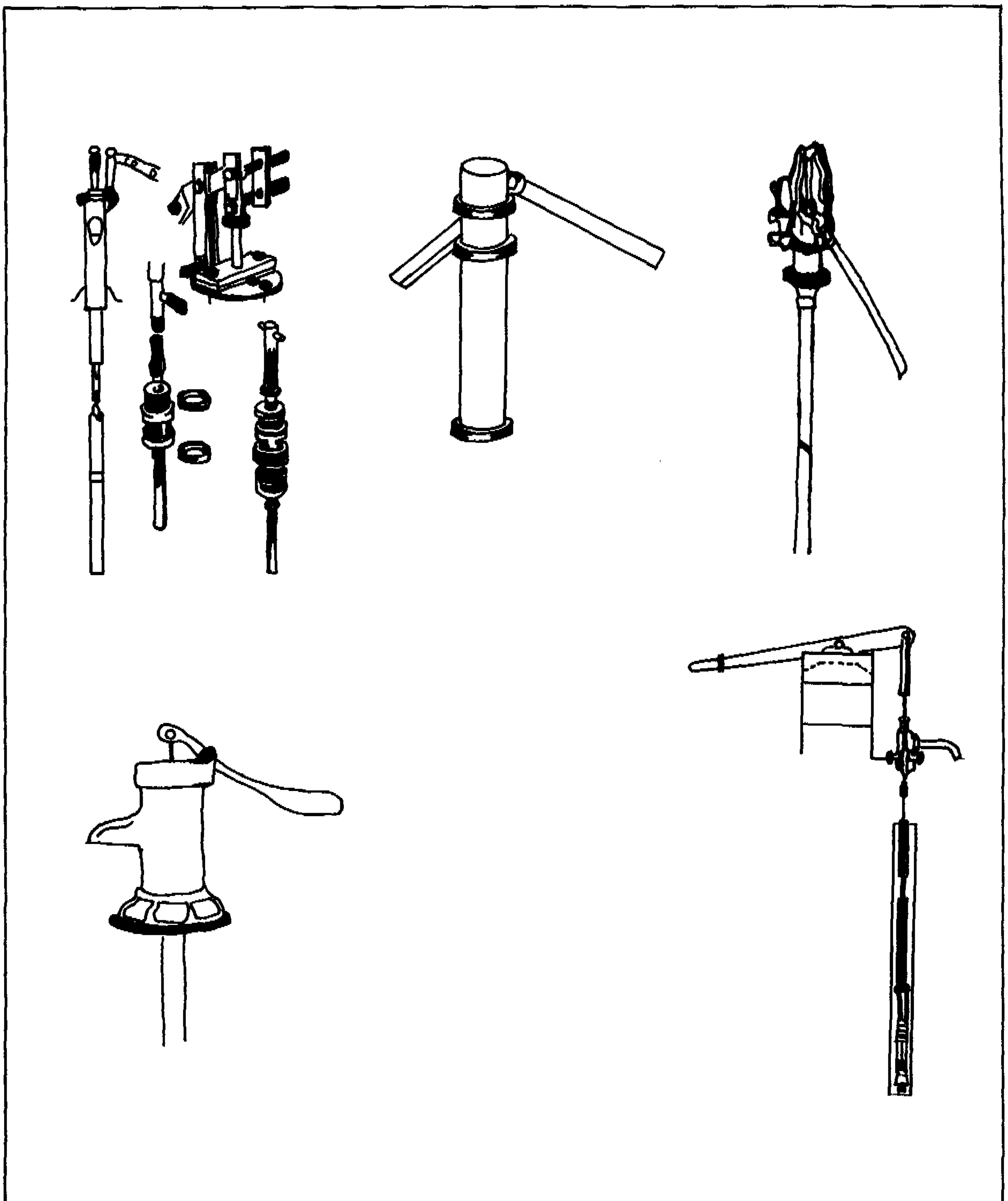


Fig. 2. Project pumps (from top left, clockwise): IDRC Mark II, Mark III, Jetmatic, Clayton Mark, Pitcher

b) Jetmatic pumps

These are the locally made suction version. The piston and footvalve are of sandcast and drawn-iron materials fitted with rubber seals and flap valves. The stand and leverage are likewise sandcast except for the handle, which is made of light gauge GI pipe. The whole assembly can be screwed onto a GI drop tube, while the latter can be sunk into a bare borehole and backfilled, eliminating the need for a casing.

Contrary to an earlier World Bank-UNDP study, this pump type proved suitable for community shallow well use. Of 121 units, only 14 were non-functional after an average of two years use at service loads of up to 200 households per unit. Three cases were due to the pumps being stolen (they were easy to disassemble), 10 due to breakdown of the leverage assembly and wear-out of rubber seals, and one due to cracking of the pumpstand.

The cast iron construction was acceptably resistant to corrosion and the units were cheap (around \$25-30 or 1/4 to 1/3 the cost of an IDRC-UM model). Parts were widely available and because this pump type has been around for several decades, users were quite familiar with its use and mechanisms. Beneficiaries easily replaced corroded handles with thicker gauge GI pipe, wood or even bamboo while loose connections were repaired with wire. Although the lack of bushings resulted in high wear-out rates of hinges, considerable extension of service life was facilitated by regular lubrication through built-in oiling ports.

c) Pitcher pumps

These are cast-iron suction pumps of simpler design and fewer parts. They were even cheaper (\$15-20 per unit) than jetmatic pumps although the small bore of the cylinder (5 cm versus the latter's 8.75) and the short cast iron handle limited the pumping capacity.

All of the seven units installed were still operational. Like the jetmatic, this pump is commonly available in the country and users were well acquainted with its maintenance. Wire was commonly used for repairing connections, while unserviceable fulcrum pins were replaced with nails, steel bars, wood, bamboo or even engine valve stems.

d) Clayton Mark brass pump type

Two of the 8 units visited were not working due to breakdown of below-ground parts (piston seal and pumprod thread). These breakdowns were minor, however, beneficiaries were reluctant to repair the defective parts because these were located deep below ground. Spare parts were also scarce.

The unavailability of above ground components (at the time, the pumps were sold as sets of below ground assemblies) forced users to make improvised stands and leverage configurations.

3.2.2 Rainwater Tanks

The types of tanks used included the 400-liter wire-reinforced mortar jar, the 12 m^3 interlocking block tank (IBT), and the 10 m^3 ferrocement tank.

Although these proved to be technologically viable (the IBTs developed some leakage due to dissolution of calcareous deposits used in the mortar), they supplied only a fraction of users' requirements for previously mentioned reasons (see 3.1.3). Due to poverty, the household roofs of many users had no gutters which, therefore, prevented the efficient collection of rainwater to the collection tanks. In one church, the collection potential of the main roof (area of 1,080 m^2) was overlooked and its IBT was installed on the roof of a smaller building.

The lack of suitable aggregates in the project sites (which were mostly coral limestone islets) required procurement from larger islands and resulted in higher costs. This in turn limited the number of units constructed to only 6 out of 19 IBT and ferrocement units targeted. Organizational difficulties between proponents and beneficiaries further reduced the number of completed units to only 3. Of the 3 units constructed and completed, only one was being fully utilized. One tank was not connected to the catchment roof while the other had a catchment which was allowed to clog with fallen leaves.

Nevertheless, each operational 400-liter jar saved users $15-30 annually in terms of reduction in the purchase of peddled water (in effect the jars paid for themselves five to ten times over in a year). For IBTs, on the other hand, the savings were $120-400, implying payback periods of one to three years. Had proponents and beneficiaries been informed of these figures, they might have taken better care of, maximized or even expanded their systems.

3.2.3 Spring-fed Systems

Water yield from the two systems studied were below the pre-project estimates. It was surmised that the initial flows attained by enlarging the spring eyes were not sustainable by the aquifers. In one system, persistent filamentous algal growth inside the upstream portion of the transmission pipes decreased carrying capacity.

3.3 Water Quality

The additional effort in bringing samples to laboratories limited the number of potability testing done on the proposed sources of water by the project staff. Furthermore, by the time the sources can be sampled, much infrastructure work has already been invested (e.g., the boreholes have already been drilled) so that it would have been more economical to continue with construction rather than abandon it had the water been found not potable.

In a related TSTF study, about two-thirds of 22 local water sources analyzed were found to be below international bacteriological standards. This may also be the case for the projects covered by this study. However, as no breakouts of water borne diseases have been reported, it may be surmised that users have become accustomed to the water from their respective systems.

3.4 Beneficiary Profile and Consumption Patterns

An overwhelming majority of beneficiaries were economically disadvantaged. They were small farmers, small fishermen and aquatic products gatherers, cottage industry workers, laborers, and the partially employed. About 5% were urban poor.

In an in-depth survey of the beneficiaries of 27 pumps in one project area, the following data were taken:

Average Household Size:	8 persons
Average Water Consumption:	(liters)
drinking	4.15
bathing	11.66
washing clothes	10.16
washing dishes	3.47
toilet flushing	4.90
Total	34.34

3.5 Existing Modes of Water System Maintenance and Operation

In the sampling surveys on pump systems, beneficiaries delegated the repair and maintenance tasks to either an informal caretaker who is usually a member of the family on whose lot the pump stands (46% of systems sampled), through cooperative effort by some or most users (39%), or outside persons (community officials, government technicians).

In 34% of the sampled pump systems, funds for repair came out of the caretaker's pocket, while another 46% of the users contributed money when needed or in regular amounts of $0.02-0.10 monthly per household. No fund raising scheme was employed in the remaining 20%.

3.6 Impact on Beneficiary Communities

In-depth surveys on impact on beneficiaries were done in only 27 pump sites of a single project area. The results are shown in Table 5.

Table 5. Beneficiaries' rating of the impact of the projects in improving their water supply situation

Criteria	Percentage of Users Perceiving Improvement
Water quality:	
drinking	66
bath use	60
washing clothes	60
Water quantity	58
Ease of drawing/transporting water	45
Lowering of water-borne diseases	54

While rainwater tank users had a poor record in cooperative effort for maintaining their systems, beneficiaries of spring-fed systems had a strong and regular program for cooperative cleaning of pipes and spring boxes. The availability of tools was a minor problem.

3.7 Political Interventions

The TSTF pursues a policy of coordinating with and informing the local political leadership in the project areas on the purpose and mechanics of each project so as to minimize interference or enlist their support. Despite this, the following cases of intervention were noted:

- 2 out of the 3 cases of pump theft were reportedly done by communist insurgents;
- a local government proponent was unable to account for the location of 10 pump projects they had implemented; and
- some proponents sited pumps to favor certain users (e.g., sectarian groups).

As some proponents were closely allied with local politicians, it was not rare to find credit for some community water systems attributed to the latter. The TSTF believes that these incidents deviate from the self-reliance principles under which such projects should be pursued, as credit (and responsibility) should first and foremost go to beneficiaries.

4. Conclusions

The evaluations showed that while the TSTF may, on the whole, be on the right track in achieving its mission through the concerned projects, there is room for improvement.

Some of the lessons learned were:

- The availability of parts and the ability of users to understand and adapt the technology involved are major determinants for the successful use of pump systems.
- A more rational approach in designing and packaging rainwater systems is needed to ensure their success (the TSTF is now developing software for economical sizing of tanks and catchments).
- There is need to address the problem of water potability in CWSPs (the Foundation is already planning research on water treatment technologies).

Post-Project Evaluative Surveys as a Cost-effective Tool for CWSP Management:

About $2,600 were spent on the evaluative surveys or less than 4% of the surveyed projects' aggregate cost.

In return, aside from insights derived from retrieving 440 pump-years of experience (75, 4 years for rainwater tanks and spring-fed systems, respectively), the surveys also:

(1) repaired 8 pumps, thus, salvaging roughly $2,440 worth of project investment; and
(2) located $1,230 worth of left-over and junked but still usable project materials.

In one rehabilitation project, which was estimated to cost up to $15,000, evaluation data reduced the projection to no more than $2,000. In addition, parts importation cost estimates decreased from $3,270 to $680.

A method for lubricating jetmatic pump hinges using a common medicine dropper, which requires little effort and expense was "discovered" by the evaluation team and was estimated to further save the project $900 annually if disseminated.

Last but not least, the surveys presented a reaffirmation of the *Tulungan sa Tubigan Foundation's* continuing concern for the people's welfare.

References

ANONYMOUS (Undated) "Tapayan Gawa sa Semento Para sa Pamilya", Phinma, Philippines.

ARLOSOROFF, et al. (1987) "Community water supply: The handpump option", The World Bank, Washington, D.C., U.S.A.

GENDRANO, C. (1989a) "Evaluation of installed Northwestern Samar rural potable water supply projects", Tulungan sa Tubigan Foundation, Philippines.

________ (1989b) "Evaluation of Antique potable water supply", TSTF, Philippines.

________ (1989c) "Evaluation of the Bantayan rainwater catchment project", TSTF, Philippines.

________ (1989d) "Evaluation of the Eastern Samar potable water supply project", TSTF, Philippines.

GENDRANO, C. and M. VALERA (1989) "An assessment of the village handpump project (Philippines)", TSTF, Philippines.

GENDRANO, C. and E. VITERBO (1989) "Field visit report: Tubigan ng Kalayaan program.,Nueva Ecija barangay level operated and maintained potable water project", TSTF, Philippines.

VADHANAVIKIT, C. and S. VIWATANATHEPA (1983) "Interlocking mortar block water tank", Proceedings of the Regional Seminar and Workshop on Rainwater Catchment, IDRC, Khon Kaen, Thailand.

Acknowledgements

To Sonny Resoso and Pinky Gendrano for typing and illustrating this report.

Evaluation of Small-scale Drinking Water Supply System in Rural Areas of China

Bo Ling
Associate Professor
Institute of Environmental Health and Engineering
Chinese Academy of Preventive Medicine
Beijing, China

Abstract

In line with the Water Decade, small-scale tap water systems have been developed for rural areas in China since 1981. With the common efforts of the central and local governments, collectives and individuals, a great amount of funds, manpower, and material resources have been and are being funnelled into this national project in order to meet the drinking water requirement of the rural population. This project will benefit approximately 15 million people per year on the average. Until 1990, only about 20% of the rural population has access to tap water.

The various water resources that have been utilized in small-scale tap water systems in China's rural areas are:

(1) Groundwater sources, including spring, shallow and deep well;
(2) Surface water sources, including river, stream, lake, pond and reservoir;
(3) Special water resources, having higher concentration of fluoride or iron and manganese.

Water supply systems with complete water treatment serve about 9% of the rural population. The water quality can meet the health standards in terms of turbidity, color, and total coliform. The incidence of intestinal contagious diseases have decreased remarkably among the population served.

The systems with partial treatment serve 4.75% of the rural population, while the direct supply systems without any treatment serve the remaining 6.25%. Without disinfection, 54.2% of potable water does not meet the health standards microbiologically. Water-borne diseases, such as bacillary dysentery, typhoid and hepatitis show an increasing trend, and epidemic diarrhea is prevalent in some areas.

Special treatment processes are used to improve the quality of water from sources with high fluoride, iron and manganese content and keep them within the health standards.

Taking account of total costs, including capital and operational, and total income, including water charges and conversion values from the reduction of water-borne diseases and man-hours for carrying water, the capital investment was found to be recoverable in 3 to 5 years.

1. Introduction

In line with the Water Decade, small-scale tap water systems have been developed for the rural areas in China since 1981. With the combined efforts of the central and local governments, collectives and individuals, a great amount of funds, manpower, and material resources have been and are being funnelled into this national project in order to meet the drinking water requirement of the rural population. This project is expected to benefit approximately 15 million people annually. Until 1990, only around 20% of the rural population is serviced by tap water. With respect to the sanitary surveys, which were conducted nationwide, the specific health, economic, and social effects of sanitation to the rural areas are reviewed in this paper.

2. Technical Process

Various technical processes which have been undertaken in the small-scale tap water system in rural areas are summarized below:

2.1 Groundwater Sources

Groundwater sources, including spring, shallow and deep wells account for 26% of the total sources in the whole country, and are usually untreated as shown in Fig. 1.

(1) Well → Pump → Elevated Tank/Water Tower → Pipeline → Household

(2) Spring → Tapping Chamber → Elevated Tank → Pipeline → Household

(3) Well → Pump → Pressure Tank → Pipeline → Household

Fig. 1. Direct drinking water supply system

Springs are the most suitable source when sufficient capacities are available. Infiltration drains are used for shallow wells. Dug wells are more appropriate for reaching groundwater at medium depth, while tube wells are generally most suitable for drawing water from deeper water-bearing ground strata.

The transmission of water is either by gravity or by pumping, depending on the topography and the local conditions. For community water supply purposes, pipelines are the most common means, but canals, aqueducts, and tunnels are also used for conveying both drinking water and agricultural irrigation, especially in the arid areas of northwestern China.

2.2 Surface Water Sources

Surface water sources, including river, stream, lake, pond, and reservoir make up 73% of the total sources nationwide and have to be treated by complete and partial processes, as indicated in Figs. 2 and 3, due to its direct exposure to possible pollution.

For rural drinking water supply, the relatively clean waters from lakes or reservoirs are treated by slow sand filtration. Pre-treatment is provided by plain sedimentation or roughing filters prior to

(1) Coagulant

Source → Pump → Flocculation & Coagulation → Sedimentation →

Disinfectant

Rapid Filtration → Storage Tank → Pump → Network → Household

Backwash

(2) Coagulant Disinfectant

Source → Pump → Package Purifier → Storage Tank → Pump → Network → Household

Coagulant

(3) Source → Pre-sedimentation → Flocculation & Coagulation → Inclined-Tube Settling → Sand Filtration → Activated Carbon Filtration → Storage Tank → Network → Household

Disinfectant

Fig. 2. Complete treatment process

(1) Source → Pre-sedimentation → Slow FIltration → Pump → Water Tower → Network → Household

Coagulant

(2) Source → Pump → Direct Filtration in Water Tower → Network → Household

Coagulant

(3) Source → Pump → Pressure Filtration → Water Tower → Network → Household

Fig. 3. Partial treatment process

slow filtration for river waters with heavy silt, such as in the Huanghe River basin. For small-scale water treatment plants, the process in which coagulated effluent directly enters the filter without sedimentation is widely applied for economic and operational considerations in areas with a network of rivers as in southeastern China.

Only as a last resort are sources treated by chemical coagulation, rapid filtration and disinfection. Even then, only simple and practical technologies such as gravity chemical feed with solutions, hydraulic rapid mixing and flocculation, horizontal-flow sedimentation, and manually operated filters are used. The disinfection of potable water can result in destruction or at least inactivation of harmful microorganisms that could transmit water-borne enteric diseases to the consumers. Throughout the rural areas in China, hypochlorite is widely used as disinfectant, because of its ability to kill pathogens fairly quickly, its wide availability, and moderate cost. However, it is often produced in provincial capitals, hence its cost and transportation problems in outlying communities may increase proportionally to the distance from the cities. Also, the supply could not meet the demands of all rural drinking water supplies.

Simple package water treatment units are adopted in places where a large number of small treatment facilities are needed or where local conditions are unfavorable for on-site construction.

2.3 Special Water Resources

Special treatment processes deal mainly with water which contains high concentrations of fluoride, iron and manganese as indicated in Fig. 4. Coagulation-sedimentation or adsorption-filtration are usually used for fluoride removal. The coagulants used are polyaluminum chloride, alumina and aluminum trichloride. Activated alumina is also used as adsorption material. The costs of defluoridation are so high that it is better to go to the alternative source, even if it is far away. In some high fluoride areas where other sources are not available, a tap water system is built to provide the expensive treatment only for drinking purposes.

For removing iron and manganese, the aeration-filtration process is used in Hubei, Hunan, and Jiling provinces.

(1) Fe and Mn Removal

Well → Pump → Aeration → Manganese Sand Filtration → Storage Tank → Pump → Network → Household

(2) F Removal

Coagulant

Well → Pump → Reaction → Sedimentation → Pump → Water Tower → Network → Household

Well → Pump → Activated Alumina → Storage Tank → Pump → Water Tower → Network → Household

Fig. 4. Special treatment process

3. Evaluation of Processes

3.1 Complete Treatment Process

This amounts to 9% of the total rural population coverage throughout the country. The quality of treated water is able to meet the health standards for domestic drinking water under proper operation. Turbidity, color and total coliform are very much improved. Tables 1 and 2 indicate that the water quality ranking provided by complete treatment is higher than the partial or no-treatment processes.

The incidence of contagious intestinal diseases has decreased. For example, the health assessment of drinking water supply in Chongyian County, Hubei Province indicated that the morbidity of bacillary dysentery decreased with the increased population of those who had been drinking water that have been completely treated, as shown in Fig. 2.

Table 1. Water quality comparison between complete and partial treatment

Water Quality Rank	Complete Treatment (%)	Partial/No treatment (%)
A	36.81	18.61
B	35.18	31.71
C	28.01	46.08
Total	100.00	100.00

Table 2. Health criteria for ranking water quality

Item	Unit	Water Quality Ranks		
		A	B	C
Color	Degree	< 15	15-50	> 50
Turbidity	Degree	< 5	5-25	> 25
pH		6.5-8.5	6.0-9.0	< 6.0/> 9.0
Total Hardness	mg/L (as $CaCO_3$)	< 450	450-700	> 700
Iron	mg/L (as Fe)	< 0.3	3.0-1.0	> 1.0
Manganese	mg/L (as Mn)	< 0.1	0.1-0.5	> 0.5
O_2 Demand	mg/L (as O_2)	< 0.3	3.0-6.0	> 6.0
Chloride	mg/L (as Cl^-)	< 250	250-260	> 600
Sulphate	mg/L (as SO_4^{-2})	< 250	250-260	> 400
Fluoride	mg/L (as F^-)	< 0.1	< 0.1	> 0.1
Arsenic	mg/L (as As)	< 0.05	0.05-0.1	> 0.1
Nitrate	mg/L (as N)	< 20	20-23	> 23
Total Coliform	per L	< 3	3-60	> 60

As indicated in the morbidity statistics of water-borne enteric diseases among 27,762 people in five counties of Liaoning Province, where the small-scale water supplies have been developed with a loan from the World Bank in 1985, the morbidities of hepatitis, bacillary dysentery, and enteritis were lower at 0.151%, 0.148%, and 1.746% in 1986, respectively, compared with 0.576%, 0.387%, and 4.636% in 1985.

The epidemiological investigation of liver cancer in a certain county during 1986 implied that the highest mortality of liver cancer occurred in the population which took drinking water from ponds [about 6.708 per million people (Table 3)], even when the water was treated by the complete process. The results suggested that filtration, including rapid, pressure or direct filter and hydraulic cycle purifier, can not remove carcinogen, and disinfection can even raise the level of carcinogen, especially with raw water containing the precursors of the carcinogen, as in the case of polluted surface waters.

In the case of high contents of natural nuclide in some groundwater sources of the mountain areas in Liaoning Province, the radioactive substances can be purified by the complete treatment process. In particular, sand and activated carbon filtration exerted outstanding effects, based on a survey in 27 rural water plants (shown in Table 4).

Table 3. Mortality of liver cancer versus drinking water source

Drinking water Source	Mortality of Liver Cancer (per million people)
Pond	6.708
Spring	5.777
Shallow well	4.605
Stream	4.559
Irrigation canal	3.595
Deep well	2.750

Table 4. Radioactive levels in raw and treated water

	Raw Water				Treated Water			
Water Source	Total α ($\times 10^{-2}$ Bq/L)	Total β (Bq/L)	^{226}Ra ($\times 10^{-3}$ Bq/L)	U (q/L)	Total α ($\times 10^{-2}$ Bq/L)	Total β (Bq/L)	^{226}Ra ($\times 10^{-3}$ Bq/L)	U (q/L)
Surface Water	4.8	0.29	0.9	12.8	4.2	0.28	0.7	8.3
Groundwater:								
< 50m depth	4.0	0.15	1.3	8.8	3.7	0.10	1.0	7.7
100-500m depth	5.5	0.19	5.4	10.0	5.4	0.18	5.0	7.4
> 1000m depth	2.6	0.23	2.0	3.0	2.4	0.13	1.6	2.7

3.2 Partial Treatment or No Treatment Process

Partially treated systems account for 4.75% of the total rural population served nationwide, while the direct supply systems without any treatment account for 6.25%.

Without disinfection, 54.2% of the potable water sources do not meet microbiological health standards for domestic drinking water. Such water-borne diseases as bacillary dysentery, typhoid and hepatitis show an increasing trend, and epidemic diarrhea is prevalent in some areas, resulting from the absence of disinfection facilities or ineffective disinfection of waters contaminated by nightsoil, domestic wastes or hospital wastewater. For instance, the cases of typhoid went up to 140,000 throughout the country in 1988, as compared to 4,666 cases in 1983.

Pollution incidence occasionally occurred in partial/no-treatment systems, resulting from pollution at the source (68.9%), contaminated pipeline networks (25%), and polluted storage tanks (3.8%) countrywide between 1979 and 1984. In a certain county, a total of 21 pollution outbreaks in drinking water supplies caused 9,075 cases of intestinal communicable diseases, with the morbidity reaching 9.78% and the pathogens consisting of typhoid bacillus, bacillus paratyphosus, salmonella, bacillus dysenteriae, and rotavirus.

3.3 Special Treatment Process

There were 37.53 million cases of dental fluorosis and 1.72 million cases of skeletal fluorosis nationwide in 1984, basically attributed to high fluoride in drinking water which averaged 8 mg/L, with a maximum level of 32.5 mg/L. Due to such serious adverse effects on human health, defluoridation and selection of water sources with low fluoride are becoming more and more important and have had significant results. For instance, with high fluoride water in a village of Yianyuang county, Hubei Province, 82.3% of skeletal fluorosis has been mitigated since fluoride in drinking water has been decreased for three years.

Under normal operation, the special treatment processes are able to reduce the fluoride or iron and manganese contents to within health standards.

3.4 Cost-Benefit Analyses

As indicated in the assessment of drinking water supply systems covering a population of 27,762 in five counties of Liaoning Province in 1986, not only have the water supplies decreased the morbidities of water-borne enteric diseases and fluorosis, but annual per capita incomes have also increased, from 432 Yuan in 1985 to 608 Yuan in 1986, and village and town enterprises enhanced, from 1.71 million Yuan of output values in 1985 to 9.39 million Yuan in 1986. In addition, running water saved 130 thousand man-days for carrying water, equivalent to 0.54 million Yuan. Moreover, the food processing raised its efficiency using treated water. Therefore, taking account of total cost, including capital and operational, and total income, including water charges, and conversion values from reduction of water-borne diseases, and man-days for carrying water, the capital investment can be recovered in three to five years.

4. Conclusion

The key to ensuring the quality of small-scale water systems in rural areas is the selection of unpolluted water source, effective treatment processes, complete disinfection, and strict operation and management.

References

HONG LIYIAN (1989) "Assessment of regional drinking water supply in Chongyian County, Hubei Province", NPHCC, October 1989.

LIAN GENWANG (1987) "Epidemiological investigation of drinking water vs. liver cancer", Environment vs. Health, 6(3).

LI YISUAN (1987) "Assessment of drinking water supply in five counties of Liaoning Province", Public Health, 8(3).

NPHCC (1988) "Nationwide survey for drinking water quality and water-borne diseases", August.

Self-help Training Program in Small-scale Water Resource Development in Rural Areas

Prinya Chindaprasirt
Dean
Faculty of Engineering
Khon Kaen University
Khon Kaen, Thailand

Abstract

One of the most severe problems in the Northeast region of Thailand is the lack of water. This problem can be solved effectively through the development of small-scale water resources using the self-help concept. Although this concept is not new, its wide scale implementation for the development of small-scale water resources in rural areas is a formidable task. The Department of Local Administration, Ministry of Interior in collaboration with the Faculty of Engineering, Khon Kaen University and the South East Asia Program Office of the Carl Duisberg Gesellschaft had conceptualized the "Thai-German Self-Help Training Project on Small Water Resource Development in Rural Areas" along the lines of this concept towards helping alleviate the problem of water shortage. The program utilized the local government structure by building up district training teams to help train the villagers in developing their own village water resources. Two provinces in Northeast Thailand were selected as program site. The training modules consisted of three main components, viz. planning and decision making, technical skill and training of trainers components. The training contents consisted of project overview and objectives, planning for small-scale water resource development, construction/operation/maintenance of water resource facilities, water sanitation and villager participation. A total of 135 district personnel comprising 45 deputy district officers, 45 district technicians and 45 assistant district technicians and 675 village technicians had been trained to help train the villagers on small-scale water resource self-help development. A total of 14,000 villagers had been trained in planning how to assess and solve the water shortage problem through their own efforts. The result of the project was very encouraging. During the training, a total of 700 rainwater tanks and 300 shallow drilled wells were constructed by the villagers. After the training, a number of trained villagers helped plan and construct the water resources in the villages using their own money and some Government funding.

1. Introduction

The Northeast region of Thailand, with a population of 18 million and an area of 17 million ha (170,226 km^2) constitutes nearly one-third of the Kingdom in terms of population as well as area. Almost all major indices used to reflect the quality of life have consistently identified the Northeast region as poor, if not the poorest, in comparison with other regions. A major contributory factor to this condition is the severe lack of water. The problem is mainly due to the very long period of dry spell (about 7-8 months) and the unfavorable soil condition.

Realizing the magnitude of the problem, the Royal Thai Government (RTG) has given the region its priority. Included in the 6th National Economic and Social Development Plan (1987-91) are provisions for increasing the drinking water supply from 2 L/person/day to 5 L/person/day for 95%

of the population, and increasing the domestic water supply to provide 45 L/person/day (obtainable within a 1 km walking radius or within an hour) for 95% of the population (KKU, TAVWSP, and NRDCC, 1987). Additional water resources for agriculture are also needed.

Several RTG agencies are assigned responsibility for the implementation of the development of small, medium and large-scale water resource facilities. It was realized, however, that the provision for adequate water supply for the rural population could only be achieved through small-scale water resource development (ARBHABHIRAMA et al., 1978).

The small-scale water resource facilities such as jars, rainwater tanks, shallow dug wells, small drilled wells, deep wells, dug ponds, weirs and small reservoirs have all been constructed and tried in the rural areas of Thailand. Traditionally, the programs to do this have been sponsored, organized and implemented by RTG agencies. The programs are very costly and often do not answer the real need of the villagers. Inefficient utilization and problems of operation and maintenance are, therefore, prevalent (CHINDAPRASIRT et al., 1985).

The development of small water resources should rely on villagers' participation or self-help which would lead to a sense of ownership, better maintenance, more efficient utilization and more effective use of Government budget. In order to promote this self-help concept at a large scale on the grassroots level, the Department of Local Administration, Ministry of Interior (DOLA), and the Faculty of Engineering, Khon Kaen University (KKU) in cooperation with the South East Asia Program Office of the Carl Duisberg Gesellschaft (CDG-SEAPO) had conceptualized the "Thai-German Self-help Training Project on the Development of Small Water Resources in Rural Areas".

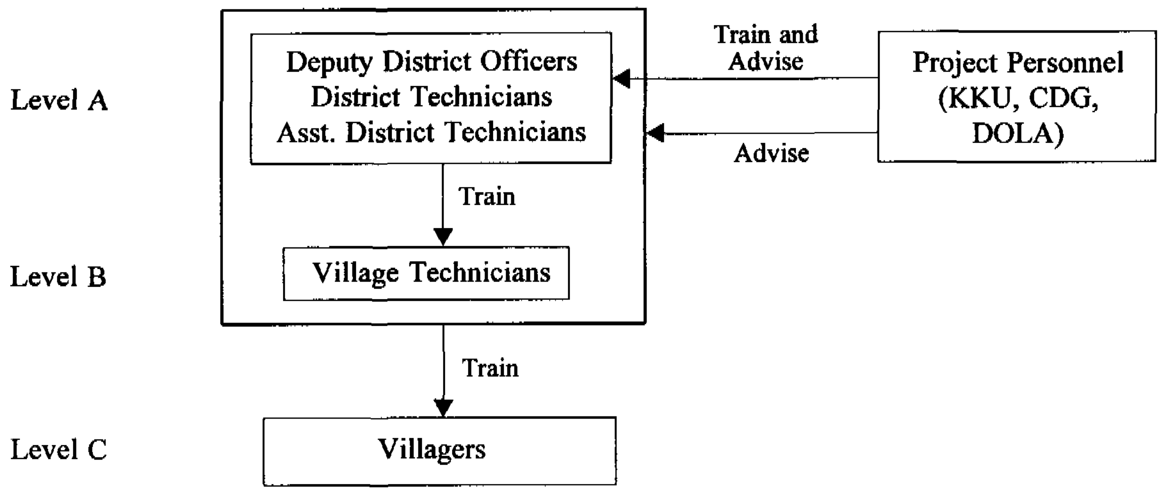
2. Details of the Program

It is realized that for wide-scale self-help implementation, the development of the existing Government personnel's capabilities to help train the villagers is a viable alternative. Thailand's local government structure consists of provinces made up of districts, which are sub-divided into sub-districts comprised of villages. To build up as many training teams as possible, it is believed that a training team based at the district level is most appropriate. The program, therefore, utilized district training teams to train villagers in developing their own village water supply systems.

The district training team consisted of Deputy District Officers (DDOs), District Technicians (DTs), and Assistant District Technicians (ADTs). The DDO is designated as district training manager and is responsible for the planning and development of the small-scale water resources of his district. The DT is designated main trainer and is responsible for the construction and actual implementation of the small-scale water resource development. To make the district training team more effective, an ADT was selected from the district personnel actively working in this area. The other assistant is the Village Technician (VT) who helps in the training and extension activities in the village. The VT is selected by the district technician in consultation with the village leader.

The training project had three target groups as shown in Fig. 1.

The Northeast region of Thailand consists of 17 provinces. To experiment with the self-help program training concept at a manageable scale, two provinces, Nakhon Ratchasima and Ubon Rachathani were selected as project sites. These two provinces are the largest in terms of area and population. Nakhon Ratchasima and Ubon Ratchathani consist of 23 and 22 districts, respectively. This resulted in 45 training teams under two provinces. Each district training team conducted 15 trainings in 15 villages of their own districts and a total of 675 villages were, therefore, involved. For effective training, participants per training course were limited to approximately 20 persons.



Level A: The project personnel provided training and advice to the Deputy District Officers (DDOs), District Technicians (DTs), and Assistant District Technicians (ADTs).

Level B: The trained DDOs, DTs, and ADTs in turn trained the Village Technicians (VTs) with the assistance and advice of the project personnel.

Level C: The trained DDOs, DTs, and ADTs of each district formed a group of trainers and with the VT they trained the participating villagers in their own village within the district.

Fig. 1. Schematic representation of the training program structure

The training program was spread over a period of two years. A summary of the target participants at every level is presented in Table 1.

Table 1. Target participants in the training project

Year	Province	Level A (DDO, DT, ADT)	Level B (VT)	Level C (Villagers)
I	Nakhon Ratchasima Ubon Ratchathani	69 66	138 132	2,760 2,640
II	Nakhon Ratchasima Ubon Ratchathani	* *	207 198	4,140 3,960
	TOTAL	135	675	13,500

* Additional training and refresher course.

3. Training Methodology

In order to transfer the self-help concept in the development of small-scale water resources to the villagers, training materials and modules were developed. The training materials comprised of manuals, books and booklets, video tapes, and flip charts.

The trainers' manuals consisting of training details and session designs were prepared as a guideline and framework for training at each level. A book on comprehensive knowledge of small-scale water resources including short descriptions of various types and selection of small-scale water resource facilities, water sanitation and villagers participation were prepared to equip the trainees with general knowledge of small water resources. Four booklets were prepared; one was on the description of the project, the other three were on the general knowledge of construction (e.g. concrete work, earth work and cost estimation). Manuals, video tapes, and flip charts on the construction of wire-reinforced mortar tank and shallow drilled wells were prepared to be used in the technical hands-on training. A manual and video tape on the construction of a concrete weir were also prepared to give participants some knowledge on the construction of this type of structure.

The training modules consisted of three main components:

(a) Planning and decision making component
(b) Technical skill component
(c) Training of trainers component.

The planning and decision making component was considered as an effective tool for learning in limited time. The *project casework approach* (THARUN, 1986) through which the participants underwent exercise in problem analysis, problem prioritization, development of objectives and alternatives identification, selection of solution and implementation planning based on the acquired knowledge and information, was utilized. Two cases were constructed based on the data and conditions of the Northeast. These cases on the village water resource development were used in the training of District Technicians, Assistant District Technicians, and Village Technicians. For the training of villagers, the actual situation of the village was used.

The technical skill component was also considered essential. Firstly, the participants gained technical skills to be able to construct, operate and maintain their own small-scale water resource facility. Secondly, the hands-on construction gave additional incentive to the villagers to participate in the program since the constructed facilities would belong to the villagers after the training. The general knowledge about the construction of various small-scale water resource facilities were given in lectures and discussions. For the hands-on practical training, wire-reinforced mortar tank (CHINDAPRASIRT, et al., 1985) and shallow drilled well (SRIBOONLUE, et al., 1987) were chosen since the construction steps were not too difficult and would give the participants skill on concrete and earth work, and they are likely to be built by the villagers themselves in the future.

The training of trainers component was considered very essential for the training at Level A. The *project casework* training methodology was presented to the trainees through lectures and group discussions. The participatory approach of training was emphasized to get all the participants to be involved in the training. The participants were trained also on the use of instructional aids. The practicum as real trainer, with close collaboration and advice from the project personnel, was also included in the program.

The emphasis on self-help was given in every level of training. The training was designed with a decreasing degree of complexity through Levels A, B and C to suit each level of participants.

4. Training Delivery and Results

4.1 Training of Deputy District Officers, District Technicians, and Assistant District Technicians (Level A)

The Deputy District Officers (DDOs) acted as district training manager and oversaw the training of Level C in their own respective districts. The course, therefore, emphasized on the project policy and objectives, construction techniques, water resources planning, community preparation and planning for project implementation. The training was designed for seven days duration and consisted of lecture sessions, group and plenary discussions, field visit and field training.

This training was evaluated as good by the participants. However, the training delivery was still not very smooth. This was expected as this was the first training they have organized together and their backgrounds were diverse. One of the important observations from the group discussion was that the DDOs seemed to be quite skeptical of the training program. They were concerned about the training at Level C where no money is provided as per diem or allowance in contrast with other Government programs.

The training of District Technicians (DTs) and Assistant District Technicians (ADTs) was designed for a duration of 13 days. The contents of the training were basically the same as the training for DDOs (i.e. project overview and objectives, planning for small-scale water resource facilities, construction/operation/maintenance of water resource facilities, water quality and sanitation, community participation, training methodology including the use of instructional aids). The *project casework* approach through which the trainees underwent problem solving and decision making process with exercise in information gathering, problem analysis, problem prioritizing, development of alternatives, selection of solutions and implementation planning was incorporated.

The participants were divided into eight groups and worked on two cases, which were based on actual data and local conditions. This was followed by the field training component, which was a village-based application stage, in order to allow the trainees to practice as trainers in training the villagers to solve their own water supply problems as well as to construct the needed water resource facilities.

The training as a whole was evaluated as good. However, skepticism over the successful implementation of the program due to the lack of per diem allowances in the latter stage of the project was again evident. It was also observed that the district technicians' backgrounds were very technically oriented. They were not used to participatory training approach and as a result were not at ease with the group discussion and presentation of the group findings. They were more at ease with the technical sessions which were their strong and familiar points. As the participants at this level were very well equipped with technical skill, the technical sessions were, therefore, adequate. However, the sessions on the problem solving and decision making process should be emphasized more. Time and effort must be spent to familiarize the participants with the participatory training approach.

4.2 Training of Village Technicians (Level B)

The Village Technicians (VTs) were to help the training team (DDO, DT and ADT) in the technical training of villagers (Level C) and to lead the extension activities in their own villages after the training. For each province, groups of trainers consisting of DDOs, DTs, and ADTs from 5-6 districts were formed. Under the supervision and guidance of the project personnel, each group conducted the training for Village Technicians in their respective zones. The training was designed for 8 days with emphasis on the planning and decision making process through *project casework* and training on technical skills. The contents included project policy and objectives, planning for small-scale water resource facilities, construction/operation/maintenance, water quality and sanitation and community organization.

The overall training was evaluated as good. This training was the real training for the DDOs and DTs as trainers. Some of them performed very well and quite a few also had problems in conducting the *project casework.* Towards the end of the training, they felt more confident and realized that good training needed a lot of preparation and hard work. For the trainees, it was observed that their backgrounds were quite diverse, hence, the ability to absorb the training contents varied. Also, it was observed that the Village Technicians were more at ease with the construction technique than the group discussion and presentation. This was also due to the villagers' character, tradition and the level of education. The training sessions on the project policy, self-help concept, problem solving and decision making process should be further strengthened.

4.3 Training of Villagers (Level C)

Level C training programs were conducted simultaneously in 45 districts in the two provinces. The district training team (DDO, DT, and ADT) now reinforced by the Village Technicians (VTs) had the liberty to plan their own logistics based on the villagers' needs and the guidelines of the training program with extra help and monitoring from the provincial and project personnel. The training was designed for 7 days duration with emphasis on the planning and decision making process through *project casework* and training on technical skills. Similar course contents as before were included.

After the introduction, lecture and discussion sessions, the villagers were assigned to work on their own village water resource case with actual village data and conditions. This was followed by a technical hands-on training session, whereby, the villagers had the opportunity to build their own water resource facilities.

In general, the training at this level was satisfactory. It was noticed that the backgrounds of the trainees at this level were quite different. The education levels of some of the trainees were quite low which led to some difficulties in the expression of ideas. A lot of effort was needed to get the villagers involved in the group discussion and presentation.

In the first year, the Level C training started late such that some training sessions were conducted during the planting season. This was not a suitable time as the villagers were busy in the paddy fields. The training had to start as early as possible in the year to avoid this disruption. The disruption also arose from the damage of tools and equipment. This was, however, unavoidable and spare parts and good quality tools were needed.

It was also observed that this self-help training program ran into some difficulties when it conflicted with other programs by the Government, wherein per diem allowances were given. In contrast, this project asked the villagers to give their labor free of charge. Thus, more publicity for the program had to be done to get the villagers familiar with the self-help concept.

5. Outcome of the Program

The direct benefit of the program is the development of the capabilities of the Government personnel as well as the villagers in the area of small-scale water resource development. A total of 135 district personnel comprising 45 DDOs, 45 DTs, 45 ADTs and 675 village technicians had been trained to help train the villagers on small-scale water resource self-help development. A total of 14,000 villagers had been trained in planning how to assess and solve the water shortage problems through their own efforts in planning and construction of small water resource facilities. During the hands-on training, approximately 700 rainwater tanks and 300 shallow drilled wells were constructed.

After the training, the extension activities in the villages were initiated. For drinking water, villagers built jars and tanks for rainwater storage using their own resources. For domestic water, shallow dug wells and shallow drilled wells were constructed. These small water resource facilities were not too expensive and were within the reach of many villagers. For very poor villagers, they still had to rely on Government funding. Also, for larger facilities such as concrete weir, the villagers were unable to meet the cost so that the RTG had to provide the funding while the villagers provided the construction labor. In some villages where the groundwater was good, the villagers used their training and skill to tap the groundwater for both domestic use as well as for growing small vegetable plots and trees. They modified the drilling rig and hand pump using locally available equipment, tools and materials.

The training program also created a very profound effect on the career development of masons, skilled construction workers and shallow well drillers. Previously, villagers not equipped with any technical or construction skill were hired to work as unskilled laborers and consequently paid very low wages. After the training, some of them utilized their new skills to earn twice as much as before.

Another noteworthy effect is the development of self-help shallow drilled well program. From the feedback during the training and the extension activities, it was found that the villagers liked the shallow drilled wells. However, the capability of the manually operated shallow drilled well rig is too limited. A slightly better version which was motor-driven was, therefore, developed. The capability of this rig is very good and the cost was quite reasonable. The RTG adopted the design and named it TR-60 (Thai Rig 60) on the occasion of the 60th birthday of the King. The RTG has since allocated some budget for the promotion of the shallow drilled well using the TR-60 rig through the Department of Local Administration.

The RTG is slowly realizing that the give-away method in the water resource development program is very costly and not effective. It is now, therefore, shifting the emphasis from fully funded projects to joint programs between the Government and the villagers. The Government provides the material, necessary equipment, and technical support while the villagers provide the labor. The budget of the Department of Local Administration for this joint program in small-scale water resource development in rural areas has increased from 3.5 million Baht a few years ago to about 300 million Baht in 1990.

Based on the very encouraging results of this self-help training project, the RTG intends to make full use of their valuable project experience to cover the rest of the Northeast region.

6. Conclusion

For the wide-scale implementation of self-help program in small-scale water resource development in rural areas, the utilization of the existing local government structure is a viable option. The use of district training teams to help train the villagers proved to be highly successful. In developing the district training team, the training modules consisting of three components (i.e., planning and decision making component through *project casework* approach, technical skill component through practical hands-on training, and training the trainers component) were found to be effective. For training the villagers, the use of planning and decision making process through which the villagers were assigned to work on their own village water resource problems and practical hands-on training were appropriate.

Although the program proved to be suitable both in methodology and practicality, some areas that needed improvement and strengthening had been identified. In both the training of the district training teams and the training of villagers, the planning and decision making process needed to be strengthened while time and effort were needed to get the participants familiar with participatory training. It was also found that in implementing a self-help program at the village level, the project should not run into or compete with other Government projects particularly the give-away programs. Intense publicity and good community preparation were needed to get the villagers familiar with the self-help concept. Also, the training of villagers should not be done during the planting season as the villagers have to take some time off to tend the paddy fields. Good preparation, logistics, as well as good quality tools and equipment were needed in order not to interrupt and disturb the progress of the training as well as the villagers.

This training program was rated highly by the participants. Moreover, this training program is in line with and complements the Government's interest in tackling the needs of the Northeastern rural poor.

References

ARBHABHIRAMA, A., et al. (1978) "Water for the Northeast: A strategy for the development of small water resources", Asian Institute of Technology, Bangkok, Thailand.

CHINDAPRASIRT, P., et al. (1985) "Utilization of weirs and small reservoirs in the Northeast", Project Report, Khon Kaen University, Thailand.

CHINDAPRASIRT, P. and P. WIROJANAGUD (1985) "Wire reinforced mortar tank", In the Third Conference on Technology for Rural Development, Khon Kaen University, pp 2-107 to 2-118 (in Thai).

KKU, TAVWSP, and NRDCC (1987) "Action plan of the rural water supply program during the sixth national economic and social plan period (1987-1991)", Khon Kaen University, Thai-Australia Northeast Village Water Resource Project and National Rural Development Coordinating Center, May 1987, 53 p.

SRIBOONLUE, V., et al. (1987) "Village well drilling method for the Northeast", Thai Agricultural Engineering Journal, Jan.-Apr., 1987 (in Thai).

THARUN, G. (1986) "Project casework-based training for better planning and management of water pollution control in developing countries", Proc. World Water '86 Conference, London, pp. 231-239.

Project Casework Training Approach for Self-help Training Program for Small Water Resources Development

Günter Tharun
Head
Carl Duisberg Gesellschaft - South East Asia Program Office
Bangkok, Thailand

1. Introduction

Through the eighties, which was proclaimed as the United Nations International Drinking Water and Sanitation Decade, quite a number of programs and projects, ranging from small-, medium-, to large-scale, were initiated and carried out all over the developing world. However, relatively little attention was paid to the crucial software aspects of such programs. This condition is reflected in the enormous number of international water conferences-cum-exhibitions usually focused heavily on either available technical equipment and related technical expertise, and the obvious intention to sell both widely, or on purely academic questions only.

In contrast to such technically and academically oriented projects, an increasing number of small project initiatives relied more on the "soft" aspects of development, e.g. community involvement, self-help, appropriate and/or indigenous technology, basic needs, traditional wisdom, the local socio-cultural fabric, women as prime target group, participatory training, among others. Such grassroots level initiatives were often devised, implemented and/or supported by local communities, NGOs, churches or their charity organizations, temples, small foundations, volunteer services or women's groups. Being close to the real needs of local communities, they are also perceived as faster and more adequate response to those pressing needs.

Being hardly noticed and, thus, recognized by the "development expert community" and therefore widely neglected at international water development forums, such small water resources development projects also pose too many problems to international, multilateral or national development agencies in terms of their institutional arrangements, logistics, and administrative procedures.

It is time to gather and assess what is really happening with regard to successful small water development ventures at grassroots level and exchange related experiences to learn from one another in improving and strengthening on-going and future activities in this field.

The Thai-German Self-Help Training Project on Small Water Resources Development in Rural Areas, promoting the community-borne construction, operation, and maintenance of small water resources at a relatively wide scale in terms of number of involved people and size of target area, might be one interesting example. It might be worthwhile to know more about this project which worked only through training to develop the abundant human resources for small water resource development, mainly relying on rural people's own effort, i.e. self-help.

This paper describes and analyzes how it worked, inspite of the various difficulties encountered, and seeks the answer to what made it work.

2. Water Development through Training

The Thai-German Self-Help Training Project on the Development of Small Water Resources in Rural Areas of Northeast Thailand was carried out in the two provinces of Nakorn Ratchasima and Ubol Ratchathani from July 1987 until the end of April 1990.

This project was different from many others insofar as it emphasized the "soft" aspects of development through action training aimed at generating and nurturing self-help attitudes in development, operation, and maintenance of small water resources by poor villagers affected by perennial water shortages for drinking, domestic, and agricultural purposes.

2.1 Background

Proposed by the Faculty of Engineering of Khon Kaen University (KKU) to the author in January 1985, the Project had taken another two years before the German Government's approval could be obtained in January 1987. The Project was officially inaugurated on July 1st of the same year with the signing of the Letters of Agreement by the collaborating parties.

A project implementation planning and management workshop was held in September 1987, bringing together the would-be project staff from the Department of Local Administration (DOLA), both from the central as well as provincial levels, the Faculty of Engineering of KKU, and CDG-SEAPO, plus the training and project management consultants from Training Associates (TA) Co., Ltd. which had been commissioned by SEAPO for workshop arrangement as well as, later on, for providing further training expertise and project management inputs for the project.

From October onwards, project team building workshops were conducted by TA and training materials were developed taking into account the preliminary results of the baseline study which had been carried out in late August until mid-October 1987 by a team of social scientists from Mahidol University, Bangkok.

The first training output for Level A participants (see Fig. 1) was generated in November 1987. Subsequently, in a period of two years, numerous training courses at Levels A (A1-A3), B and C were conducted. The bulk of training took place during the months from November 1987 to February/March 1988 because of the villagers' inability to attend the training during the planting and harvesting seasons. By the second half of 1989 the project targets were achieved and even exceeded, with approximately 700 training courses conducted at grassroots levels, where more than 14,000 villagers and village technicians had been trained in solving their own water shortage problems through appropriate actions. Furthermore, as visible concrete results of the project, more than 1,000 small water resource facilities were built during technical hands-on training. After the completion of training, more than 1,200 small water resource facilities were already constructed by various village communities until late summer 1989.

Because of the gradually emerging success of the project then, DOLA requested in 1989 that KKU and CDG-SEAPO consider an extension of the project throughout the seventeen provinces of Thailand's Northeastern region. A respective project proposal for Phase II (1990-1994) was completed by CDG-SEAPO late November 1989 and submitted to CDG HQ in Cologne and the Federal Ministry for Economic Cooperation (BMZ), West Germany's official development assistance body, for approval.

Another noteworthy offshoot of the project was DOLA's initiative in 1989 to utilize the Project Casework-based training materials for a manual on rural development to be distributed to all sub-district chiefs and village headmen throughout the country, which was launched only recently.

2.2 Main Project Characteristics

For the purpose of sharing the lessons drawn from this Project, it might be worthwhile to take stock of some of its key characteristics.

2.2.1 Training Only

The Project itself consisted of different **training** activities through which the overall project goal of reducing or overcoming serious water shortages by making the villagers self-reliant in taking adequate actions towards solving their water supply problems was to be achieved.

However, this complex training project was unusual as it was structured in a *hierarchy of three-tiered-training* with snowballing effect (Fig. 1). Yet to make it work at all, the effective transfer and dissemination of required knowledge, skills, and attitudes needed to be secured through an *integrated train-the-trainer (TTT) component* at Level A and *full utilization of educational technology expertise* for curriculum development and media production.

Though the water shortages were real (and still are), they affected villagers at different locations differently. Training needed to be offered only to those villagers who still suffered from the problems and where training could really provide a practical solution to *satisfy real needs*.

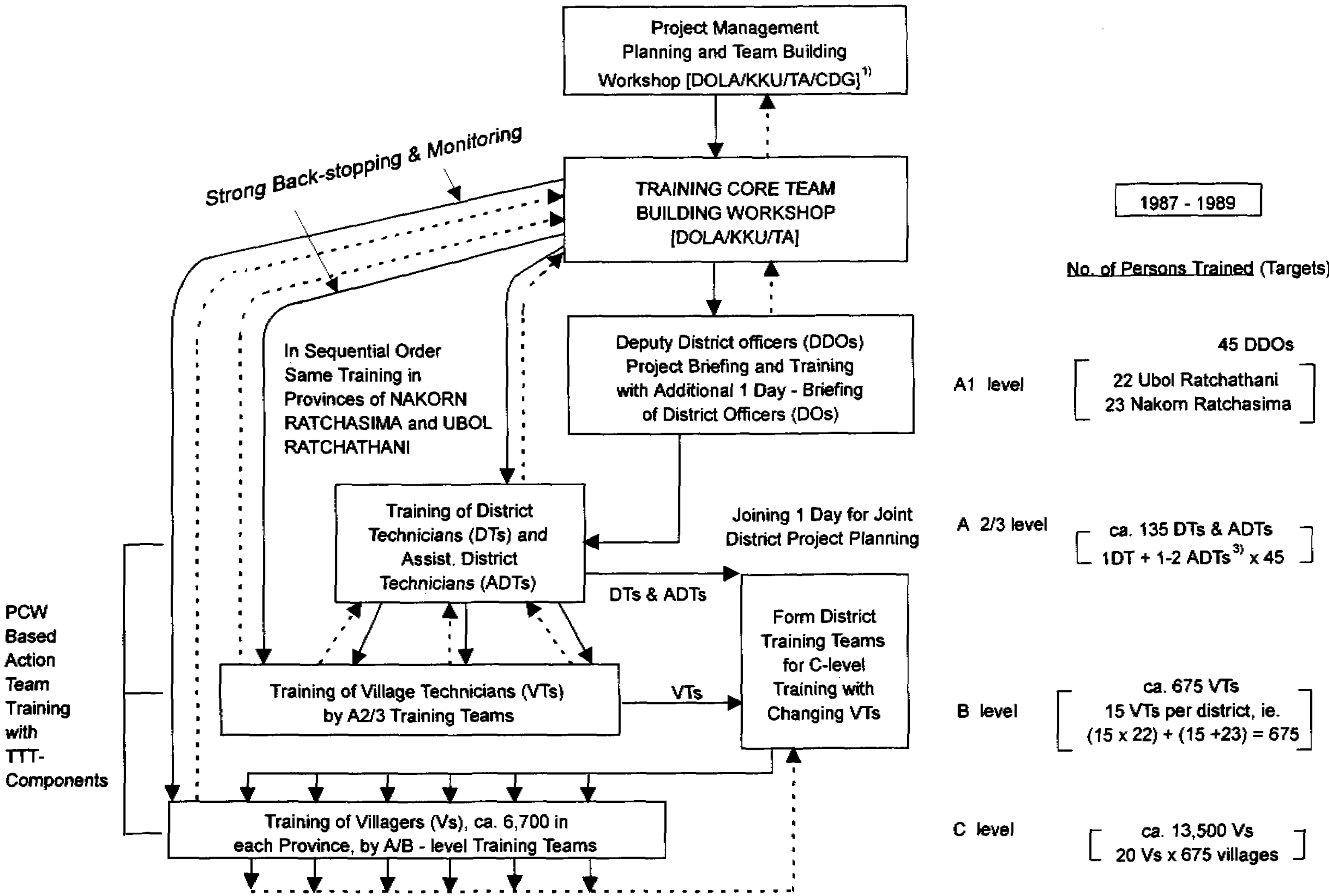
By way of action training as the most effective way of learning, and by way of confidence building through mastery of knowledge and skills (thus resulting in a higher probability of applying what has been learned), the *Project Casework approach* was employed as the core element to generate the needed knowledge, skills, and attitudes for self-generated solutions and subsequent actions for problem solving.

At the grassroots level, action training evolved already into action planning or, in other words, took place through real action planning, both of which representing two aspects of the same indistinguishable process. This *action training-cum-planning was geared for action implementation.* In this case, training remained no longer (as usual) just a medium for action in the real world, but became already part of it.

2.2.2 Nurturing Self-help Attitude

Although it has been purported in many declarations and statements that the aims of development efforts support self-help, it remains highly questionable whether in most instances the chosen action can fulfill such aims at all. Many of those activities might have been useless at best and even outright counter-productive at worst.

An effective way of generating, nurturing, and strengthening a sense of self-help among the villagers is to involve them primarily as equals, as the ones who have to analyze their own water supply situation and problems, devise their own water resources development objectives, develop their own alternative strategies or options to achieve their own objectives, compare and cost the different options and, finally, select the one which seems to be (to them!) the most suitable problem solution. On this basis, they should develop their own action plan. Such *involvement and participation of the villagers as their own problem solvers make them masters of their own affairs*. They were not only motivated to learn, contribute, and participate actively, but gained more self-confidence in seeking and mastering their own solutions to their problems, which essentially means self-help. As their solutions were primarily the products of their own efforts, they develop a strong sense of ownership to their solutions. The vehicle to produce and nurture such self-help attitude was



(1) DOLA - Department of Local Administration
KKU - Khon Kaen University
TA - Training Associates Co., Ltd.

(2) The number was even higher in year one as Nakorn Ratchasima sent more of its staff, i.e. 50 DDOs, 30 DTs and 60 ADTs
(3) During year one 1-2 ADTs per district attended whereas during year two, one only.

Fig. 1. Structure of multi-layered training model for self-help in small water resources development (Broken lines indicate feedback to involved parties/participants at preceding level(s) of training)

the Project Casework (PCW) approach (see Section 3). Closely connected with the PCW process was the full involvement, participation, and self-development of teams, in this case the members of a given community participating in a training course. Thus, *voluntary community involvement and participation further led to community development which was mainly self-development.* Community participation, self-development and support were mutually reinforcing a sense of and pride in self-help whether on communal or individual basis.

To (self-) generate, maintain and strengthen a self-help attitude, all other aspects of the project activities must be chosen and arranged in such a way as being adequate to this crucial goal and process. This means that to achieve self-help, it must be realistic. Thus, in this case, it was a must to use fairly *simple, so-called appropriate technology* which can not only be easily understood but also financially afforded by the rural poor. Furthermore, all training curricula, materials, and media had to be devised and applied accordingly, using the *right language as spoken and easily understood by the prime target group at the village level.*

As much as possible, the *villagers' own traditional indigenous knowledge* with regard to locating water sources, etc. should be tapped and utilized for achieving the project goals, thereby, involving them further into the process of mutual learning and confidence building for self-help.

Since women usually take all or the main responsibilities in all household chores, they are tasked with collecting and using water. Thus, *women need to be involved as a key group in self-help development* and, subsequently, potentially realistic gains in further socio-economic development at village level, however modest these might be.

2.2.3 Project Framework

As any project has to operate within a certain framework, the small water resource development (SWRD) project created its own distinctive framework which is outlined below.

Although the SWRD project was a rather independent joint venture between KKU, DOLA, and CDG, it, nevertheless, *formed an integral part of the Thai Government's Northeastern Water Resource Self-Help Development Project (SHP)* as organized by the Department of Local Administration of the Ministry of Interior (see Fig. 2). The shaded area represents the Thai-German SWRD Project while the blank area stands for all other respective small water projects and programs. It therefore enjoyed, from its inception onwards, the *full political-administrative support* from the top civil servant down to the field officers. The Permanent Secretary of the Ministry of Interior committed himself to serve as Chairman of the Steering Committee which was tasked to set the overall direction and provide political-strategic guidance and back-up.

Being a rather complex pilot project, a unique project management structure emerged which distinguishes between *strategic* and *operational* functions and responsibilities. While the former was mainly discharged through the Coordinating Committee, the latter fell under the charge of Project Administration and the Core Training Team (see also Table 1). Whereas CDG-SEAPO itself had to concentrate its scarce manpower resources mainly on strategic project management only, KKU had to shoulder most of the operational project management tasks in which it was assisted by TA, which was brought in by CDG, and provincial staff of DOLA. CDG-SEAPO also commissioned an evaluation and monitoring team from Mahidol University whose work should have served as additional steering instrument, yet in practice was hardly operational due to delays in adequate reporting.

The project evolved basically as a tripartite cooperative undertaking between the *university, central and provincial administration*, and a *professional training organization*. Being the only university

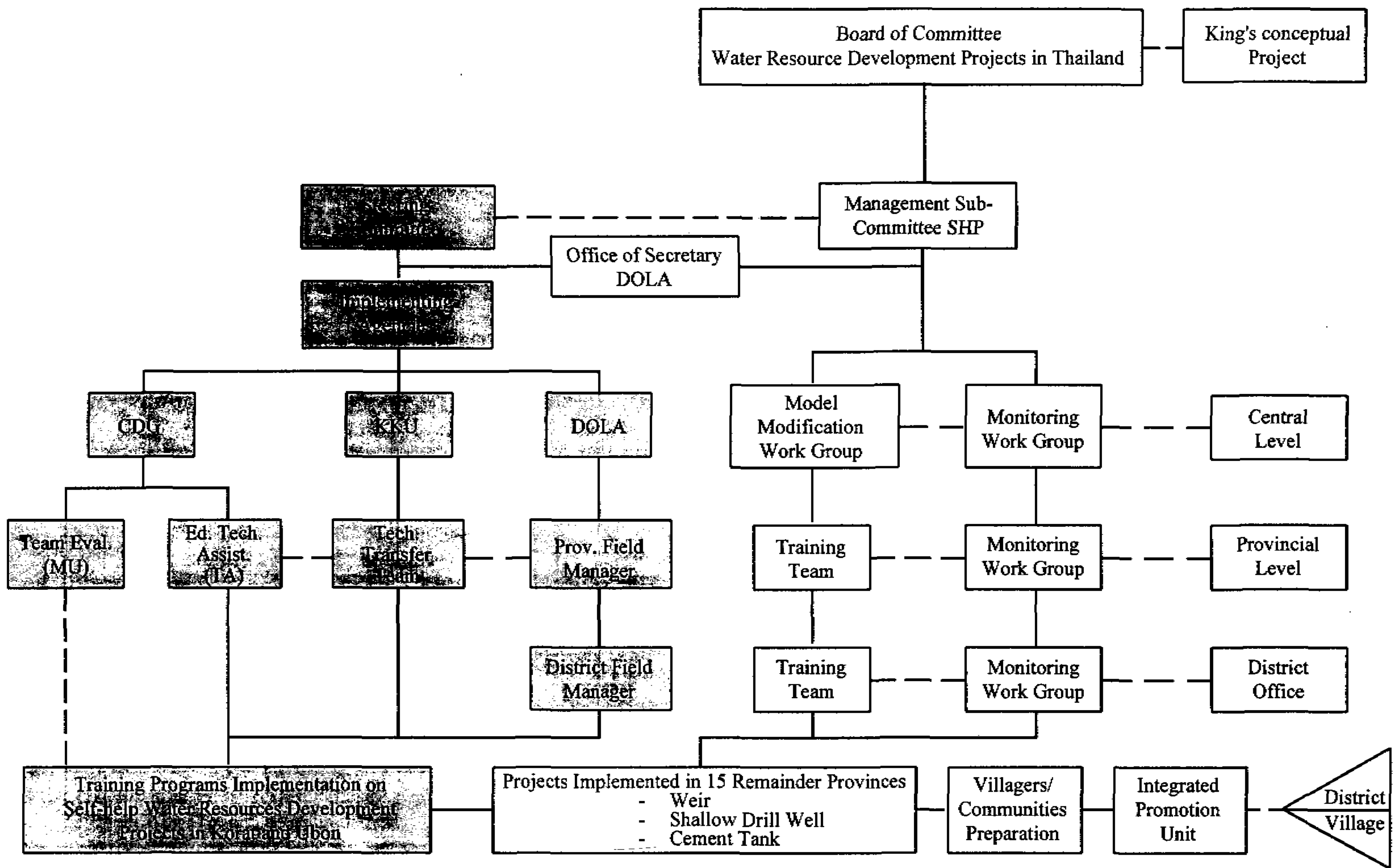


Fig. 2. Organizational chart of Northeastern Water Resource Self-help Development Project (SHP), according to 5-year plan of Ministry of Interior (1988-1994) (Source: DOLA, 1987)

Table 1. SWRD project framework in brief

1. **Project Title:** Thai-German Self Help Training Project on Small Water Resources Development in Rural Areas

2. **Project Type:** Training

3. **Type of Training:**
   (a) *Action training consisting of 3 main components:*
   - planning and decision making (Project Casework approach)
   - technical know-how and hands-on training on suitable technical options (construction, operation and maintenance)
   - training and communication skills (training of trainers)

   (b) *Multi-layered training packages with intended snowballing effects:*
   - Level A: district staff (trained by Training Core Team)
     - A 1 Deputy District Officers (DDO)
     - A 2 District Technicians (DT)
     - A 3 Assistant District Technicians (ADT)
   - Level B: village technicians (trained by Level A teams with further assistance from Training Core Team)
   - Level C: village leaders (trained by Levels A and B teams with gradually decreasing involvement by Training Core Team)

   (c) *Self-help oriented*

4. **Project Objectives/Aims:** to provide technical, planning/decision-making and, partly, training know-how and skills to 5 types of trainees (deputy district officers; district technicians/assistants; village technicians; villagers) on development of small-scale water resources in rural areas in order to alleviate the perennial water problems for drinking, domestic and also agricultural purposes through the villagers' own efforts, i.e. Self-Help activities.

5. **Co-Implementing Agency:**

   (a) South East Asia Program Office, Carl Duisberg Gesellschaft, Bangkok
   (b) Faculty of Engineering, Khon Kaen University, Khon Kaen
   (c) Department of Local Administration, Ministry of Interior, Bangkok

6. **Funding Sources:**

   (a) *Project planning and implementation:* German Federal Ministry for Economic Cooperation
   (b) *Project utilization/extension:* Thai Ministry of Interior/provincial administration/villagers' own contributions

7. **Project Management Bodies:**

   (a) *Policy Support:* Steering Committee
   Chairman: Permanent Secretary, Ministry of Interior, Royal Thai Government
   (b) *Strategic Project Management:* Coordinating Committee
   Chairman: Guenter Tharun, Head, Carl Duisberg Gesellschaft - South East Asia Program Office
   (c) *Operational Project Management:* Project Administration/Training Core Team
   Project Manager: Dr. Prinya Chindaprasirt, Dean, Faculty of Engineering, Khon Kaen University

8. **Project Period:** 1987-1990

9. **Target Area:** Selected villages of UbonlRatchathani and Nakorn Ratchasima provinces in the Northeastern Region of Thailand

10. **Target Groups/Beneficiaries:**

    (a) ultimate target groups are the villagers, especially the village leaders, to enable them to satisfy the basic water needs in their communities;
    (b) intermediate target groups are the Levels A and B participants to reach out to grassroots level

11. **Project Status:** Concluded (Phase I)

12. **Results/Outputs:**

    (a) *direct:* (first figure indicates target output, second one in brackets indicates actual output) 13,500 [13,832] villagers, 675 [675] village technicians, 316 [328] (out of which 135 [138] took part in refresher courses during year 2) district technicians/assistants and deputy district officers trained until the end of 1989;
    (b) *indirect:* water shortage problems in target villages, i.e. 25% of pilot provinces, to be resolved through villagers' own initiatives and contributions until the end of 1990; with additional support from Thai government agencies

in the Northeast, KKU's Faculty of Engineering set out to serve its natural hinterland. In essence, the project also aimed to apply and transfer scientific engineering knowledge for the benefit of the rural poor in the region.

The project made maximum use of mobilizing local manpower resources and expertise for developing and delivering the training concept and materials. Thereby, the project operation was not only very economical, but was also in harmony with its socio-cultural environment.

As the project fully utilized locally and nationally available indigenous material and manpower resources, so it did as well in implementation planning. This joint planning effort provided each project party ample opportunity to actively contribute to and influence the actual project implementation, its direction, and its mode of operation.

In the course of project management, numerous adjustments and changes were made in the interest of achieving and maintaining sound quality in inputs and outputs. Making these adjustments required a *high degree of project management flexibility*. As such, the project was a good example that project authority of anyone party can be rather limited, whereas *project responsibility* tends to be quite extensive and comprehensive. Therefore, under such situation, no one party could really dominate the other, hence *project management evolved in matrix format*. It necessitated the application of *socio-interactive management skills of coordination, negotiation, motivation, communication, conflict resolution, and participative leadership* (THARUN, 1989a).

Strategic project management at the Coordinating Committee level functioned primarily through consultation and coordination between more or less equal partners. Operational project management obviously followed mainly the top-to-bottom command pattern, as far as vertical communication with project field staff was concerned, but also switched to consultative modes of operation whenever horizontal communication took place between staff from different project parties.

The German side provided funding for human resources development in project planning and implementation, and respective professional training input. On the other hand, the Thai government side allocated its resources more on project utilization and extension activities. The Thai government continuously increased its respective budgets from Baht 3.5 million in 1987 to Baht 63.5 million in 1988 and Baht 120 million in 1989 (Letter of the Permanent Secretary of the Ministry of Interior to the German Ambassador, 31 August 1989, MOI 0409/12018).

The SWRD project achieved an impressive input/output ratio of approximately DM 100 or US$ 60 in total training cost per villager trained. With only DM 1.4 million project budget, 14,000 villagers were trained in about 700 courses of one week duration in a time span of two years of project implementation.

2.3 Drawbacks and Difficulties Encountered and Lessons Learned

Since hardly any human action or undertaking is perfect, no project with a complex set of specifically arranged and coordinated actions will materialize without facing various difficulties and problems.

The SWRD project was somewhat a challenging experiment. For different reasons it proved to be a novelty to all involved parties. Several mistakes were made, also because one could not imagine the tremendous difficulties in communication to be coped with. Misunderstanding of concept and roles made things even more complicated; some personality clashes surfaced at the beginning too.

A substantial amount of time, energy and patience was needed to pull the parties together, especially with regards to the Project Casework action training approach which posed more difficulties to the young engineering professors than to administrators and professional trainers. At times, inappropriate perception of the requirements for a pilot scheme made it more difficult, as some project staff just opted for an easy-going attitude instead of being more careful and hardworking to avoid any disaster which would impair the whole project. At the start, training quality and mode of cooperation was seriously affected and required urgent crisis management.

Frequent transfers of trained deputy district officers and district technicians were also hampering further training implementation at B and C levels.

Selection of target villages as well as villagers in terms of need and suitability was sometimes lacking. More careful consideration on the part of the provincial administration will be needed in the future.

Also encountered was a dysfunctional competition from other government's programs that were more attractive as they usually provided everything free including pocket money. These were counter-productive for self-help programs. Moreover, public relations work and publicity for the project in general was not adequate and needs to be improved.

At the beginning, too much emphasis was given to technical hands-on training instead of planning and decision making skills as advocated by CDG-SEAPO. Better maintenance and availability of equipment for training and extension activities were needed. Also, coordination in the field showed certain shortcomings. Furthermore, better and more follow-up measures in the field will be needed as reinforcement and back-stopping. The monitoring report was not very useful for project steering and management because of delayed submission. A more practical system would have to be installed in the future.

The project management system should have been streamlined and sufficiently clarified regarding roles and responsibilities.

Due to the very limited understanding of PCW concept by the project staff, only a rudimentary PCW version was developed after more than a year. Thus, many opportunities in training effectiveness were lost. Nevertheless, this delayed version, despite all its shortcomings, still generated positive effects leading to better training quality. It should have been mandatory for CDG-SEAPO - although unforeseen then by the author - *to organize an introduction workshop on the PCW approach right at the start of the project.* Such an intensive PCW exercise could have served, firstly, to familiarize the other parties and their involved key staff with this unique action training concept following the general or rational problem solving format. Secondly, many of the misperceptions and resulting frustrations, delays and, technically lopsided training sessions at the beginning could have been minimized if not avoided on one hand, while training effectiveness could have been greatly improved on the other. However, *one always knows more after something has happened* which is the crux of any project manager, especially in quite complex projects such as the SWRD training project which in many respects proved to be a pioneering (ad)venture involving a great degree of uncertainty and risk. This was true particularly with regards to overall scope and number of people involved and the testing of the PCW approach as the core part of this grassroots level training for self-help.

3. The Project Casework Action Training Concept

As Project Casework (PCW) still is a relatively new action training concept, it is largely unknown as yet. It is often misunderstood as either case study, project work assignment or just an assembling scheme of project planning, case studies, group work, lectures, field trips, etc..

Furthermore, as the PCW approach - even in its very rudimentary form - served as the main self-help mobilization springboard of the SWRD project phase I (1987-1990) and as it will assume even more prominent role in phase II (1990-1994), there is a need to introduce it to a wider audience and clarify the mind-boggling questions involved.

3.1 Rationale for Application in SWRD Project

Although the ultimate target groups of the project are poor villagers with a relatively low level of primary education, it was still decided by the author in early 1987 to try and use the seemingly demanding PCW method as the tool to actively involve the villagers in seeking (their own!) solutions to their water shortage problems. It was assumed that by doing so, sufficient motivation for learning - as a prerequisite for rational action for improving one's lot - could be generated. Furthermore, so that a gradually growing sense of ownership of one's own solution and, thus, a strong determination of self-help in rural water supply in particular, and rural development in general, could be ignited and nurtured.

This decision was reached then, after a long cognitive search for a suitable training methodology for two evolving CDG-SEAPO projects on small water resources development and on small entrepreneurship development, respectively. Although the Project Casework concept was originally developed in the summer of 1977 for the purposes of adequate professional training in the field of environmental management, the author assumed ten years later that in all complex planning and decision making situations the PCW-based-training should be a viable option. Rationally assessing and solving their water shortage problems poses to be quite a complex task for the villagers, and not only for them! Even if a given situation in a village seems to be very clear-cut and obvious for a so-called technical expert, who is used to perceiving and transforming such problems into one-dimensional technical tasks only, no single best solution exists to complex problems, irrespective of the level of education of the target group or the scale of target area.

Project Casework proved workable despite all the earlier odds against the decision to try and apply it. Even the professional trainers involved did not believe its viability as they rightly presumed that simple villagers were not used to active learning methods. Their professional preconception told and misguided them to believe that PCW must fail as the villagers will never assume active roles. Therefore, they took it for granted that the villagers would not change their learning behavior and, thus, would need intensive lecturing, supervision, and close guidance or instruction. However, it just turned out to be the opposite.

The underlying hypothesis was then proven and validated while being tested and applied in the field and can now be formulated as a proven thesis:

Project Casework is a viable active learning or action training approach for all complex planning and decision making tasks.

3.2 The Basic Concept

The main issue underpinning the whole PCW approach, its structure and function is the *focusing on appropriate action for anticipated meaningful problem solving or task accomplishment.* Its basic concept can be described as learning-cum-planning tool for bridging the gap between awareness of any problem, shortcoming or task, on one hand, and suitable actions as contributions to solving these problems or tasks in practice, on the other (KAISER, 1976). Fig. 3 simplifies the basic difficulties involved in any such transformation process from idea generation or formulation of goals and its translation into adequate action and behavior. All attention and efforts are to be focused on the "How to do it (?)", from perceiving something as a problem or task to solving it, from reasonable idea to relevant action.

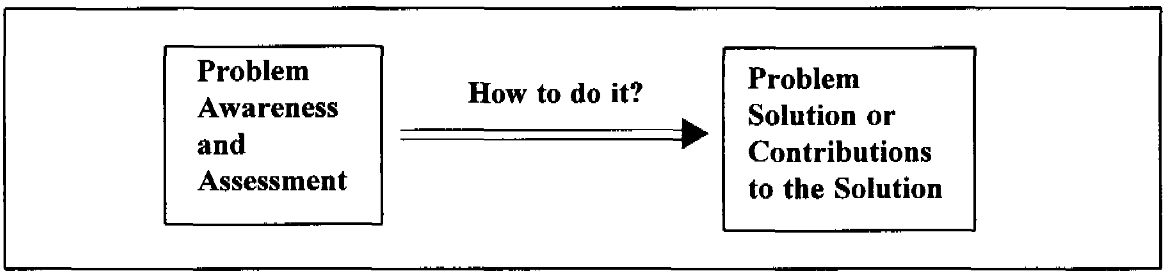


Fig. 3. Basic difficulty (problem) in transforming problem awareness and analysis into appropriate action for solving the problem

This basic bridging or transformation process can be packaged into a step-by-step approach of problem solving following the "general-purpose problem-solving format" (REYNOLDS, 1980) which depicts the formal logical structure, process, and direction of any PCW exercise in principle, as shown in Fig. 4. Thus, Project Casework is based on a format of rational problem solving and utilizes its procedure as guideline for structuring action learning through action training.

In other words, Project Casework is a training approach which follows established ways of rational problem solving, i.e. by analyzing the problems or task first, in conjunction with a clarification and/ or development of (own) objectives on the basis of constraints and available resources; then, by generating different options to reach these objectives; costing and comparing these alternatives with all their respective pros and cons for selecting the most suitable alternative, and most importantly, acting on it accordingly.

Before jumping hastily into any action, the PCW logic demands:

(a) analysis and assessment of WHAT IS the situation, problem or task, then
(b) development and work on WHAT SHOULD BE the solution or goal,
(c) computation of cost and evaluation of different options on WHAT CAN BE DONE to achieve such more desirable situation, and
(d) consideration, and selection of the most suitable strategy option implying WHAT MUST BE DONE then as real action.

PCW is an intensive learning approach

- *not only **on** rational problem solving (content)*
- *but, above all, **through** rational problem solving (method)*
- *for rational problem solving (goal), its ultimate purpose.*

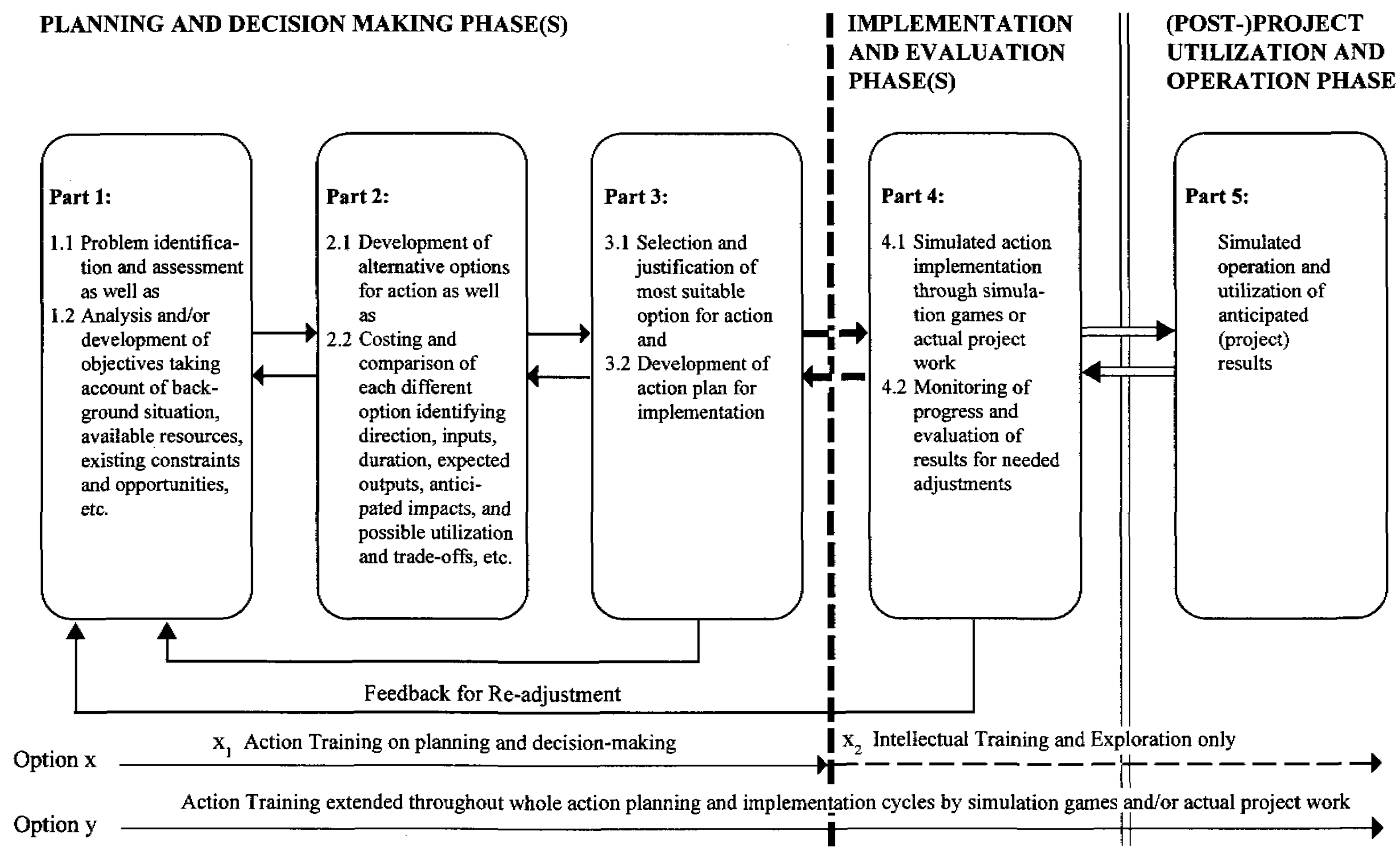


Fig. 4. Basic action training concept indicating range of content and exercise for learning by doing in problem solving

PCW is an action learning/training approach on planning and decision making in two senses: the participants are made to think and act freely on their own unique solutions to given problems within the context of a realistic scenario, either derived from a real case or hypothetically constructed from a variety of real life situations. The experience and eventual self-confidence gained from this process of active learning by doing is expected to prepare them better mentally for real action in real situations, which should be the ultimate *goal* of any training effort.

However, it has to be borne in mind that action training on problem solving is usually only possible and viable as far as the planning and decision making phase or function goes. Beyond that, i.e. from the implementation phase onwards, the training function will be reduced unavoidably to some form of intellectual "training" and exploration only. This has been the fact in most of CDG-SEAPO's PCW-based seminars or training courses so far, with notable exception on our Small Water Resources Development Project in Northeastern Thailand where there existed the almost unique opportunity of immediate transfer and application of learned skills into real action or implementation, provided the necessary financial means were made available. In all of our other training projects, the aforementioned limitation is a basic one which can not be overcome unless the extension into simulation games or small trial projects can be arranged. Fig. 4 shows the prospects of action training and its usual limitations.

One must also remember that any training, even the most effective versions of action training including the PCW approach, can only be a **MEDIUM** for projected change and improvement; it can never replace action in the real world itself. Nevertheless, it does play an essential role in better preparation of trainees for real action (THARUN, 1987).

Accepting participants, in principle, as capable partners in problem solving by letting them work through the whole process of devising and selecting practical solutions, they basically create their own answers and solutions to given problems and develop strong commitment, sense of ownership, and responsibility towards their own work.

The practical transformation of problem awareness into appropriate action for problem solution is considered the main task and purpose of the PCW approach, while its structural process and mode of learning must be considered as the main tools for attaining it.

3.3 The Main Features

PCW is *an innovative action training approach through sound management of learning resources*. It is a blend of several active learning methods whose main characteristics are molded into a distinctive approach of its own. Project Casework derives its dynamic product achievement function, its main ingredient, from the **prospective PROJECT method**. Its strong analyzing and structuring function comes from the **retrospective CASE study** while its mobilizing, motivating, synergistic, and built-in controlling function stems from **interactive group WORK**. These are coupled with an immediate test simulation and interpersonal energizing function as generated through interchangeable role playing between the groups during presentation and discussion of their results.

PCW is open to *additional functional inputs*, such as simulation games, actual case studies, brainstorming sessions, field trips, lecture presentations, film or experimental demonstration, actual project work, etc., depending on their suitability.

The PCW can be just an additional input to any seminar, workshop or training course as in CDG's very first environmental management seminar in September 1978 at the Asian Institute of Technology. It can also be made the dominant feature of the entire course, providing its overall framework, direction, and structure. This full-fledged realization of the PCW-based action training approach - as originally conceptualized and intended by the author in 1977 - was made possible from 1979 onwards, with very encouraging results. Fig. 5 amplifies the central position of Project Casework according to its conceptual model.

The PCW exercise itself is steering the participants to and through systemic/systematic problem solving by not only encouraging, but more on requiring to look beyond the immediate situation and problems, as well as the contemplated objectives and anticipated measures, actions and projects, for better and more realistic positioning of oneself in a changing world (systemic component). However, it also goes beyond such situational (systems) analysis. Sound project management principles have to be followed in a systematic way to better facilitate the process.

In other words, the whole PCW training concept is designed to *guide the participants to focus their attention, imagination, and energies* on the four major tasks of:

(1) how to address and assess a problem issue or task and develop pragmatic objectives for practical actions, on the basis of the overall situational setting, i.e. the different stakeholders or players involved with often conflicting values and interests, available resources in terms of time, money, manpower, equipment, materials, etc. in view of the socio-cultural and physical environments, political will, constraints and opportunities.

(2) how to design, analyze, cost and compare suitable options for goal achievement or as contributions, at least, to appropriate problem solving, while considering available technical, economic, financial and social possibilities, legal requirements, anticipated capital and operating costs of each alternative, manpower and training needs, PR work, socio-political and cultural acceptability, time requirements for bureaucratic/administrative procedures, loan conditions, development efforts, etc.

(3) how to agree, select and decide on the (most) practical options and to design an operational action plan, program or project which is technically, economically and financially feasible, socio-culturally acceptable and environmentally safe and thus, appropriate within the socio-cultural fabric of the existing local community, its dominant values and preferences.

(4) how to start the implementation of a project or activity and ensure the achievement of targets by setting up an appropriate control mechanism for progress monitoring and evaluation with necessary feedback for correction and adjustments, and taking into account changing circumstances in development priorities, adverse influences, etc.

In short, the PCW objective is *to help participants become aware of, identify, and assess existing problems in order to develop (own) solutions to create new initiatives through their own efforts.*

As previously mentioned, most forms of action training, including the PCW approach, usually fall short of Item (4) as they normally cover planning and decision making phases only as far as simulated action is concerned.

Such strong orientation on problem solving and its methodology leads to a very *functional arrangement of all inputs* and even of the outputs produced by the participants throughout the course. This refers not only to the functional placement or scheduling of course activities (such as lectures or paper presentations, group work assignments, field visits, and presentation and critical appraisal of group results), but also to the internal functional structuring of each input. Furthermore, it gives the opportunity to decide whether an input is needed at all or better discarded if it has little or questionable potential contribution to the intensive learning process on problem solving.

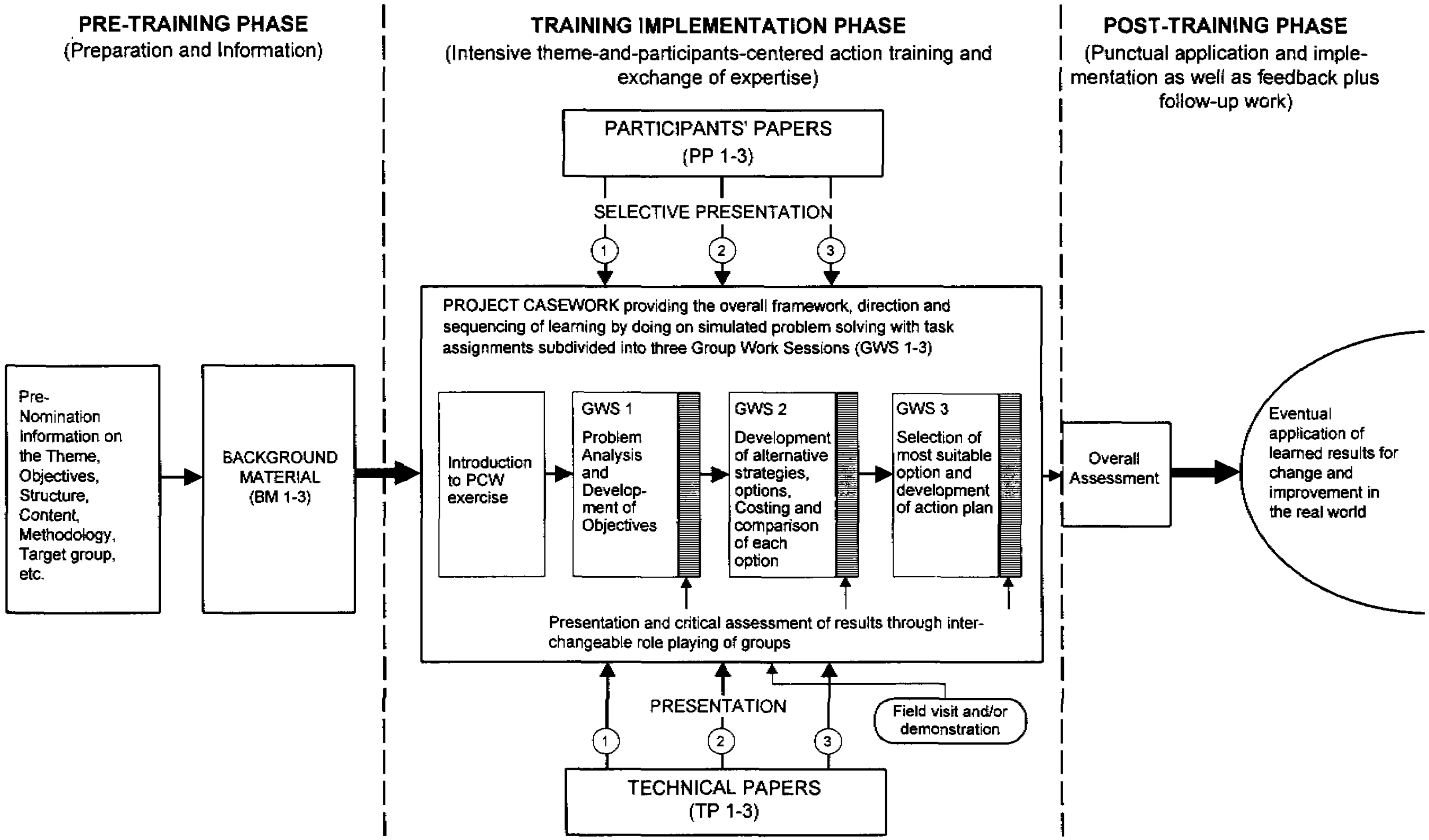


Fig. 5. General conceptual model of project casework based training

PCW requires *sequencing of group work sessions as well as presentation and discussion of results* after the completion of each major assignment. The presentation and plenary discussion of group outputs is essential because it:

- provides further learning from among the groups;
- allows for corrections, adjustments, and improvements of intermediate results due to immediate feedback;
- packages overall assignment into manageable units with observable results;
- puts pressure on participants to stay realistic and practical;
- builds strong team spirit;
- leads to better understanding of different roles and results.

PCW entails considerable *time pressure* for task accomplishment which is intended, as it:

- resembles real life job situations;
- exerts pressure to form and work as a team to be able to accomplish the assignments;
- necessitates early decisions within the groups on how to proceed, how to distribute the tasks, and whom to elect as project manager who must have strong cooperative leadership qualities;
- makes them stay realistic and practical and appreciate available time as valuable resource.

Another striking feature of the PCW is that it leads to a *healthy divergence* of:

- produced results,
- the conclusions drawn from them,
- and the recommendations presented by the different working groups.

This stimulates very animated and constructive discussions and exchange of ideas and opinions by the different role players as, after having worked through the same exercise themselves, all groups are quite familiar with and authoritative on the topics. This divergence also clearly demonstrates:

(a) how different values, ideas, perceptions, opinions, priorities and decisions can and will lead to different results;
(b) that the results are influenced and even shaped by the experience, expertise, educational backgrounds, value judgments, attitudes and beliefs of people working on solutions to given problems;
(c) that the group dynamics and formal or informal/hidden procedures of problem or task assessment are also important to the obtained results because these are, above all, decision making processes themselves and not just a so-called 'objective' technical exercise.

It further shows clearly that there hardly exists a single best solution to complex problems in a complex world, since the problem solving processes themselves are quite complex, involving different personalities with different preferences dealing with different operations and, thus, differing interpretations. Nevertheless, this learning experience is quite remarkable in stimulating healthy competition within and between the groups and intensive communication and exchange of opinions, ideas and experiences.

One more noteworthy feature is the **active involvement of the participants** which is not only wanted, but definitely needed if the PCW approach is to work at all. The results of the PCW assignments (from problem analysis and development of objectives, over to the development of alternative strategies, their costing and analysis, to the selection of most reasonable option, and the development of an action/implementation plan) are the fruits of the group's own hard work, creative and innovative thinking and consensus building, and are thus, unique creations of the group members. However, the groundwork has to be prepared and laid down beforehand, through sound PCW training material development by seasoned practitioners or, at least, in collaboration with them. These materials also constitute the framework and structure of problem solving processes within which the working groups should be relatively free to operate while searching for and working on meaningful solutions, which are genuinely their own distinctive products of problem solving. As such, the participants also bear the responsibility for them, i.e. their liberty to act responsibly is both a privilege and obligation.

PCW evolves along the principles of **self-organized group work** within the pre-arranged framework of a relevant action field scenario and well-structured and packaged project task assignments.

Successful application of the approach *demands the total commitment and involvement of the trainees in a participative way* to assimilate themselves as the 'citizen' of the simulated situation which stimulates their sense of 'ownership' of the scenario. It further requires appropriate conditions which have to be created, nurtured and facilitated for interactive communication and intensive self-learning processes in small groups as well as between the groups.

3.4 The Key Principles

Intimately connected with the needed active and productive role of the participants is the understanding of the PCW approach as a **theme-and-participant-centered method**. As such, it supplies the only adequate tool for the participants' role as potentially active problem solvers in the real-world itself after the training.

Related to this principle is the unique **role of the trainer** primarily as actively observing resource person whose main task is to stimulate and facilitate the self-organization of learning-cum-problem solving processes among the participants, not so much through lectures, but more on encouraging their own initiatives and efforts in the accomplishment of their assignments. This role of facilitator is best discharged by a *special breed of resource persons* who must be:

- seasoned technical specialists/practitioners in their respective field(s);
- familiar with specific socio-cultural circumstances of target groups/regions/countries; and
- conversant with and convinced of the merits, principles and functioning of the PCW approach.

Both the aforementioned aspects are related to two key principles. The first one is **learning by doing** which is the key to action training in both its aspects: (a) as active learning experience which is not only motivating but also highly effective, and (b) as mental preparation and disposition for future action implementation in the real world, which is the ultimate goal of training.

The other one is the **role of the intervenor** which carries the notion of doing what one can do here and now with one's own resources and not waiting for other people's initiatives or a grand solution, which is a convenient pretext for doing nothing or too little too late (JONES, 1981).

Another important principle of the PCW approach is its **RELEVANCE**, i.e. the relevance of its training potential. Relevance of training is to be understood in terms of: (a) *its closeness to real world practice*; (b) *its problem solving capacity*; and (c) *its practicality*. All these concepts will determine the relevance of training which is closely interrelated with the operational factors of training management, such as contents, learning objectives, methods, media, target groups, quality of resource persons, etc. besides other inputs like money, time, venue, etc. (DAVIES, 1972).

The achievable training quality will mainly depend on sound judgment by seasoned practitioners among the organizers and curriculum developers with regard to what is considered essential and relevant and what is not, as there is no valid cookbook at hand with ready answers to these questions.

Linked to this key principle is the issue of having the training materials developed, as far as possible, by experienced professionals with rich subject-matter expertise based on field exposure. This is a very crucial issue directly affecting the quality of training and its relevance. As this is not always possible, seasoned subject-matter expertise has to be involved, at least, in the development and delivery of training whenever available and affordable. The other input must come from equally experienced curriculum specialists for better packaging and delivery of content with regard to the chosen objectives, the qualifications of the target audience, etc.. PCW training success *depends greatly on the quality of the problem scenario and the ability of the resource persons* in administering the training.

Finally, the guiding principle and combining force of all other aspects of the whole exercise is to focus the attention and energies of all involved, the participants, organizers and resource persons, on the transformation of problem issues into suitable action for problem solving, i.e. for improvement of real life conditions.

3.5 Advantages and Constraints

While many of the described features and key principles somehow imply positive attributes, there are also drawbacks involved (as any man-made scheme or system or part of it has its pros and cons to be reckoned with). Beyond the numerous aspects already mentioned before, one can also stress that PCW is obviously a very effective, efficient and economical training approach which can easily handle 30 to 35 participants. However, there should be at least 15 participants as two working groups are required. At least two groups are needed to work on the same problem scenario to make comparisons of results, conclusions and recommendations possible.

The PCW method also accommodates and encourages - depending on the tasks and topics - *the participation of trainees with multi-functional, interdisciplinary, and cross-sectoral background.* If professionally handled, PCW methodology develops and/or improves the participants' *knowledge, skills and attitudes* in *team-work, planning and decision-making* towards producing practicable implementation plans for the real world.

But to accommodate efficient and effective learning, PCW also *needs adequate room facilities with appropriate training media equipment.* The rooms for the small working groups must be accessible to the respective groups at all times.

It might also be highlighted here that PCW possesses strong *built-in mechanisms to self-generate, stimulate and strengthen high motivation, involvement and participation of trainees* and does not need fancy psychological activation games as are widely used in more fashionable 'professional' training. Though often overlooked and not fully appreciated by many co-organizing parties, there must be one working room for each group! Therefore, more and better facilities are needed than in usual continuing education courses.

Furthermore, as already proven hundreds of times in the village-level training of the SWRD project where PCW acted as both an action learning and actual action planning tool, the approach offers more choices of applications.

PCW, although being primarily a holistic problem solving-oriented, action learning/training approach, can likewise be used as a planning tool as it follows the same basic principles of sound project planning and management. This is why it can even be considered as a project management concept or:

> **Project Casework is a suitable action training approach**
>
> - ***on*** **project management**
> - ***through*** **project management**
> - ***for*** **project management**

As is true in any training program, if effective at all(!), PCW training *results are mainly affected by the training program arrangement, the characteristics of the trainees, and the role of the trainers* as managers of learning resources in a systemic sense. However, if the PCW material is sufficiently well developed and applied professionally as the central part of action training, it assumes a strong 'carrying capacity' which can easily absorb a certain 'waste load' in shortcomings of other aspects and inputs. Since PCW definitely means much less teaching or lecturing (or, ideally, none at all) in stark contrast with dominant teacher-centered lecturing (or more modernized technocratic versions of excessively carried-out intensive teaching, a misperceived attempt of much more of the wrong things), it has other requirements to make it work.

PCW *needs more input in relevant expertise, lead time, and preparation than conventional training methods*. The development of training materials by resource persons and organizers needs intensive efforts during the pre-training planning and preparation phase. The participants' willingness and capacity to work hard and be creative are highly challenged during the training phase when the resource persons' role is moved to the sidelines. However, they have to be available as long as the groups are working, even if that means beyond midnight! It is also not an easy task to find the right resource persons as effective facilitators or to tune them in to their new roles.

As mentioned before, PCW is a relatively new active learning/action training methodology which is perhaps unknown as yet and often misunderstood as something else. Therefore, it involves tremendous risks if one wants to apply it without taking into account all the other factors involved, especially the constraints. Nevertheless, after numerous applications and continuous fine-tuning of the approach it can be safely stated here that PCW is **always a viable action training approach if one deals with relatively complex planning and decision making situations/tasks/problems.** For that matter of course, it is only then a viable training or HRD option if it is handled professionally, i.e. from material development to its effective delivery (THARUN, 1989b).

4. Conclusion

The reality of the small water resources development project has shown that it takes tremendous efforts in time, communication, energy, and money to secure the 'soft' components' rightful place in development. These 'soft' aspects of the socio-cultural sphere, (e.g. community participation and self-determination, self-help, communication, interaction, commitment, motivation, feelings, attitudes, etc.) play a significantly more important role than usually acknowledged by development 'specialists', even in their sphere of hardcore engineering technology and economics when it comes to their successful application and utilization in bigger technical or financial assistance programs and projects. These 'soft' socio-cultural aspects must even be made to play the dominant part in grassroots level programs and related training for these activities to succeed at all.

As politics follow fashionable trends, the sector of development policy and inherent development concepts, strategies and their underlying ideologies are no exception. Thus, self-help concepts or those of women's participation, etc. are in vogue at various times in varying degrees. To stay fashionable, especially in order to obtain much wanted or needed development aid funds, many development 'experts' also pay lip-service to these concepts as catch phrases yet without really making them work.

Though often honored as indispensable functional requirement for (success in) development, there is much more to gain (or to lose if not really appreciated) from the concept of self-help in terms of human dignity and high moral value in the self-determination of one's life as a basic human right.

That the SWRD project has succeeded in inculcating the idea and will of self-help among the increasing number of poor villagers alone, can be rated as a remarkable achievement. That a realistic sense and determination to help themselves could be generated and disseminated among the villagers, must be attributed a great deal to the actual inclusion of the Project Casework-based action training. Despite the many obstacles, PCW became the major vehicle in moving the villagers to free themselves of their water shortage problems through their own self-organized and -determined contributions and actions. Through the learning by doing PCW style, many villagers gained more self-confidence in managing and improving their own lives which, therefore, has much bearing beyond the immediate targets of the water project, but also on human resources development towards self-organized rural development as a whole.

References

DAVIES, I. K. (1972) "An extract from the management of learning", An Introductory Course in Teaching and Training Methods for Management Development, ILO, Geneva, pp. 19.7-19.10.

JONES, P. H. (1981) "Educating the intervenor", The Environmentalist, 1:33-37.

Letter of Permanent Secretary of Interior, RTG to German Ambassador to Thailand of 31 August 1989, MOI 0409/12018.

REYNOLDS, J. I. (1980) Case method in management development: Guide for effective use, Management Development Series No. 17, ILO, Geneva.

THARUN, G. (1987) "Project casework-based training for better planning and management of water pollution control in developing countries", World Water 1986, Water Technology for the Developing World, Proceedings of an International Conference Organized by the Institution of Civil Engineers and held in London on 14-16 July. London, pp. 231-239, 242-243.

__________ (1989a) "Future trends in environmental education and training", In: Vigneswaran, S., T. Mino, and C. Polprasert (eds.), Environmental Perspectives Towards the Year 2000 and Beyond, Proceedings of the Symposium, 9-10 November 1989, Asian Institute of Technology, Bangkok, Thailand, pp. 75-98.

__________ (1989b) "The Project Casework (PCW) concept in brief - Its rationale, structure, function, development and origin in 42 statements", CDG-SEAPO, Bangkok.

Training on Low-cost Water Supply and Sanitation: An Indonesian Experience

Juli Soemirat Slamet
Department of Environmental Engineering
International Training Network Center
Institute of Technology Bandung
Bandung, Indonesia

Abstract

Experiences in developing countries on low-cost water supply and sanitation (LCWSS) showed that successes can only be achieved if technologies were appropriate to the local socio-cultural conditions and that it can be achieved if the implementation of these technologies as "hardware" were integrated with its "software", such as management and community participation, hygiene education, etc. The mission of the International Training Network (ITN) Center at the Institute of Technology Bandung (ITB) was to conduct training on LCWSS and its approaches to promote the needed improvement in both the effectiveness of water supply and sanitation investments and the extension of service coverage, particularly to low-income population groups in the urban fringes and rural areas in developing countries. Within a two-year period, 80 instructors, 160 practicing engineers, and 60 decision-makers had attended training at this Center. It was interesting to note that at the start of the training, most engineers felt that the "software" of LCWSS was not of their concern, but at the evaluation, one of these "software" modules always came out as the most interesting and relevant module in LCWSS work. Based on the follow-up questionnaire it was concluded that there is a need for massive reorientation of knowledge and attitude of all staff involved in LCWSS; a change of program and policy is also necessary in order that the community can participate in LCWSS projects. To support the needed flexibility of these LCWSS programs, an information system should be developed. Also, engineering education curricula should include "software" besides the traditional "hardware". It is recommended that ITN should develop an internal network within the country to enhance training, and that monitoring of these activities be based on the real indicators of (health) impact, namely morbidity of water-borne diseases.

1. Introduction

The Government of Indonesia has been giving priority to water supply and sanitation since more than 20 years ago. In providing these services, Indonesia had traditionally followed the methods and approaches used by developed nations. In urban areas, piped water supply was the tradition, while in rural areas, simple systems were introduced. In urban areas, the high costs of these systems had the unintended effect of providing the rich with services while leaving the low-income population with deficient or no services. In rural areas the importance of having safe water supply and sanitation service was not fully understood, hence 40- 50% of the rural systems were no longer functioning one year after construction. This condition is aggravated by the rapid population growth, so that the situation remains unmitigated despite the increasing investments and priorities given by the Government of Indonesia (AKHTER, 1982; SOEMIRAT, 1985; WORLD BANK, 1986).

The International Drinking Water Supply and Sanitation Decade called attention to this matter and encouraged the search for low-cost solutions in water supply and sanitation sector, which are more suitable to the local environment. To support the goals of the Decade, the UNDP and the World Bank developed a series of modules on *Low-cost Water Supply and Sanitation (LCWSS) Technologies*, which include implementation approaches. The approaches suggest integrated ways of implementating LCWSS technologies with management, community participation, health, hygiene education, and other related aspects. In this way, the technologies will become effective, affordable and culturally acceptable to the population. These modules were meant to be used in training sessions conducted by training centers established throughout the world, called the *International Training Network (ITN)* for water supply and waste management. It is a joint initiative of the UNDP and the World Bank. Its principal objective is to promote the needed improvements in both the effectiveness of water supply and sanitation investments and the extension of service coverage, particularly, to low-income population groups in the urban fringes and rural areas of developing countries (ITN-ITB,1987-1989).

Realizing that most of our population is in the rural areas, where high-cost technologies are not affordable, that habits, customs and traditional beliefs could adversely affect the use of good water supply and sanitation, and that there are institutional weaknesses, and extreme shortage of staff trained to promote rural services, organize communities, etc., the Government of Indonesia was, therefore, very enthusiastic on the intent of the World Bank to develop an ITN Center in the country. Also, even if the current policy requires integrated and participative actions in LCWSS, most of the professionals in this field were not aware of the existing technology alternatives. In 1987, two centers were established in Indonesia, one center at the Directorate General of Human Settlement, Cipta Karya, Ministry of Public Works, which is called the *ITN-Cipta Karya (CK) Center* and another one at the Environmental Engineering Department of the Institute of Technology Bandung called the *ITN-ITB Center*. Each center has almost the same tasks, but with different target groups. The ITN-CK Center conducted training within their own department, while the ITN-ITB Center targetted all other engineers outside the Ministry of Public Works, such as the Ministry of Health, Home Affairs, non-governmental organizations, student engineers, etc. This paper will mostly discuss the experiences gained in the trainings conducted at the ITN-ITB Center.

2. Training

2.1 General

The education of sanitary engineers in Indonesia follows the technology and approaches used in this country. Hence, most of the existing curricula offered courses related to the conventional water supply and sanitation systems. At the ITB, however, there is a 2-credit course offered on rural sanitation. However, up to 1987 the approach was traditional, i.e. only the hardware of these technologies was taught. It is, therefore, understandable that in order to improve the effectiveness of investments on the use of alternative technologies, training should be provided to all levels of organization, starting from the decision makers, instructors and the practicing engineers.

2.2 Training of Trainers

Within the last two years, 80 instructors coming from universities, academies and polytechnics attended training on LCWSS and its approaches at the ITN-ITB Center. These instructors were those who already have teaching experience in water supply and sanitation. The training was, therefore, conducted as workshops. Each workshop lasted for 10 days and had the following objectives:

Upon completion of the workshop, the participants should be able to:

- discuss low-cost technologies, approaches and corollary activities;
- plan, implement and evaluate specific training and information dissemination activities using the ITN materials;
- demonstrate the correct application of the teaching and learning principles;
- demonstrate awareness of their role by submitting realistic action plans.

The typical objective of the workshop was to enable the participants to use the teaching materials and apply them in their own classes. Two participants select a module of their interest, study that together and present it in class. The rest of the class then criticize and suggest improvements through a questionnaire designed by the class. Furthermore, using a video recorder, an attendant recorded their presentation so that they could watch their own performance afterwards. The typical design of the workshop was as follows:

	No. of Sessions
Registration and pre-assessment	all day
Introductory program	3
Demonstration of ITN materials	15
Training concepts	3
Course design	3
Field trip and discussion	3
Participants' presentation	9
Action planning	2
Evaluation and closing program	2
Total	40

Each typical audio-visual (AV) assisted session was constructed as follows:

An introduction to the module	3-5 minutes
Slide and sound show	20-30 minutes
Clarification, if needed	5-10 minutes
Discussion	30-40 minutes
Conclusions	3-5 minutes
Total	61-90 minutes

2.3 Training of Practicing Engineers

As with the training of trainers, the participants in this case were also experienced in the field of water supply and sanitation projects. A total of 160 engineers came to these workshops, representing all provinces of the country. The duration of each workshop was only five effective days because they were not required to develop the ability to teach using the AV materials. The first two objectives were the same as those of the instructors' workshop; however, in addition to these, practitioners were expected to demonstrate some basic skills in the construction principles of LCWSS technologies. For this last objective, the ITB Center had constructed a demonstration unit and some materials for exercise. The typical design of the workshop is as follows:

	No. of Sessions
Registration	all day
Introductory program	3
Demonstration of ITN materials	11
Exercises and discussions	4
Field trip and discussion	3
Case presentations	2
Workshop practice	2
Evaluation and closing program	2
Total	27

2.4 Decision Makers' Workshops

The typical decision makers' workshop had a duration of one day and was attended by 20 to 30 persons who are involved in decision making tasks in the water supply and sanitation sectors. Within a two-year period, three such seminars were accomplished. The main objective was to create an awareness of the existence of various LCWSS alternatives and to suggest ways to implement them. The typical design was as follows:

	No. of Sessions
Opening and introduction	1
Demonstration of ITN materials	4
Discussions, conclusions	1
Total	6

2.5 Evaluation

The success of a workshop was assessed by the resource persons and the participants. The participants were asked to assess the workshop right after its completion or after they have returned to work.

To get feedback from resource persons, the ITN-ITB Center arranged meetings with them right after the completion of each workshop. The participants were asked to evaluate their workshop using post-workshop and follow-up questionnaires.

2.5.1 Evaluation by Resource Persons

Resource persons were expected to report on unusual events, difficulties, inhibitions, as well as the positive aspects in handling their sessions. In general, no difficulties were found during sessions discussing the technologies, but it was somewhat different during the "software" sessions. Most engineers at the start of the workshop felt that all other aspects of LCWSS technologies were not of their concern. They paid attention to what was being shown and discussed, but they were quite reluctant to engage fully in the discussions. When asked about this attitude, they usually referred to the existing conditions in their work area, wherein each aspect was being handled by the respective Department with their own employees. Health aspects, for instance, are the responsibility of the Health Department, hence an engineer will practically have nothing to do with it. It was also the same with instructors from engineering schools. They also admitted sometimes that they have difficulties, since they did not have the right background or experience to discuss these matters. Again, this is due to the engineering educational system existing in the country.

2.5.2 *Evaluation by Participants*

The post-workshop questionnaires consisted of four parts: (1) organization and administration; (2) objectives, design and contents; (3) teaching materials, quality of resource persons; and, (4) recommendations on future activities, and others. In general the results were positive and only some interesting points will be discussed here.

Most participants wanted the modules translated into Indonesian, and the slides adapted to Indonesian conditions. They also liked to see Indonesian case studies.

Despite the fact that the participating engineers at the start of the workshop were not interested in the "software" of the training materials, the post-workshop evaluation consistently showed that one of the most interesting and relevant modules (according to them) was always one of the software types, which were user participation, hygiene education, and management and community participation. So, it was really worth doing these workshops.

Another evaluation was accomplished by participants 2-15 months after returning to their work. Follow-up questionnaires were mailed and an average of 70% response was achieved within 50 days. The results were, in general, again positive. Most respondents felt that they did actually learn new techniques and attitudes. The instructors were able to apply their knowledge in their class by adapting new teaching methods (more interactive and modular), discussing concrete cases with integrated approaches, and they also felt that they are now more self-confident.

Some, however, found that there were too much constraints in their work conditions, to be able to fully apply what they had learned. Among these were insufficient budget and teaching materials, and insufficient support from their employer.

Constraints found by the practicing engineers, on the other hand, were due to the local customs and existing Government regulations. For instance, the rigidity of the budget-year concept made it impossible for engineers to motivate the community to participate in their project, or there was little time left to do hygiene education. Also, inter-sectoral cooperation, e.g. between the health, home affairs, and public works offices turned out to be difficult, especially if any budget was involved. Most of the local staff in rural areas were used to work based on instructions from the higher echelons of the Government organization. This means that they were not used to work from the bottom up. This is then where the role of the decision makers come in.

The success of the decision makers' seminar can be gleaned from the conclusions made by the participants at the end of the seminar. In general, they felt that there is no one technology that is applicable in all areas of the country. This is very important, since currently all systems are standardized. It is, therefore, rigid and does not allow changes to accommodate the differences in socio-cultural conditions or preferences of the prospective users.

Another important conclusion was that the community should be willing to take the major role in LCWSS projects. Up to the present, however, it is the project manager or Government that decides what is good for the people. It is also interesting to note that the decision makers recognized the need for the collection and dissemination of LCWSS technologies and their approaches. Success achieved in one part of the country should be disseminated to other regions to increase motivation, to enhance the extension of services, and to make investments more effective.

3. Conclusions and Recommendations

A massive reorientation of knowledge and attitude on LCWSS technology alternatives is needed for all staff involved, such as practicing engineers, instructors and decision makers. For the implementation of these alternative technologies, a change of program and policy at the highest level is needed, which would allow flexibility, community participation, multi-disciplinary approach, etc.

It is recommended that:

- to enhance training, an internal network within the country should be developed.
- the curricula of environmental or sanitary engineering be adjusted to cover both the hardware and the software of LCWSS technologies.
- new policies and programs should be adapted, in order that LCWSS technologies and its approaches can be implemented effectively.
- an information system be developed to support the needed flexible program.
- a monitoring agency be established to assess the real benefits of these activities using morbidity rates of water-borne diseases.

References

AKHTER, M. (1982) "Pelaksanaan proyek-proyek air bersih dan sanitasi di daerah-daerah pengembangan UNICEF", In Laporan Rapat Kerja Pengembangan Penyuluhan Program Pengadaan Air Bersih Pedesaan di Daerah-Daerah Pengembangan UNICEF, Ministry of Health, Jakarta.

ITN-ITB CENTER (1987-1989) "Reports on the Workshops" and "Quarterly Reports", ITN-ITB Center, Bandung.

SOEMIRAT, J. et al. (1985) "Studi Pengembangan Penyuluhan Pengadaan Air Bersih di Pedesaan", Puslitbang Pemukiman, Bandung.

WORLD BANK (1986) "Water supply and waste disposal", Poverty and Basic Needs Series, World Bank, Washington D.C.

Part 4:

Case Studies

Mueda Plateau Water Supply: A Complex Rural Case

João M. Salomão
Minister
Ministry of Construction and Water
People's Republic of Mozambique

Abstract

The Mueda Plateau Rural Water Supply scheme is the largest rural water supply in the country, which has been the focus of a three-phase upgrading project. The project aimed at improving the system's water quality and making its public standposts easier to access compared to the previous situation when people, especially women and children, had to descend to the valley and climb back to the plateau, to fetch water from unprotected springs and streams. In 1980, after a three-year emergency phase, during which means were mobilized to carry out improvement work at the existing high lift pumping stations, while design work was going on, the first phase was started. This phase drew massive support from the population, which helped construction work by opening hundreds of kilometers of earth roads along the new pipelines being laid to facilitate the work of the construction teams. At the same time, some repair work was carried out on the existing facilities, and new pumping stations and storage reservoirs were built in addition to the laying of the pipeline network. Because maintenance requirements started to be felt after the system was already in use, a maintenance team was organized and later incorporated into the water company that was set up to manage the scheme. The second phase got under way in 1984, after hydrological and feasibility studies were completed, and decisions had been made on the recommended design alternatives. Additional construction work was done to extend the system to new villages on the plateau, while operation and maintenance requirements also claimed a lot of attention from the water company managers and staff. Up to now, the investment and current costs have been met by the central budget and foreign assistance, while the local population has provided labor as requested. The third phase is to begin in 1990, since civil works are already complete, and will concentrate on more efficient operation and maintenance of the waterworks. Although the five independent systems that make up the Mueda Plateau scheme are not sophisticated, they are geographically scattered, cover more than 2,000 km^2 and serve 51 villages. Thus their operation and maintenance is not an easy job. During the current phase, operation and maintenance are to be rationalized, while trying to develop and maintain a high standard of service with the maximum possible use of local skills. To conclude, the difficulties encountered were discussed, such as the limited yield of the springs compared to the demand, the large fuel consumption of the lift pumps due to the adverse topography, the management shortcomings, the great dependence on imported spare parts and fuel, and the lack of a clear status of the Mueda Water Company, as up to now, the state budget is footing the bill and the population gets the water free of charge.

1. The Mueda Plateau

The Mueda Plateau Water Supply scheme is classified as a rural system (although very complex and extensive), and has been the focus of an upgrading project for more than a decade.

The Mueda Plateau is situated in the extreme northeast of Mozambique, in the Cabo Delgado Province. The plateau, with a 3,000 km^2 area, has a very high population density compared with the rest of the rural areas in the country (more than 50 inhabitants/km^2). More than 95% of the plateau's population lives in the rural areas.

Before the construction of five piped water supply systems, thousands of people - especially women and children - had to descend to the valley and climb back to the plateau (about 200 m) to fetch water from unprotected springs or streams. Before the beginning of the project, only the small village of Mueda had a small piped water supply in the whole plateau.

2. The Mueda Plateau Water Supply Project

In 1976 the National Directorate for Water Affairs (DNA) prepared the project and an initial UNICEF contribution was requested. The intended goal was to set up a long-term partnership to progressively and rationally solve the problems on supplying water to the villages on the plateau.

The ultimate goal was to develop four or five water supply systems to provide a minimum supply of good quality water to serve 120,000 rural villagers, through public standposts, assuming a 20-liter per day per capita consumption. The conceived systems were to serve only the plateau's scattered villages, the small village of Mueda, and the sanitary and educational centers. As a matter of fact, only a few people lived outside these settlements.

The designed project was to be implemented in three phases. However, as the project was being prepared and the procurement of the necessary external funds was taking place, some emergency projects were started and completed.

2.1 The Emergency Phase

Right after independence in 1975, the government decided on a widespread intervention. Local and national mobilization of the required means, and reinforced by a specific UNICEF financing, made the start of the emergency phase possible in 1976.

Some rehabilitation and improvement work in the existing systems was carried out to minimize the lack of water on the plateau. New construction and reconstruction work was done in the N'tamba, Chude, Chomba and Muatide systems, while a decision was made to postpone hydrogeologic surveys.

During this period, the general concept for the projected systems which was based on the extraction of surface water from springs at the foot of the plateau, lifting the water up to the supply level, and building there the necessary storage facilities, was modified. It was decided to supply all the water through public standposts only.

2.2 The First Phase

In 1979 UNICEF approved the first phase of the project and hired an engineer to act as project supervisor. Engineering work started in 1980, and it comprised:

- Making use of existing intakes;
- Installation of hydro-mechanical equipment (diesel driven pumps);
- Construction of new pumping stations (buildings);
- Construction of water storage facilities before the long distance pumping;
- Construction of water storage facilities to serve the distribution network;
- Repair of the distribution network and the public standposts;
- Improvement of the filter well intake in the N'tamba river.

During this phase, the project had the massive support of the population, who helped in the construction work by opening hundreds of kilometers of earth road along the new pipelines being laid to facilitate the work of the construction teams.

In 1980, following the appointment by DNA of two water supply technicians to join the project and the arrival of an expatriate engineer, construction work gained new momentum.

In the meantime, maintenance requirements started being felt, since the scheme was already in use and the newly built extensions or facilities were also put in use as they were being constructed. Because of this, the construction brigade was divided into two, one carrying on construction work, while the other doing maintenance work. The latter was afterwards incorporated into the water company that was set up to manage the scheme.

The first phase civil construction works were completed by the end of 1982. However, some work was extended up to 1984 (installation, testing, maintenance). This time was also used to plan the second phase and to secure new financing.

2.3 The Second Phase

The second phase started by the end of 1984. The time delay between the end of the first phase and the beginning of the second phase was caused by the extended time that was needed for hydrogeologic and feasibility studies, appraisal of alternatives, and detailed design of hydraulic works.

The objective of the second phase was the construction of the new Muambula system and the optimization and extension of the Muatide system. These two systems would serve 35,000 more people.

Although the second phase ended in 1987, a so-called "Extension Phase II" was added (starting from the Chomba system) to benefit four more villages with 15,000 inhabitants and to redress the intake of the Muatide system, which was being seriously threatened by erosion.

The extension of this phase was also characterized by initiatives to get specific support for the operation and maintenance of the system so far built and upgraded.

In 1990, about 157,000 people were actually served by the water supply systems, which exceeded the design target of 120,000. As the pumps were motor-driven, special attention regarding fuel, lubricants, and spare parts, on one hand, and regarding training of operators and mechanics, on the other hand, had to be given in order to guarantee reliable operation and maintenance.

Since construction work was virtually complete, and operation and maintenance routines became more important, it was thought necessary to organize the Mueda Plateau waterworks for it to perform adequately. Thus, the third phase was conceived to develop the company managing the five upgraded, rehabilitated or newly built systems. Although applied for by the end of 1987, financing was only secured at the beginning of 1990. This caused some difficulties in the water supply company, as some systems were operating with obsolete equipment.

2.4 The Third Phase

In the third phase, no new investment for civil construction is foreseen. The focus will be directed on the operation and maintenance of the five systems.

Although the five independent systems that make up the Mueda Plateau Water Supply scheme are not sophisticated, they are geographically scattered, covering more than 2,000 km^2 and serving 51 villages, thus, their operation and maintenance is not an easy job.

The Mueda Plateau Water Supply is, indeed, the largest (as far as extension is concerned) rural system in the country, and it is now characterized by:

- Five independent systems (some with more than one lifting level);
- About 157,000 people served;
- Fifty one villages or social infrastructures served;
- More than 140 km of pipeline (with a pipe diameter of 66 to 150 mm);
- Eleven pumping stations;
- Twenty five diesel motorpumps;
- Great geographic dispersion, but with a central workshop;
- Consumption of 30,000 liters of diesel per month;
- Difficult access to the individual systems from the central workshop;
- Lack of security in the south of the plateau, due to rebel activity.

The main activities to be carried out in this phase are:

- Rationalizing the operation of the five systems comprising the scheme, using local skills as much as possible;
- Developing a high technical and organizational level;
- Developing a high standard of maintenance;
- Defining technical assistance that needs to be covered on a contractual basis;
- Setting up a stock of spare parts and accessories;
- Ensuring reliable operation of the five systems.

3. The Financing of the Mueda Plateau Water Supply

From the beginning, the project internal costs have been financed from the central budget.

The central budget funds were earmarked for study and design, purchase of equipment and materials, and more importantly, for civil construction including the installation of equipment by local contractors. Provincial budget funds, on the other hand, were used to pay for management and operation costs.

The Swiss Government has provided external funding, through UNICEF, particularly in the second and third phases.

Up to now, the rural population does not contribute to meet any costs, but provided labor when requested.

Overall investment costs until the third phase were estimated at more than US$ 8 million. For a "small rural scheme", these costs were quite high. That had political reasons, given the paramount role played by the plateau population in the independence struggle, and the particular hydrogeological conditions encountered.

4. The Main Difficulties

Among the main difficulties in the project since its inception and up to the present are the following:

(a) A relative shortage of water at the intakes (at the foot of the plateau): water source yields are limited and do not allow any expansion of the systems or the construction of more public standposts, although there is now a need to do so. The five systems currently have outputs in the range of 3 to 17 L/sec, which limits the amount of water that can be served to such a large number of people;

(b) The high lift requirements are considerable (100 to 250 m), necessitating the use of high pressure motorpumps, thus, resulting in high fuel consumption;

(c) Management shortcomings of the water company in areas like:

- lack of facilities for maintenance and for storage of stocks;
- inadequate capacity of the local workshop;
- serious transport problems due to frequent and long distance routine trips;
- geographic dispersion of the system and lack of adequate transport, thus making communications difficult and maintenance erratic;
- operation and maintenance problems due to the lack of skilled and motivated staff (good technicians with a sense of responsibility are not easy to retain in the hard condition of rural life);
- limited funds to meet operation costs, especially the cost of fuel, as only a few large consumers with house connection in Mueda village are paying for the water;
- bottlenecks in supplying the plateau due to its remote geographic position. The plateau lies in a rural area, 375 km away from the provincial capital. The acquisition of equipment or of spare parts can only be done in a neighboring province (Nampula) or at the national capital, which is more than 2,000 km away. Moreover, 90% of the items are imported from abroad, which is quite alarming when future maintenance requirements are considered;
- the giving of water free of any charge to 90% of the consumers, (partly due to political reasons), which means that the production costs are not recovered;
- the hydro-mechanical equipment was acquired from foreign countries (mainly from Europe) by the donor agency, a troubling factor as there are no dealers of these equipment in the local market;
- the unclear nature of the water company, which is almost fully subsidized by the State. This means that it is not a true company and is more of a public service, which makes it rather difficult to claim any increase in subsidies, as long as the question of charging for the distributed water in rural areas is not dealt with.

5. Conclusions

The "struggle for water" at the Mueda Plateau has huge costs and it will never be definitely won. Nature does not allow simple technical solutions, however desirable they may be. Nevertheless, the political and professional determination, the support of the population, as well as the active role of the international community made it possible to establish infrastructures which serve about 150,000 people in a relatively isolated rural area.

After all the construction work was done, the continuing challenge - common to all rural water supply projects - is the provision for maintenance service, so as to guarantee the economic feasibility of the now existing infrastructures. Let us hope that all those involved, both the directly benefitting population and the donors, will know how to win the next battle.

Impact of State Intervention: A Case Study of Two Anicut (Weir) Systems in Sri Lanka, State-sponsored vs. Farmer-managed

Rajindra De. S. Ariyabandu
Research and Training Officer
Agrarian Research and Training Institute
Colombo, Sri Lanka

Abstract

As the avenues for expanding acreage have their natural limits, the State has turned to an approach based on the intensification and maximization of agricultural production through the rehabilitation of existing small-scale irrigation systems. This accounts for more that 40% of the total irrigated area and 35% of the paddy acreage in the country. It is believed that there are 47,000 small-scale irrigation works in Sri Lanka, of which 16,500 tanks and 10,000 anicut systems are in working order. A further 12,000 small-scale irrigation systems can be rehabilitated with State assistance.

The author conducted a study to identify the impact of State intervention on a State-constructed anicut (weir) system compared with an anicut system wholly managed by the farmers. The State-constructed anicut was entirely built using the government decentralized budgetary allocation while the subsequent management of the system was the responsibility of the State agency (The Department of Agrarian Services) and the beneficiaries. The study was carried out in the wet zone of Sri Lanka during two wet seasons. The assumption prior to the study was that the State-constructed anicut system is more beneficial to the farmers and the obvious consequence of which would be the increase in paddy production in the system. However, the assumption proved wrong and indicated a negative impact from State intervention. In the light of this result, it was decided to examine the degree of intervention on small-scale irrigation and its effect on system performance.

State intervention can be two-fold, physical intervention or institutional intervention. What the author observed in the study was largely physical intervention and very little institutional intervention, a good example of which was the "State intervention system". This system basically had an anicut and a canal system constructed by the Irrigation Department but the institutional arrangement that should have followed was below expectation. The imbalance thus created between the two processes caused system deterioration with time. However, during the *Vel Vidane* (irrigation headmen) period, these two processes proceeded simultaneously creating an ideal form of State intervention. It was reported that during the *Vel Vidane* period, irrigation system performance was at its best and the living conditions as well as matters related to paddy cultivation were greatly improved.

Giving more emphasis to mere physical intervention and neglecting the institutional aspects have forced the beneficiaries out of the intervention process. In many instances, the farmers attributed the ownership of the anicut system to the State. They have lost the early feeling of ownership. This situation has been created mainly because the beneficiaries were ignored and neglected in the earlier stages of system construction and rehabilitation. In many instances, it was the wish of the

State agency that prevailed and most of the rehabilitation works were *ad hoc* without a proper plan or beneficiary participation.

1. Introduction

The Government of Sri Lanka in its main agricultural policy, emphasizes the need to achieve self-sufficiency in rice. To achieve this goal, the Government adopted two strategies, (a) to expand the paddy acreage under major irrigation schemes and (b) to intensify agriculture on existing paddy lands.

However, since the avenues for expanding paddy acreage have their natural limits, the Government of Sri Lanka focused attention on the intensification and maximization of agricultural production through rehabilitation of existing [1]small-scale irrigation systems.

Presently, small-scale irrigation accounts for about 35% of the total paddy land under irrigation which covers about 25% of the total *asweddumized* area under paddy and contributing approximately 22% of the total paddy production of Sri Lanka.

According to the latest estimates of the Department of Agrarian Services (DAS) there are 19,000 small-scale irrigation systems (both tanks and anicuts) in Sri Lanka, 2,294 of which are small-scale tank systems with a command area of 148,599 ha while 9,796 are anicuts (weir) systems covering a command of 87,074 ha of paddy land.

Investments in small-scale irrigation have increased substantially since 1970. The rationale for the increased investment in small-scale irrigation stems from the fact that (a) investment in small-scale irrigation are cost effective, (b) farmers' income increased and drought related risks were reduced, (c) the gestation period compared with major irrigation schemes is short, (d) better dispersion of Government funds to the rural areas, and (e) a favorable condition for more efficient use and control of water and expansion of crop acreage is created. From a social welfare perspective, investment in small-scale irrigation has improved the socio-economic conditions of farmer households.

It is estimated that about 50,000 ha of new lands can be brought under cultivation by rehabilitating existing small-scale irrigation schemes. This could provide irrigation facilities for 50,000-75,000 farm families without resettling them elsewhere. The average cost of developing a hectare under small-scale irrigation is only Rs. 10,000 [2](US$ 312) which amounts to only 16% of the development cost of a hectare under the largest major irrigation scheme - the Mahaweliganga Development Project (ECONOMIC REVIEW, 1986).

With the State intervention in the physical rehabilitation of small-scale irrigation, an attempt was made to introduce institutional mechanism for improved water management under the rehabilitated schemes. These institutional mechanisms were largely borrowed from past experience which were deemed to have been successful.

This paper argues that even if the past experiments were fruitful, they have not been successfully replicated today as the social and economic fabric of small farmer communities is not what it was five to six decades ago.

1 Small-scale irrigation systems are defined as those under which the extent irrigated is less than 80 ha (200 acres).

2 Estimated at 1986 figures, 1 US$ = Rs. 32

The major features of this change are concentration of wealth and power, disintegration of traditional social ties and kinship patterns, and a shift from communal to individualistic type of resource use and control in the present small-scale irrigation systems, especially in areas that have been intervened by the State.

In this paper, I pose this dichotomy by way of two small-scale irrigation schemes, one with State intervention (*Induruwela*) and the other farmer-managed (*Paragommane*). The paper will attempt to elicit the drawbacks of the State intervention particularly in terms of the institutional mechanism that followed the physical rehabilitation, the result of which was a total failure in the water management program leading to poor production.

On the contrary, the farmer-managed system which had no State input performed better due to its strong kinship ties and social integration.

In the light of the above, I shall pose that the manner in which the State intervened in small-scale irrigation is debatable and warrants better understanding of the community before attempting to introduce the "best-fit" mode of institutional mechanism following the rehabilitation of small-scale irrigation schemes.

2. The Case Study

A case study of two anicut (weir) schemes were conducted to assess the impact of State intervention in small-scale irrigation system. For the above purpose, one anicut was selected to represent the State intervention case - *Induruwela* anicut scheme, while the other one was to represent a typical farmer-managed irrigation system - *Paragommane* anicut scheme.

Both the schemes are located in Ratnapura District in the wet zone having an annual rainfall of 3,500 mm.

3. Socio-Economic Profile of the Study Locations

Population and size of the two schemes are small compared with other small-scale irrigation schemes found in the dry zone. The intervention scheme has 50 farm families cultivating 13.1 ha, while in the farmer-managed scheme, 20 farm families cultivate 5.5 ha. Educational levels of both the communities are more or less similar with the intervention community having a slight edge of having two university graduates. Housing in both schemes are permanent, built with tile roof, brick walls and cemented floors. In both cases, the houses of owner operators are located close to the paddy tract while the share tenants reside away from their paddy plots.

The farming community of both schemes cultivate paddy purely for consumption. While growing paddy is the main occupation of the community, farmers are also involved in "gemming" and "rubber tapping" as secondary sources of income. Though the latter two occupations are more economically lucrative farmers still give priority to paddy cultivation mainly because it ensures family consumption requirements and prestige. Besides, cultivating a plot of land symbolizes ownership rights to the land.

Farm family income in both the schemes are poor. Paddy production valued at Rs 80 (US$ 2.40) per bushel (21 kg) gives an income of less than Rs 5,000 (US$ 149) per [3]season. However, as the

[3] A season consists of 6 months including the time gap between harvesting and beginning of the next season.

entire paddy production is consumed the actual income to sustain the family comes from gemming and rubber tapping which provide an income in the range of Rs 20,000-25,000 (US$ 588-735) per annum per farm family.

4. Land Tenure and Pattern of Land Use

The entire command area of both schemes are devoted to paddy cultivation during both wet and dry seasons. Upland crops are not grown even during the dry season due to high rainfall.

Fifty seven percent of the farmers in the farmer-managed scheme are owner operators cultivating 40% of the land while 30% of the farmers in the same scheme cultivate 44.5% of land on *thattumaru* (rotational share tenancy) basis. In contrast, the majority (88%) of the farmers in the intervention scheme are rotational share tenants cultivating approximately 80% of the total acreage while the rest are leases and owner operators cultivating 8% of the land. The high proportion of *thattumaru* land in the intervention scheme indicates that it has been cultivated over a long period of time.

5. Cultivation Practices

Commencement of land preparation in both schemes depends upon the availability of water in the anicut. In the intervention scheme 70% of the farmers have used draft power for land preparation, while in the farmer-managed scheme 60% of the farmers used manual labor for land preparation. High yielding varieties (HYVs) are being cultivated in both the systems with as much as 90% of the farmers of the intervention scheme adopting the new technology, while only 60% of the farmers in the farmer-managed schemes have adopted the same.

Although HYVs have been cultivated in both schemes, potential yields have not been achieved due to inappropriate fertilizer use. Labor use patterns for both the schemes are typical of wet zone small-scale irrigation schemes in Sri Lanka. The two main types of labor use are *attam* (exchange labor) and family labor. *Attam* labor had been more utilized in farmer-managed scheme depicting a sense of communal responsibility which largely exists in farmer-managed irrigation schemes. In the intervention scheme more family labor had been utilized indicating a sense of individualism.

Methods of pest control in these schemes are more traditional than chemical. Farmers of the intervention scheme gave equal weight to traditional and chemical control methods, whereas, in the farmer-managed scheme majority of the farmers have resorted to traditional methods.

From the above discussion, it is evident that the intervention scheme is in an advantageous position, giving access to all the new technologies primarily due to State intervention. The situation is reversed in the farmer-managed scheme where the existence and sustainability depends a lot on the traditional methods adopted by these farmers.

6. Water Allocation and Distribution

The farmer-managed scheme, having a single kin group, followed a definite water allocation principle. The main allocation principle is that those who constructed the anicut and their descendants have a legitimate claim over the land that can be cultivated using the same water. Besides this principle the two other allocation patterns followed are: (a) according to size and location of the farm plot, and (b) according to farmer consensus on time and amount of water required. The former applies to head-enders while the latter applies to those who cultivate from [4]plot to plot.

These types of definite allocation patterns are not followed in the intervention scheme at present. Prior to State intervention two allocation principles have been followed: (a) tail-end farmers cultivating 30 days after the head-end farmers begin cultivation, and (b) tail first water allocation principle. The reason for non-adoption of these principles in the present day context is due to the demoralized integrity and lack of understanding among the farmers as a result of State intervention and the deterioration of authoritative village irrigation leadership.

The main water distribution pattern in both the schemes is plot-to-plot irrigation. However, only 30% of the farm plots in the intervention scheme are irrigated in this method while 70% of the farmer-managed scheme irrigate through plot-to-plot. This system of plot-to-plot irrigation warrants high degree of farmer cooperation as the water has to traverse from head-end plots to the tail-end plots. Due to this reason, plot-to-plot irrigation is more successful in the farmer-managed scheme where farmer cooperation is stronger because of its community cohesiveness.

7. Maintenance and Resource Mobilization

Maintenance of both systems are carried out throughout the cultivation season. In the farmer-managed scheme routine maintenance like cleaning the field channels and repairing bunds are attended to by the farming community whenever it is deemed necessary. However, rehabilitating the anicut, which is done twice a year is an organized effort initiated by a "core group" of farmers. The comparative success achieved in mobilizing resources for maintenance activities is due to the sense of communal ownership the farmers have toward the system.

This scenario is somewhat different in the intervention scheme where the responsibility of maintaining the system is nobody's business. Lack of responsibility had resulted in perpetual damage to the anicut structure. Hence, it was imperative that a temporary anicut be built and the main canal cleaned prior to the cultivation season. These two activities were done by two groups of farmers. The latter was organized by the Cultivation Officer of the DAS and the former by tail-end farmers. The Cultivation Officer's efforts were not very successful as the attendance for canal cleaning was always very low. Building of the temporary anicut, however, was a successful effort arising through sheer necessity to cultivate the tail-end portion of the scheme.

When the question was posed as to who should be responsible for the maintenance of the intervention scheme, the farmers always reacted by saying that it is the duty of the Cultivation Officer (CO) of the DAS.

8. Conflicts and Conflict Resolution

The major types of conflicts from both the schemes are damming and water flow in the canals, removing or damaging control structures and destroying the anicut. In the intervention scheme more conflicts were reported such as destroying the anicut and damaging control structures compared with the farmer-managed scheme. The increase in conflicts in the intervention case can be attributed to the disintegration of traditional customs and obligations of the farmers with regard to water allocation and distribution.

[4] Plot-to-plot irrigation is a method of irrigation followed in many small-scale anicut schemes in the wet zone of Sri Lanka. The basic principle in this method is that once water enters the first plot it flows to the rest of the plots by gravity.

In the farmer-managed scheme most of the conflicts are resolved harmoniously by the community. In case a definite solution cannot be worked out, the farmers would seek the assistance of the Cultivation Officer (CO) of the intervention scheme. However, this system had not been very successful in resolving conflicts as depicted in the intervention scheme. The farmers in the intervention scheme being disappointed with the attitude and capabilities of the CO in conflict resolution now sought the assistance of various other prominent people to resolve their conflicts.

From the foregoing comparison, it is evident that State intervention had not made the desired impact on the farming community of *Induruwela* (intervention) scheme. On the contrary, the farmer-managed scheme without any State interference had managed their resources better. This distinction is clearly depicted in the number of conflicts. It appears that State intervention had increased the incidence of conflicts when it should be reducing them.

9. Process of State Intervention and its Drawbacks

In this section I shall confine myself to the intervention process as it took place in the *Induruwela* scheme and the possible drawbacks which eventually led to deterioration of the system.

As mentioned in the introduction, State intervention consists of physical and institutional development (intervention). The physical development component includes design, construction, and operation and maintenance (O&M). In the intervention scheme it is not clear how these processes have followed each other. However, the author's concern was to investigate the "degree" and "extent" of beneficiary participation in the intervention process by the State. It is believed that unless full beneficiary involvement is obtained from the planning and design stage, it can adversely affect the solicitation of farmer cooperation during the subsequent O&M work.

The original *Induruwela* anicut was built in 1900 by the farmers using indigenous technology and its subsequent O&M was the responsibility of the farming community. However, with State intervention in 1940 - through the construction of a concrete anicut, the community responsibility had eroded. The main reason for the erosion in community responsibility was non-participation of beneficiaries during the construction period. The consequences of this are numerous instances of damage to the anicut structure. Thus, the main objective of the Irrigation Department to provide irrigation facilities to a greater command area and thereby increase production was not realized. Farmers always saw the anicut as an obstruction to their water supply and resorted to damaging or removing the control gates. Moreover, the farmers felt that the system no longer belongs to them but to the State, and tended to pass the responsibility of maintenance on to the Department of Agrarian Services (DAS).

This situation improved, however, during the period of cultivation committees in 1972. This was an ideal institutional mechanism which followed physical rehabilitation. The success of this arrangement was wholly due to the dedication of its administrative secretary who was the former *Vel Vidane* (Irrigation Headman) of the area. The positive effects of the cultivation committees began to deteriorate with the renewed intervention of the State in renovating the anicut. The renovation was carried out by the Irrigation Department to replace the wooden control gates with cast iron gates. This intervention process again followed the same old pattern of excluding beneficiary participation. The consequences were the same as before - the newly constructed gates were damaged once more.

Thus, we are confronted with the question of finding a permanent solution to this perpetual problem of safeguarding irrigation structures from beneficiaries. The study findings suggest that we should identify the best type of institutional arrangement that should follow the physical intervention and select the most appropriate mode of State intervention in small-scale irrigation. According to the study a direct, top-down intervention without beneficiary participation is detrimental to the entire process. Therefore, an indirect, bottom-up intervention approach with beneficiary participation should be more appropriate for small-scale irrigation schemes.

10. Conclusions and Recommendations

The rationale behind the State intervention in small-scale irrigation is to improve the irrigation system performance and to raise the standard of living of the rural poor. However, this was not realized according to the present study.

More emphasis given to mere physical intervention and neglecting the institutional aspects have forced the beneficiaries out of the intervention process. In many instances, farmers attributed the ownership of the anicut system to the State. This situation evolved because the system beneficiaries were ignored and neglected at the stages of system design and construction. In many instances, it was the wish of the State that prevailed and most rehabilitation work were *ad hoc* without a proper plan or beneficiary participation. The *Induruwela* scheme was a classic example of this situation. Continuous change in Government policy and unsystematic planning had an overall negative impact on the *Induruwela* scheme. In addition, increased State intervention had weakened the rural socio-political system which resulted in the deterioration of many local institutions. Thus, for State intervention to succeed, it is necessary to have more flexibility in the whole process and to involve farmers from the first physical design and construction stage itself in minor irrigation schemes.

Therefore, State intervention should not be a mere *ad hoc* physical intervention but a well-planned process which smoothly combines both physical and institutional intervention taking into account all socio-economic and political factors at village level.

One main recommendation from the study is that when intervening in small-scale irrigation schemes, local capabilities should not be ignored. The intervention should always consider the existing local technologies. Agency-managed technologies which are beyond the capacity of the farmers should not be thrust upon the rural farming community.

Finally, the State should be well-advised to understand the village community and identify its potential in irrigation management before trying to introduce any kind of innovation.

References

ABEYRATNA, S. and J. PERERA (1986) "Changes and continuity in village irrigation systems", ARTI Research Publication No. 75.

ALWIS, J., D. GROENFELDT and J. PERERA (1987) "Strategies for improving minor irrigation systems in Sri Lanka", IIMI Working Paper No. 6.

BEGUM, S. (1987) "Minor tank water management in the dry zone of Sri Lanka", ARTI Occasional Publication Series No. 39.

Acknowledgements

I am most grateful to my colleague, M. G. M. Razaak, who helped me during field work and later contributed valuable suggestions and comments in finalizing this paper.

My sincerest thanks to his Field Investigators, M. Nandasena and G. Abeywardena, who helped me in collecting the data. Finally, I thank the Agrarian Research and Training Institute for giving me this opportunity to conduct research in the small-scale irrigation sector in Sri Lanka.

Small-scale Irrigation Command Area Development in Bangladesh - Problems and Prospects

M. R. Hoque
Associate Professor
Department of Irrigation and
Water Management
Bangladesh Agricultural University
Mymensingh, Bangladesh

M. Idris
Professor
Department of Soil Science
Bangladesh Agricultural University
Mymensingh, Bangladesh

M. A. Samad
Assistant Professor
Department of Irrigation and
Water Management
Bangladesh Agricultural University
Mymensingh, Bangladesh

S. Islam
Associate Professor
Department of Agricultural Economics
Bangladesh Agricultural University
Mymensingh, Bangladesh

Abstract

Under Bangladesh conditions, in most of the small-scale irrigation projects, especially in the more expensive deep well type irrigation projects, the actual irrigation command area is significantly less than expected. There are several aspects involved which are responsible for low irrigation command. These can be broadly classified as (a) Technical (Irrigation Engineering), (b) Soil and Agronomic and (c) Socio-economic and Institutional. Since they are very much interrelated and interdependent in irrigation command area development, an interdisciplinary field research program on command area development had been undertaken for intensive studies in the selected deep well type projects.

Investigations have been made to identify problems, and demonstrate and suggest strategies for command area development. From the study, it was evident that inspite of different constraints, there was a good prospect of significantly increasing the irrigation command area and crop yield through a well-coordinated interdisciplinary approach.

1. Introduction

Bangladesh lies between latitude north 20.6°-26.7° and longitude east 81.1°-92.6°, with an area of 144,000 km^2, and having a population of about 110 million. Bangladesh is an agricultural country influenced by the tropical monsoon climate. Almost every year the country has to face a lot of devastation due to natural calamities like flood, cyclone, etc. Every year, the country has to import 20-30 million tons of food grain from abroad to feed the vast population.

Under Bangladesh conditions, around winter (November-March) is the only safe period for crop production, avoiding the severe effects of flood and cyclone. Therefore, attention has to be given for intensive and extensive winter crop production. But in Bangladesh, the winter season is dry with very little precipitation. In order to grow crops properly during this period, supplemental irrigation is a must especially for the main crop, rice. During this period, the surface water sources for irrigation are very limited to insure successful crop production. Consequently, tube well (deep, shallow, and hand) irrigation under a small-scale irrigation program has to be introduced using ground water as a dependable constant source of water for irrigation. Therefore, the potential use of these irrigation facilities under small-scale irrigation projects is very important for successful crop production and ultimately for the economic development of the country.

The command area of an irrigation project is considered to be the index for the utilization of its irrigation potential. Unfortunately, in Bangladesh conditions, the command area of most of the small-scale irrigation projects, especially the more expensive deep tube well (DTW) irrigation projects, is much less than the potential level of command. There are several aspects involved which are responsible for low level of command of an irrigation unit. They can be broadly classified as (a) Technical (Irrigation Engineering), (b) Soil and Agronomic and (c) Socio-economic and Institutional. They are very much interrelated and interdependent in command area development of an irrigation unit. No single aspect can play an effective role in irrigation command area development at potential level. Therefore, considering the major aspects involved, a four year interdisciplinary field research program based at Bangladesh Agricultural University, Mymensingh, on command area development of deep tube well projects had been undertaken, to identify the actual constraints, and demonstrate and suggest the strategies for increasing irrigation command and crop yield through an interdisciplinary approach.

2. Methodology

The research team included teachers from the Department of Irrigation and Water Management, Department of Soil Science and Department of Agricultural Economics of the Bangladesh Agricultural University, Mymensingh, to take care of research activities in their respective disciplines towards the same goal of increasing irrigation command and economic yield. The concerned personnel from the Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Extension (DAE), and Bangladesh Rural Development Board (BRDB) were also involved in the program.

Three deep tube well irrigation project sites, two (diesel-operated) in Trishal Upazila (Dulalbari and Kanhar DTW sites) and one (electrically operated) in Muktagacha Upazila (Eswargram DTW site) under the Mymensingh District, representing three levels of performance in the country were selected for intensive studies.

Initially, the detailed benchmark survey works were performed at the selected study sites in relation to irrigation engineering, socio-economic, and soil-agronomic conditions. Based on the identified problems and suggested strategies, the interdisciplinary field activities and studies were performed in succeeding years in relation to increasing irrigation command area and yield.

3. Results and Discussion

From the studies, it was observed that in all the deep tube well study sites, the actual discharge capacity was quite less than that of the design capacity of 56.64 L/sec. The average actual pump discharge measured during the irrigation period in different study sites at different years are presented in Table 1. Initially, in 1984, the average actual pump discharge in Dulalbari and Kanhar sites were only 42.95 and 41.28 L/sec, respectively, whereas the design capacity was 56.64 L/sec. However, it was comparatively higher in Eswargram at 52.30 L/sec. The main reason for this low discharge in the first two sites was inefficient performance of the pumping unit due to poor maintenance and operation. However, in the succeeding year, the discharge was increased through proper maintenance of the pump and engine with regular overhauling, servicing and replacing of the necessary parts in cooperation with BADC. The discharge in Eswargram was comparatively higher, since it was electrically operated and well maintained.

Table 1. Pump discharge and operating hours in the study sites during the cropping season (irrigation period of about 100 days)

Study Sites	Year	Discharge (L/sec)		Average Operating Hours Per Day	Total Idle Days
		Average Actual	Design		
Dulalbari	1984	42.95	56.64	8.28	29
	1985	44.01	56.64	12.50	10
	1986	47.64	56.64	14.36	7
	1987	48.17	56.64	18.10	6
Kanhar	1984	41.28	56.64	11.18	22
	1985	44.43	56.64	14.87	9
	1986	46.21	56.64	16.22	6
	1987	47.15	56.64	18.27	6
Eswargram	1984	52.30	56.64	18.30	8
	1985	51.52	56.64	17.98	11
	1986	51.89	56.64	10.51	26
	1987	52.48	56.64	18.63	7

The fluctuation of ground water level during the study period is shown in Fig. 1. In both cases, a direct relationship was observed between the rate of decrease in discharge and the rate of depletion in static ground water level (Fig. 2).

The average daily pump operating hours and idle days at different years in the study sites are also included in Table 1. Initially in the Dulalbari and Kanhar sites, the average daily pump operating hours were only 8.28 and 11.18 hours, respectively, with many idle days of 29 and 22, respectively, due to troubles in the pumps and engines, and poor management. Afterwards, in these two sites, the situation improved significantly resulting in more operation hours and less idle days through proper maintenance, operation and management. But at the Eswargram site, in 1986, the average daily pump operating hours decreased to 10.51 with increasing idle days due to failure in the electricity supply. However, the situation improved in 1987.

From the initial benchmark survey information, it was observed that the water distribution system network was faulty with respect to canal alignment, section, grading, construction, operation, seepage, and percolation loss (Table 2). However, in the succeeding years, the water distribution system was improved with respect to proper canal alignment (Figs. 3, 4, and 5), section, slopes, and the seepage and percolation loss was reduced by 68-77% through proper compaction and maintenance of the earthen canals (Table 2). The canal improvement and maintenance work was done by the farmers themselves with the technical advice of the concerned project personnel as a result of proper motivation. The farmers volunteered their manual labor in a very cooperative way.

For a deep tube well with a discharge capacity of 56.64 L/sec, considering the available water supply and peak crop water demand (for high yielding variety of boro) with an average level of

Table 2. Seepage and percolation loss in the earthen main canals per 100 m length in the study sites

Study Sites	Year	Average Losses (%)		Reduction of Losses (%)
		Without Compaction and Proper Maintenance	With Compaction and Proper Maintenance	
Dulalbari	1984	48.50	-	-
	1985		22.83	52.93
	1986		16.26	66.47
	1987		12.14	74.97
Kanhar	1984	36.41	-	-
	1985		16.35	55.10
	1986		11.12	69.49
	1987		8.47	76.74
Eswargram	1984	33.17	-	-
	1985		16.51	50.23
	1986		13.19	60.24
	1987		10.63	67.29

system efficiency, the potential irrigation command area is supposed to be about 41 ha. But initially, in 1984, due to very low pumping plant efficiency and poor water distribution and management system, the actual command area of the study sites, especially in Dulalbari and Kanhar was very low (Table 3, Fig. 6). In Dulalbari and Kanhar sites, the command area was only 10.57 and 20.23 ha, respectively. Afterwards, through improvement of the pumping plant and water distribution system performance, and through better water management, the command area increased so that finally in Dulalbari and Kanhar sites, the actual command area was brought up to 35.61 and 34.42 ha, respectively (Table 3, Figs. 3, 4 and 6). In both the Dulalbari and Kanhar study sites the canal system development made possible the delivery of water to the relatively higher lands where the farmers grew wheat and potato. This was done in order to demonstrate to the farmers the benefits of supplemental irrigation in wheat and potato production and, thereby, encourage the farmers to grow more wheat and potato during the rabi reason as per the recommended cropping pattern and also to make the best use of the irrigation facilities.

The study site in Eswargram was considered to be the ideal one. The pump was electrically operated, and having relatively higher discharge and operating hours compared with that of Dulalbari and Kanhar sites. The water distribution system was also better but needed more development. The command area planted with high yielding variety of boro was reported to be 36.40 ha. Although the command area reported was high, the yield per hectare was low. Afterwards, the command area decreased to as low as 20.60 ha due to the failure of electric supply. Subsequently, the electric supply was cut off due to non-payment of the electric charge, which was observed to be the main problem in the electrically operated pump. However, through our combined efforts, the command area in the Eswargram site also increased to 36.93 ha with a corresponding increase in yield (Table 3, Figs. 5 and 6).

The activities performed under the soil and agronomic discipline included the physical and chemical analysis of soils from different locations of the study sites, collection of information

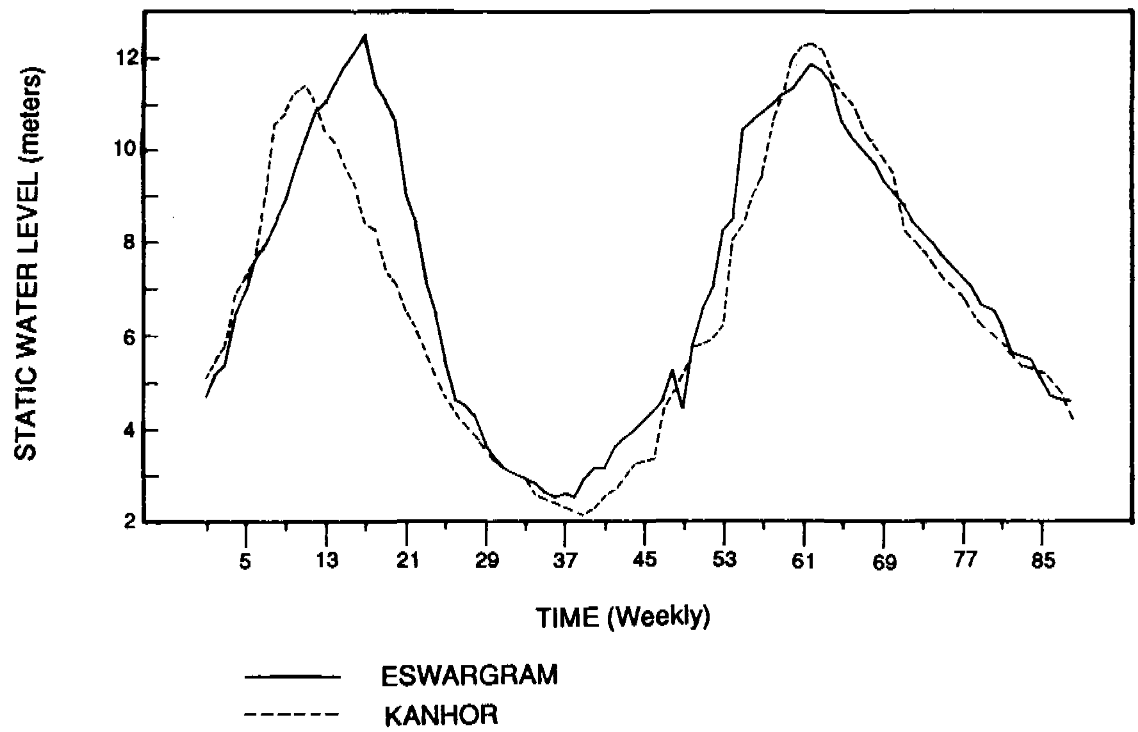


Fig. 1. The groundwater level fluctuation with respect to time (from January 1985 - November 1986) at the study sites

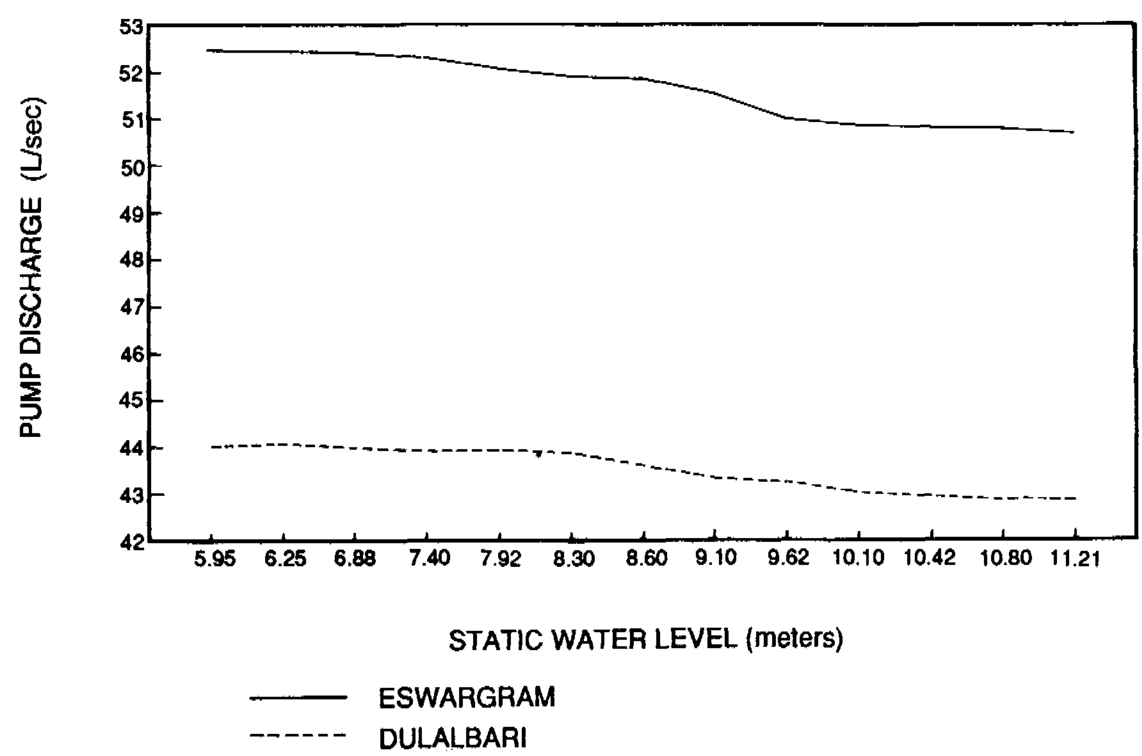


Fig. 2. The relationship between pump discharge and static groundwater level at the study sites

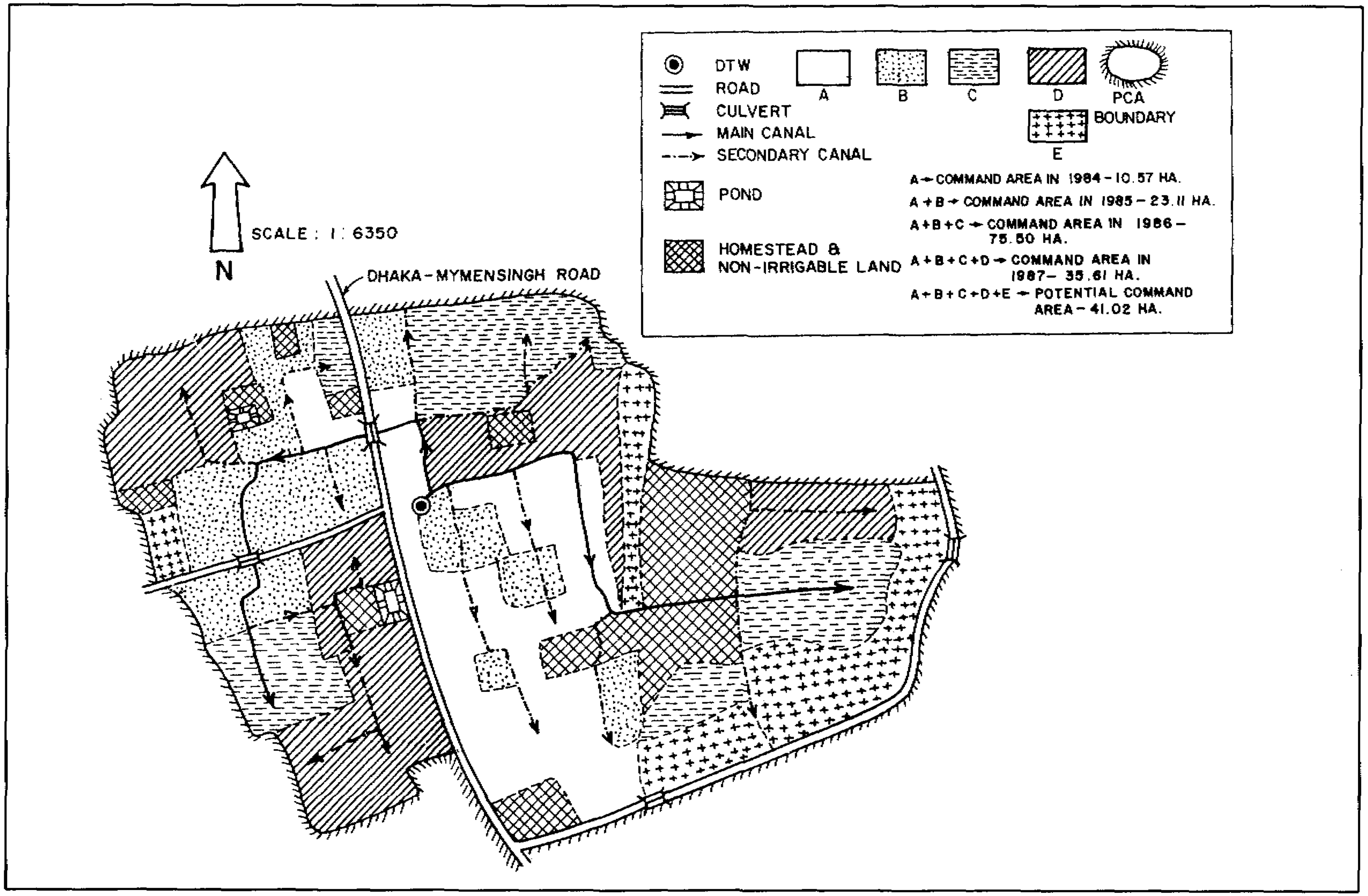


Fig. 3. Command area of Dulalbari DTW site at different years showing canal layout

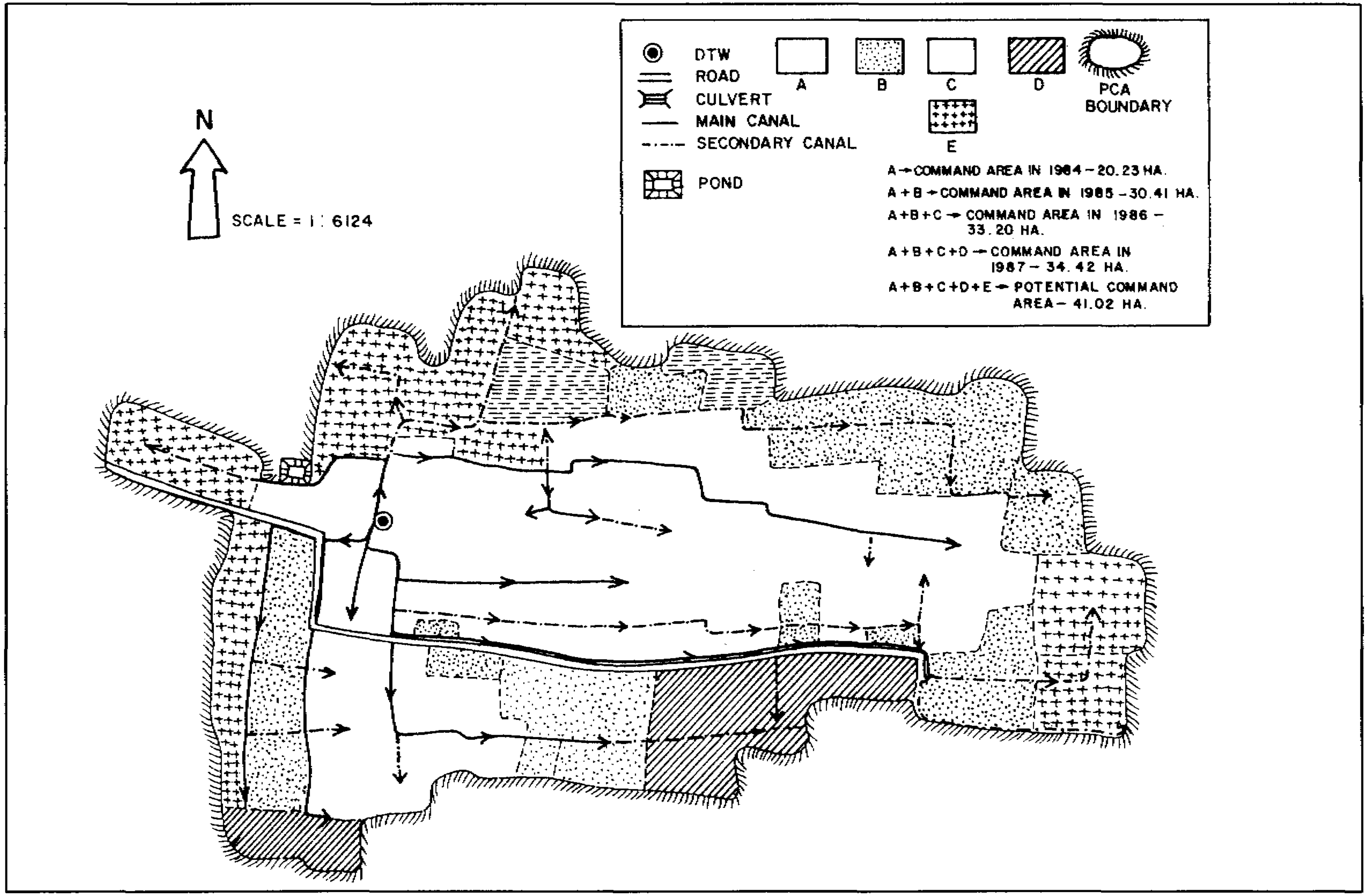


Fig. 4. Command area of Kanhor DTW site at different years showing canal layout

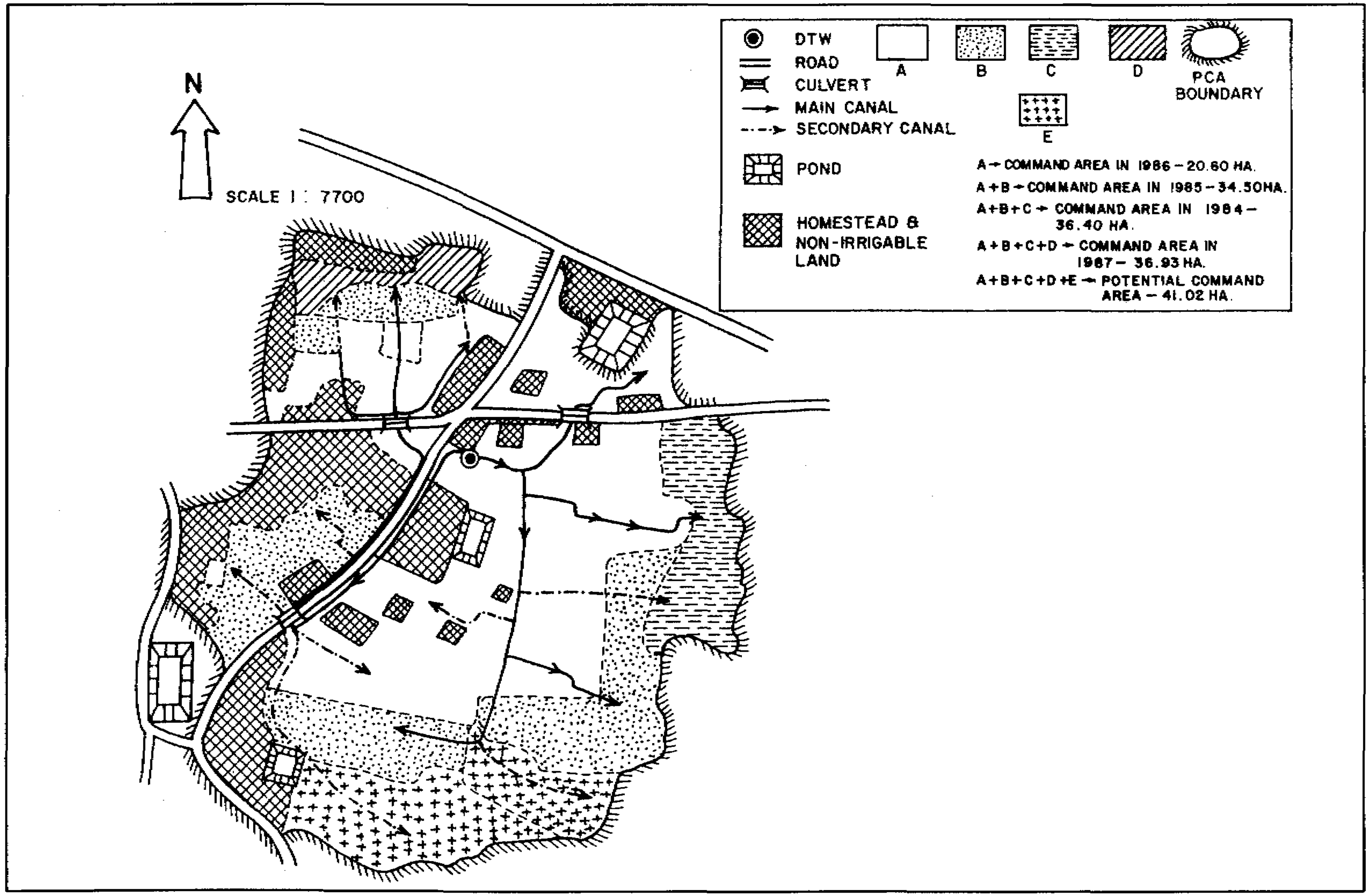


Fig. 5. Command area of Eswargram DTW site at different years showing canal layout

Table 3. Command area, average yield, benefit cost ratio, and net project benefit in the study sites

			Grain Yield (kg/ha)		Value of Products (TK/ha)		Variable Costs of Production, (TK/ha)		Net Benefit (TK/ha)		Benefit Cost Ratio		
Study Site (1)	Year (2)	Command Area, ha (3)	Demonstration Plot (4)	Farmers Plot (5)	Demonstration Plot (6)	Farmers Plot (7)	Demonstration Plot (8)	Farmers Plot (9)	Demonstration Plot (10)	Farmers Plot (11)	Demonstration Plot (12)	Farmers Plot (13)	Net Project benefit, TK 14 (3 x 11)
Dulalbari	1984	10.57		3,428		18,852		12,164		6,690		1.55	70,713
	1985	23.11		4,142		22,781		11,990		10,791		1.90	249,380
	1986	27.50	5,292	4,372	29,106	24,046	13,171	12,023	15,395	12,023	2.21	2.00	330,632
	1987	35.61	5,482	4,534	30,151	24,937	12,035	11,335	18,116	13,602	2.51	2.20	484,367
Kanhar	1984	20.23		3,475		19,113		12,742		6,371		1.50	128,885
	1985	30.41		4,025		22,138		12,299		9,839		1.80	299,204
	1986	33.20	5,376	4,503	29,568	24,761	13,552	12,698	16,016	12,063	2.19	1.95	400,492
	1987	34.42	5,593	4,703	30,762	25,867	12,418	12,031	18,344	13,836	2.48	2.15	476,235
Eswargram	1984	36.40		3,378		18,579		12,813		5,765		1.45	209,846
	1985	34.50		4,334		23,837		13,243		10,594		1.80	365,493
	1986	20.60	4,194	3,283	23,067	18,057	12,395	12,898	10,672	5,159	1.86	1.40	106,275
	1987	36.93	5,324	4,425	29,282	24,348	12,138	12,815	17,144	11,533	2.41	1.90	425,974

* 1 TK (Taka) = 0.03 US$ (approx.)

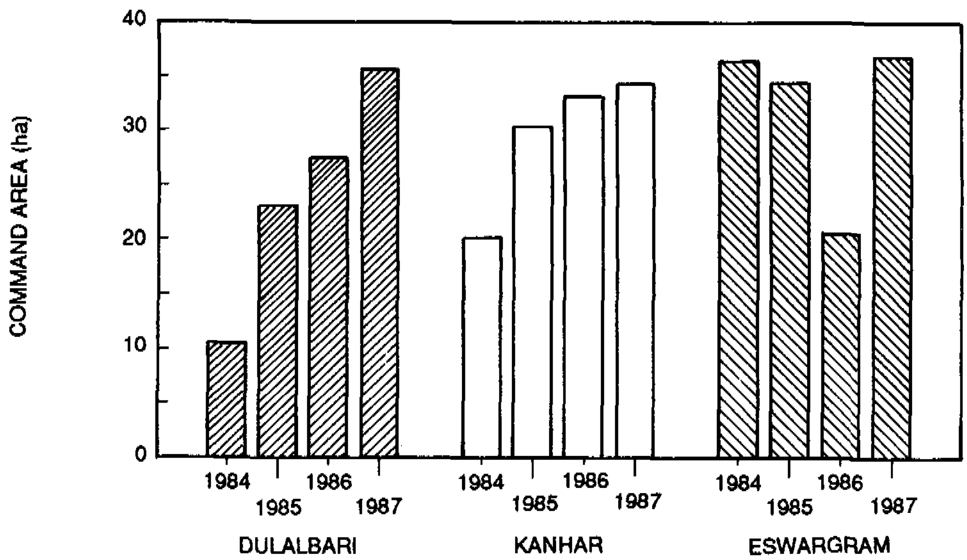


Fig. 6. Command area of the study sites at different years

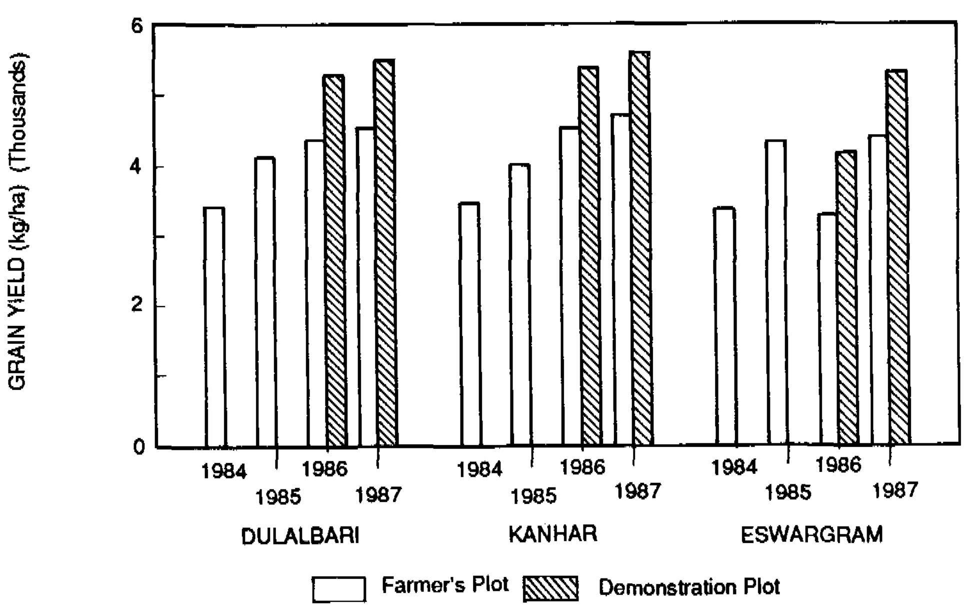


Fig. 7. The average grain yield per hectare in the farmers' plot compared with demonstration plots in the study sites at different years

about the cropping pattern, variety, plant protection practices, cultural practices including seed rate, seedling age, fertilizer use, soil and water management practices, and yield at different locations of the water distribution system (head, middle, and tail).

From the benchmark survey, it appeared that irrespective of location and variety, and due to improper cultural practice; especially low fertilizer use and poor water management, the yield per hectare was quite low. For the high yielding variety of boro (Pajam), the average yields per hectare in Dulalbari, Kanhar and Eswargram were found to be 3428 kg, 3475 kg, and 3378 kg, respectively (Table 3, Fig. 7). Afterwards, (from 1986) in the selected plots at the head, middle, and tail, proper cultural practices including proper fertilization and efficient water management were demonstrated in order to motivate the farmers to increase yield per hectare with efficient input use.

The average yields per hectare in the demonstration plot for high yielding variety of boro were found to be as high as 5482 kg, 5593 kg, and 5324 kg in Dulalbari, Kanhar, and Eswargram, respectively (Table 3, Fig. 7). Through prior activation and from the results of the demonstration plots, the farmers were motivated to follow the proper practices, and consequently in the subsequent years, the average yield per hectare in the farmers' fields also significantly increased (Table 3, Fig. 7). For the high yielding variety of boro, the average grain yields per hectare in the farmers plots at Dulalbari, Kanhar, and Eswargram sites were increased from 3428 kg to 4534, 3475 to 4703, and 3378 to 4425 kg, respectively.

The socio-economic and institutional problems were found to play a vital role in the low irrigation command and crop yield. The activities performed under the socio-economic discipline included: formation of efficient project and water management groups, motivation of the farmers about the necessity of regular machine rent and loan payment, necessity and benefit of proper pumping plant maintenance, water distribution system improvement and maintenance, use of proper cultural practices and water management, introduction of unified irrigation pricing system, and proper involvement of concerned organizations like Bangladesh Agricultural Development Corporation (BADC - Irrigation Division), Department of Agricultural Extension (DAE) and Bangladesh Rural Development Board (BRDB), among others.

Under the unified pricing system, the cost of irrigation was found to be low compared to the non-uniform pricing system. Investigation and analysis were made on the item-wise and total cost of production and the value of return both at the farmers' plots and demonstration plots. The net benefit and benefit-cost ratio were found to be much higher in the demonstration plots compared with those in the farmers' plots (Table 3). However, although initially the average net benefit per hectare in the farmers' plots was very much less than those in the demonstration plots, in the succeeding project years and at all the study sites (except in 1986 at the Eswargram site), the average net benefit and benefit-cost ratio in the farmers' plots also significantly increased (Table 3).

Considering the increased command area, the net project benefit for the study sites are also shown in Table 3 (Column 14) and Fig. 8, and appears to have increased considerably due to the expansion in command area and economic yield. In the course of this study, the farmers were found to be very cooperative and were actively involved in the program. Most of the water distribution system development works have been done by the motivated farmers themselves, voluntarily, with our technical advice only. From this study, it appeared that if the farmers can realize the possibility of getting real benefits, they do not hesitate to invest the necessary available resources, including their own manual labor. The farmers with deep tube wells in the neighboring areas also were encouraged from the results of this study and tried to follow them.

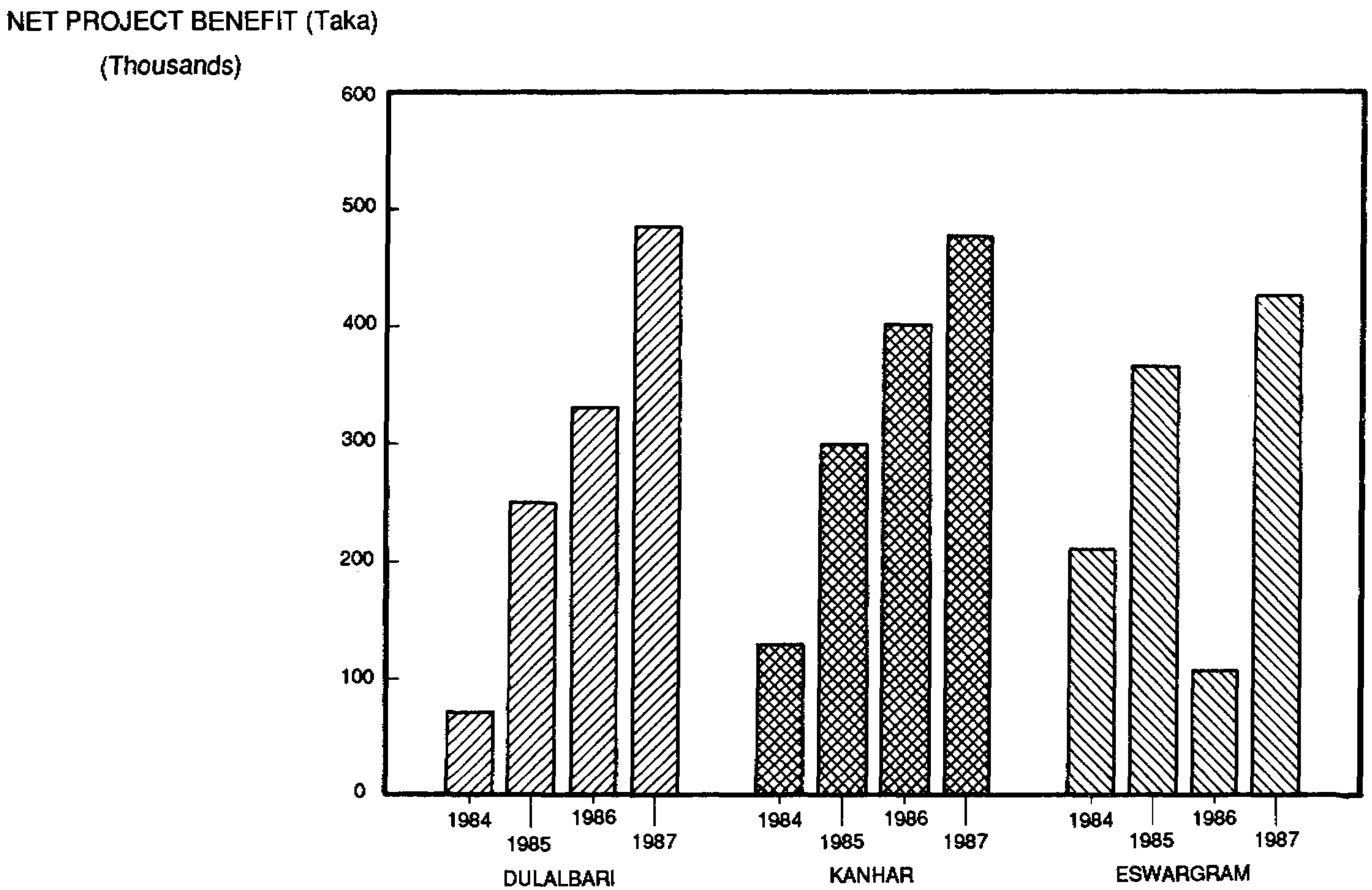


Fig. 8. The net-project benefit from the study sites at different years

4. Conclusion and Recommendations

From these studies, it was evident that most of the problems associated with low irrigation command and poor crop production originate from technical problems, while the technical problems originate mainly from socio-economic and institutional problems. With an efficient pumping plant (properly sited, installed, operated and maintained) and an efficient water distribution system (properly designed, aligned, constructed, and maintained), the water can be made available to the farmers' fields at the right time and quantity according to the crop needs, and consequently, much of the social conflict and water management problems can be easily solved with subsequent increase in command area and yield. Therefore, due attention must be given to improve the pumping plant and water distribution system efficiencies through well-integrated interdisciplinary approach in order to develop and expand the irrigation command area and maximize crop production economically.

In this regard, the concerned existing organizations like BADC, DAE, and BRDB should be well-coordinated and more actively involved at the farm level activities. They should be made responsible for making the necessary facilities and inputs timely and readily available to the farmers. There should be effective coordination of works in order to meet the field demand. The farmers should be actively involved in solving their problems. With this view, although the irrigation management program (IMP) was started involving the BADC, DAE, and BRDB, there has been an observed lack of coordination and designation of responsibilities, as if everybody's responsibility is nobody's responsibility. Therefore, with necessary authority and scope, a single organization must be made responsible with due accountability for achieving a minimum average level of irrigation command and crop yield.

There should be provision for regular monitoring and evaluation of already studied and developed projects in order to follow up the actions with proper feedback.

Finally, it can be concluded that inspite of all the limitations, including the natural calamities, with proper and positive use of the existing irrigation facilities and available resources in Bangladesh, there is a great prospect of significant increase in crop production by command area development through well-integrated interdisciplinary approach and thereby attaining self-sufficiency in food within a short time.

References

BISWAS, M. R., and H. A. S. MANDEL (1982) "On-farm irrigation water management problems", Bureau of Socio-economic Research and Training BAU, Mymensingh, Bangladesh.

DOORENBOS, J. and W. O. PRUITT (1977) "Guidelines for predicting crop water requirements", Irrigation and Drainage Paper No. 24 (revised), FAO, Rome, Italy.

GHANI, M. A. (1982) "Water subsidence technique for measuring seepage and percolation and water requirement of rice", Bangladesh Journal of Agriculture, 7(2), BARI.

HOQUE, M. R., et al. (1985) "Integrated irrigation command area development", Annual Project Report (1984-1985), Department of Irrigation and Water Management, BAU, Mymensingh, Bangladesh.

__________________ (1986) "Coordinated irrigation and water management studies", Fourth Annual Report, Soils and Irrigation Division, Bangladesh Agricultural Research Council, pp. 126-140.

HOSSAIN, M. A. and M. S. ISLAM (1983) "Planning a rotational irrigation system with suitable cropping pattern for maximizing command area of a deep tubewell", An unpublished project report, Department of Irrigation and Water Management, BAU, Mymensingh, Bangladesh.

IDRIS, M., M. S. ISLAM, and M. M. HOSSAIN (1983) "Studies on irrigation requirement of rice and jute under field and lysimetric condition to be correlated to evapotranspiration", Second Annual Report, Coordinated Irrigation and Water Management Studies, Soils and Irrigation Division, BARC, Farmgate, Dhaka, pp. 1-16.

JENKINS, D. (1981) "Irrigation water distribution system for tubewells and low lift pumps in Bangladesh", A manual on how to plan and design efficient small irrigation systems, prepared by the USAID Hydraulic Engineer.

KARIM, Z. and N. A. AKHANDA (1982) "Net irrigation requirement of rice and evapotranspiration of wheat and potato for different location of Bangladesh", BARC, Soil and Irrigation Publication No. 11.

Acknowledgements

The authors are grateful to the Bangladesh Agricultural Research Council for the financing, and to the Bangladesh Agricultural University for providing the necessary physical support in conducting this study.

Provision of Potable Water to Smaller Communities in the Gezira Irrigated Area - Sudan

Ahmed Ayoub El Gaddal
Manager
Blue Nile Health Project
Ministry of Health
Sudan

Abstract

The Blue Nile Health Project (BNHP) aims to control malaria, schistosomiasis, and diarrheal diseases in the Gezira irrigated area through a comprehensive approach adopting:

(a) Provision of abundant safe water supply
(b) Health education with community participation
(c) Use of pesticides and drugs
(d) Provision of ORS or teaching mothers how to make it
(e) Establishment of laboratories for malaria and schistosomiasis
(f) Training of water caretakers from the villages
(g) Persuasion of the people to construct pit latrines
(h) The use of carts for the collection of garbage
(i) Elimination of mosquito breeding places by volunteers

The BNHP started as a joint venture between WHO and the Sudan Government in 1980 with the help of other organizations and donor countries.

The important achievement so far is the reduction of morbidity and mortality of the three diseases and improvement of the health of the community, leading to a more productive and better life.

1. Introduction

The Blue Nile Health Project (BNHP) is a water-associated disease control project in agricultural irrigation schemes. It aims at the control of malaria, schistosomiasis, and diarrheal diseases. It is a multi-sectoral project adopting a comprehensive approach for the control of these diseases.

The project started as a joint venture between the World Health Organization (WHO) and the Government of Sudan in 1980. The project's life was supposed to be ten years, with the first five years to be spent for research, aiming at reaching a strategy which could be applied to the rest of the Gezira Project. The strategy is to be applicable, not costly, practical and within the resources of the country. Environmental measures as well as biological control methods should be tried.

The aim of the project is to reduce the prevalence of malaria to below 2%, schistosomiasis from above 50% to below 10%, and reduce mortality and consequently morbidity due to diarrheal diseases and maintain them at these low levels.

Annual assessment of the program is undertaken by the Scientific Advisory Group which meets once every one or two years to review the plan of action, budget, progress of work and research activities, and advise on new matters. The same is done by the National Coordination Committee.

1.1 Objectives

The overall objective of this project is to control and prevent the major water-associated diseases in the area through a comprehensive program of disease prevention and control and to assess its health and socio-economic impact.

1.2 Methods

The methods used for the application of the comprehensive strategy include:

(a) Provision of abundant safe water supply, such as deep bore wells, shallow wells with hand pumps, and horizontal flow roughening slow sand filters (HFR/SSF)
(b) Health education through community participation and formation of village health committees
(c) Use of pesticides and drugs, such as molluscicides for snail control (*Bayluscide*), residual insecticides for malaria control (*Fenitrothion*) and larvicides (*DIMILIN*), and use of antimalarial as well as antibilharzial drugs (*Praziquantel* for schistosomiasis)
(d) Provision of ORS or teaching mothers how to make it locally
(e) Provision of trained personnel to work in the established diagnostic laboratories for malaria and schistosomiasis
(f) Training of volunteer water caretakers from the villages to look after and maintain the water systems
(g) Persuading the people to construct their own pit latrines and providing them with the reinforced concrete slabs for the pit latrine at a nominal price
(h) The use of carts pulled by donkeys for the collection of garbage for ultimate burning
(i) Elimination of mosquito breeding places by volunteers.

2. Sources of Water Supply in the Blue Nile River Project

There are three sources of water supply in the BNHP:

(a) Deep bore wells
(b) Shallow wells (low yield wells)
(c) Horizontal flow roughening slow sand filters.

2.1 Deep Bore Wells

These are constructed by the National Rural Water Administration in towns or large villages after consultation with the BNHP authorities.

The water is pumped from a deep bore well to a storage tank by a gasoline or electrical pump and then distributed through main pipes to the center of the town or village. Sometimes, the inhabitants collect their water from water points where water taps are provided, but most of the people pay for their water connections from the main line to their houses.

The well, in addition to the pump and the storage tank, are provided by the Gezira Rehabilitation Project. Previously, it was the Social Services Department of the Sudan Gezira Board which was responsible for the supply of potable water to the residents; this was then taken over by the Tenants Union. Nowadays, the Tenants Union still helps the BNHP in providing water to the inhabitants of the Gezira Irrigated area.

The inhabitants are facing shortage of water from time to time when there is electricity failure or shortage of gasoline for operating the pump (which is common here).

Solar energy to operate the water pump has been tried, but has not proved successful.

2.2 Shallow Wells (Low Yield) with Hand Pumps

The system consists of the following:

- a well drilled by means of percussion or rotary rig
- 4-inch PVC casing
- a hand operated pump.

We found that underground water (shallow well) with hand pump is the best and cheapest method for supplying smaller groups of inhabitants with clean water. We could overcome problems of electricity failure and shortage of gasoline common in developing countries by using hand pumps for drawing the water. These hand pumps are operated manually and with the least effort; even young boys and girls can operate it.

In the BNHP we have tried many kinds of hand pumps. The following are under trial now:

- Grundfos pumps
- Monolift pumps
- Indian Mark II (both German and Indian makes)

2.3 Horizontal Flow Roughening Slow Sand Filters (HFR/SSF)

The HFR/SSF are constructed for villages located near water canals where there is no underground water or where the villagers cannot pay for one-quarter of the cost of the low yield well with hand pump.

The HFR/SSF is considered as one of the achievements of the Engineering Unit of the BNHP. This has been approved and recommended for small communities during the seminar of World Water '86 which was held in London in July 1986.

The whole process, until the water reaches the storage tank, works by gravity; no power is needed, neither gasoline nor electricity.

The system of the HFR/SSF consists of three main chambers as shown in Fig. 1:

- horizontal flow roughening filter to help in the reduction of turbidity and removal of physical impurities
- slow sand filter for removal of suspended matter as well as bacteria
- clear water tank for collection and storage of water.

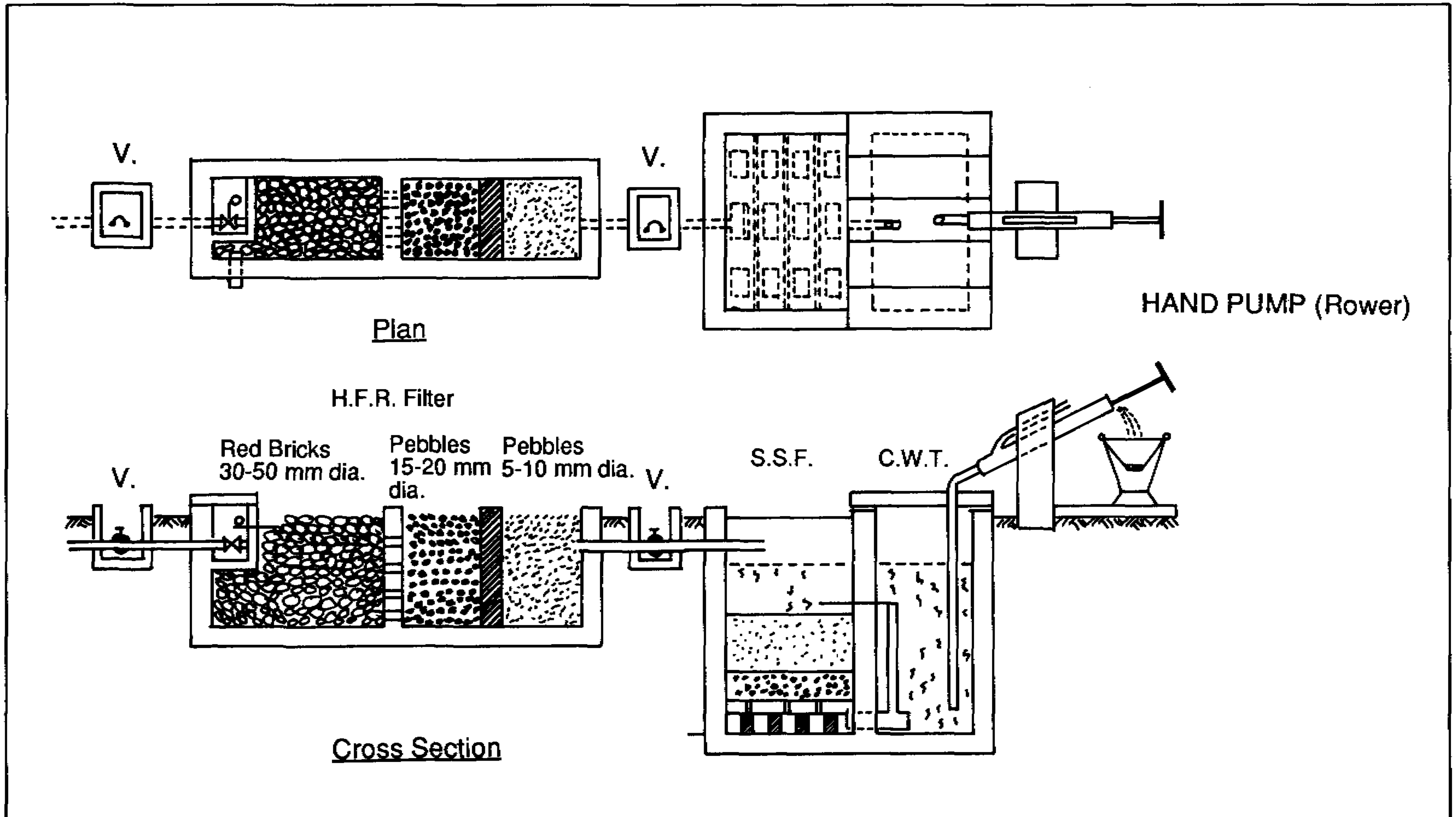


Fig. 1. Horizontal flow roughening slow sand filter

Some of the problems commonly met in operating these water points are:

- *Electricity failure and shortage of gasoline.* This is very common in towns and villages supplied from deep bore wells.
- *Spare parts and maintenance of pumps.* For the deep bore wells, the pumps are repaired and maintained by the maintenance team of the National Rural Water Administration.

Usually we get the hand pumps of the low yield wells supplied with the necessary spare parts which we keep in stock. The same applies to the rower pumps which are used in the HFR/SSF to draw water from the underground storage tank. Trained volunteers from the villages do the minor repairs and maintenance. The engineering unit takes care of the major repairs.

It is worthwhile to mention the role of the community in this aspect. We have a well-established Health Education Unit. This unit is responsible for the formation of village health committees in all the villages. Through health education, we could easily mobilize the community to participate in the construction of these filters by providing labor. For the construction of the low yield wells, the community participates by paying about one-quarter of the cost of the well with the hand pump. Their participation makes them feel that this is their own well and they have to look after it in the proper manner.

We train about two volunteers from each village that has a well with a hand pump or HFR/SSF. The training takes about a week. In towns and large villages with deep bore wells, we train the person in-charge of the water pump on pipe fitting.

Testing of the water quality is done routinely before the water is approved for consumption. Water quality tests are done from time to time for all the water points. Both bacteriological as well as chemical analysis are done in our laboratory. Sometimes, we do water testing in the field by using a mobile water testing kit (OXFAM/DELAGUE).

The Project has constructed during the last five years:

- 124 shallow wells with hand pumps
- 25 HFR/SSF
- 60 wells are under construction
- 20 HFR/SSF are under construction

Approved by the Gezira Rehabilitation Project and under construction by the Rural Water Administration for the Project are:

- 145 low yield wells with hand pumps
- 120 deep bore wells with elevated tanks
- 40 HFR/SSF

3. Recommendations

From our experience in the BNHP, we feel that small communities in developing countries must have enough potable water, either from low yield wells with hand pumps if there is underground water, or from HFR/SSF if there is no underground water.

Participation of the community is very essential, including the training of volunteers to look after the water points.

References

EL BASIT, S., D. BROWN, and A. A. EL GADDAL (1986) "Development of the horizontal flow roughening/slow sand filter for the blue nile health project in Sudan", World Water '86, London.

EL GADDAL, A. A. (1989) "Control of schistosomiasis in the Gezira", Belo-Horizonte Mg. Brazil.

Acknowledgements

The author is very grateful to the staff of the BNHP, especially the Engineering and Health Education Units. Special thanks to my secretary Madame Humeida, Mr. Jamal Khalil and Mr. Zein El Abdeen for helping in producing the manuscript.

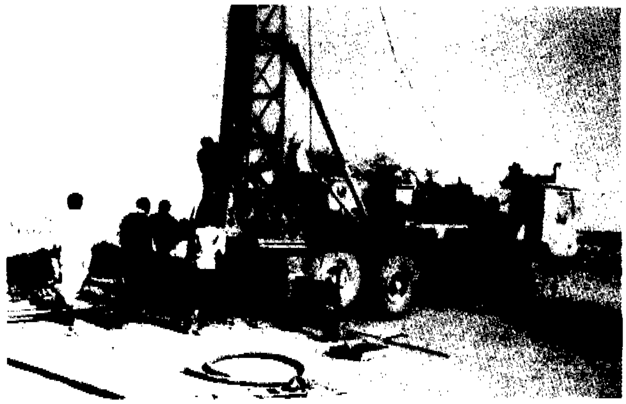


Fig. 2. **Rig in operation, drilling a low yield well**

Fig. 3. **HFR/SSF showing the red bricks in the first chamber**

Fig. 4. **Drawing clean water from the storage tank of the HFR/SSF by a rower pump**

Part 5:

Abstracts of Selected Poster Presentations

Poster Abstract No. 1

Farmer Participation in Small-scale Irrigation Projects in Northeast Thailand

Sanguan Patamatamkul
Associate Professor
Department of Civil Engineering
Faculty of Engineering
Khon Kaen University
Khon Kaen, Thailand

Most small-scale irrigation projects constructed in Northeast Thailand prior to 1985 were not effectively utilized and maintained. One main reason that caused this problem was the lack of farmer participation in all stages of project development due to communication problems between the line agency officials and the farmers' community. To bridge this communication gap, a change agent called community organizer was employed in small-scale irrigation project development in Northeast Thailand by the Royal Irrigation Department. The community organizers played important roles in developing farmer participation as coordinators, organizers, and catalysts. This participatory approach of employing community organizers is still at the experimental stage and its long-term implementation is still being studied and yet to be approved by the budgetary agency.

Poster Abstract No. 2

Development of Small-scale Hydraulic Works for Irrigation in the Rural Areas of Vietnam

Nguyen Dong
Director
Institute for Water Resources Economics
Hanoi, Vietnam

Water resources development in Vietnam has been increased, especially since 1960, with the construction of various types of irrigation and drainage facilities.

Besides several large-scale and many medium-scale irrigation systems, a lot of small-scale irrigation works have been built in various regions, particularly in the provinces of North Vietnam and the northern part of Central Vietnam.

Appropriate development of small-scale irrigation has contributed to the stabilization of human settlements and the improvement of food production in many remote regions of the country.

Irrigation systems in rural areas, though small-scale, are of vital importance to farmers and, therefore, they are involved in the construction, operation, and maintenance of these systems.

Due to the farmers' constructive activities, the effectiveness of irrigation service has been steadily improving while at the same time the national investment burden has noticeably decreased.

Approach to the Development of Small-scale Water Resources in the Rural Areas of China

Xu Jianhua
Professor
School of Environmental Engineering
Tongji University
Shanghai, China

These years, water supply engineering in most rural areas of China are developing rapidly. In order to develop the water supply engineering in rural areas smoothly, the wasting and idling of the construction investment funds must be avoided as much as possible, and the building scale should be decided rationally. Extensive research, to determine and investigate the quantity and the patterns of usage of water in the suburbs of Shanghai, and reasonable estimate of the future demand in terms of maximum per capita daily demand and the hours change coefficient, could save the construction investment funds of Shanghai's rural water resources over RMB $ 1,000,000 a year.

Scattered distribution of houses in the countryside requires comparatively longer pipelines than in urban areas. Therefore, a comprehensive analysis in terms of technology and economics is required to rationally define the appropriate water supply limitations. It was found after serious study that a water supply system encompassing 3-4 villages is most economically appropriate in the suburbs of Shanghai. Sanitary protection of the sources of raw water should also be included to prevent pollution.

Compared with the urban waterworks system, the equipment in small-scale water resources in rural areas are simpler in construction, the building investment funds are more limited, and the management of waterworks more convenient.

Poster Abstract No. 4

Pumping in Small Water Supplies with Renewable Energy Power Sources with Focus on Hydro-power Drive for Pumping

Valentin Schnitzer
Ingenieurbuero
Bammental, Germany

Small water supply systems in remote areas often face the problem of power source for pumping. In developing countries, the electric grid seldom reaches the remote areas. The power option using diesel drives is problematic due to the short supply and massive maintenance requirements.

The power source options from renewable sources are limited:

- Solar systems have not yet reached the stage to allow widespread use.

- Windpumps have gained importance in areas favored by wind and can be further promoted.

- Hydro-power is the most reliable and provides substantial renewable power source for pumping. The well established hydraulic ram pumps can be recommended for promotion. For bigger pumping capacities, pumps in reverse operation acting as turbines, which can drive conventional centrifugal water pumps, are gaining rapid importance. New developments to utilize energy of river flow have not proven successful yet.

- We are working at another option to use the flow of rivers for pumping. Besides floating propeller units, we are now working on floating water wheels driving rotary positive displacement pumps. This system is rather promising for small irrigation and small water supplies in areas near rivers with good streamflow or rapids.

Poster Abstract No. 5

Rainfall Intensity Analysis as a Tool for Water Resource Planning

Joseph Morin
Professor
Soil Erosion Research Station
Jerusalem, Israel

The rainfall-runoff relationship for any rainstorm depends on the dynamic relation between rain intensity, soil infiltration and surface storage.

Runoff occurs whenever rain intensity exceeds the infiltration capacity of the soil, provided there is no physical obstruction to surface flow. Any economical evaluation of water resources project has to be based on probability analysis which depends strongly on time.

Long period data on rainfall amount and intensity have been collected in most parts of the world. Probably, rain information is the only reliable long period information which allows us to evaluate the water resources planning on probability basis.

The spatial variability of infiltration and topography depends mainly on the area characteristics. Rain intensity spatial variability depends strongly on area and time.

Digitizing and analyzing all the available rain records charts for the target area will provide us with a great tool to evaluate project planning and alternatives. In many cases this long period information will allow us to choose the right approach in the early stages of planning.

This paper will demonstrate the systematic analysis approach as well as actual cases which can be solved by the rain intensity analysis.

In many cases surface runoff of any storm can be calculated by combining the appropriate infiltration equation with the actual rain intensity data.

Poster Abstract No. 6

Artificial Recharge of Groundwater for Small-scale Water Development in Rural Areas: A Case Study

Ahang Kowsar
Senior Research Scientist
Research Institute of Forests and Rangelands
Tehran, Iran

While water shortage is causing the *en masse* migration of rural people to the already congested towns, enormous amounts of water are wasted in the form of devastating flash floods. Deep, coarse alluvial deposits, which are abundant in most deserts provide potential aquifers that can be utilized for water storage and transfer. Artificial recharge (AR) of groundwater utilizing floodwaters is an easy method of supplying water for small communities at very low costs.

Eight AR systems covering a total area of 1,365 ha were constructed during the 1983-87 period. The number of flood events from January 1983 to February 1988 ranged from 1-7 per year, and the total volume of diverted water amounted to 37.2 million m^3.

Provision for irrigation and domestic water in four farming communities has materially changed the lives of inhabitants of the Gareh Bygone Plain in Southern Iran. Production of forage, fuel and industrial wood, stabilization of the drifting sands, and flood mitigation are some of the incidental benefits of the AR of groundwater.

Poster Abstract No. 7

A Method for Rainwater Collection, Storage, and Utilization for Small-holder Hydroculture Systems

William Hogland **Ronny Berndtsson** **Magnus Larson**

Department of Water Resources Engineering
University of Lund
Sweden

Rainwater collection, storage, and utilization in small-holder hydroculture systems is the only safe drinking and irrigation water source in many arid and semi-arid areas. Many of these systems, however, still face a number of intrinsic obstacles. This paper presents a new Swedish system for rainwater collection, storage, and utilization (RSU system) which is meant to be combined with typical small-holder hydroculture systems for crop production in arid and semi-arid regions. The proposed three-part RSU system, which consists of methods for rainwater collection, storage, and utilization on an irrigation context, is a newly-developed system and is not yet applied in full scale. However, for each part of the system, experience from other applications exists and pertinent information is reviewed in the paper. This paper examines a proposed application of the RSU system in semi-arid Kenya. Rainwater is collected from roofs, rock-sides with filled-up cracks, hillsides as well as plane areas covered by clay, concrete or plastic sheets. Water from creeks and rivers may also be diverted and collected during periods of high flow. The water may be conveyed to small-scale storages and stored during the rainy period until water is needed for irrigation of the crops. Concrete dams and corrugated drum tanks are the most frequently used storage methods and may be used in the system. Before water enters the distribution system, it is mixed with nutrients suitable for the selected crop. The pipes are designed to give optimal water quantities to the respective irrigation plots. The smallest distribution pipes are designed so that the system can be driven by gravity without any pumping. Two types of distribution and irrigation systems are included in the method: a sub-irrigation system and a localized irrigation system. The irrigated fields may contain small plastic tents for prevention of evaporation losses. In order to prepare the area for cultivation, the soil is removed by hand or by simple machinery to the recommended depth, which varies depending on the crop. A clay layer or a plastic sheet is then laid out on the excavated ground and drains are put on top of the impermeable sub-layer. Drain pipes may be fabricated on-site. The soil is then put back again on top of the drainage pipes, while the irrigation pipes are laid on top of the replaced soil. The drainage pipes and the irrigation pipes are connected to a mixing tank, into which the excess water returns, and where the irrigation water is enriched with nutrients before it is distributed to the field. The mixing tank enhances the feasibility of controlling the water quality.

Poster Abstract No. 8

Rainwater Cistern Systems Training Initiatives in Nepal: A Study of Three Cases

Shivaji Prasad Upadhyay
Associate Director
U.S. Peace Corps (Nepal)
Kathmandu, Nepal

Robin Lall Chitrakar
Senior Divisional Engineer
Central Regional Directorate
Department of Water Supply, Sanitation, and Sewerage
Kathmandu, Nepal

This paper shares and disseminates information on three rainwater catchment ferrocement tank construction trainings conducted between June 1988 and December 1989 at two rural sites in the hills and rural inter-plains of Nepal. The trainings were done in collaboration with the Ministry of Housing and Physical Planning of His Majesty's Government of Nepal and the U.S. Peace Corps (Nepal) for its engineers and overseers, and the local technicians as part of their in-country and pre-service training program.

The overall goals of these trainings were:

- to provide hands-on job training and technical skills;
- to motivate participants in identifying and establishing rainwater catchment tanks as an alternative and applicable source; and
- to demonstrate an effective training design involving community participation and governmental and non-governmental collaborative efforts to promote this untapped and available resource.

This paper describes the activities such as needs assessment surveys, selection of the sites and training staff, organization and management of the trainings, technical methods and construction techniques used, monitoring the tanks' conditions, its use and water quality, strengths/what worked and constraints faced, and recommendations on improving future trainings and promoting RWCS as an alternate technology.

Poster Abstract No. 9

Farmer Participation in the Operation and Maintenance of Government Assisted Small-scale Irrigation Projects: A Comprehensive Approach

Victor A. Gillespie
Operations and Maintenance Engineer
Mahaweli Agriculture and Rural Development Project
Colorado Institute of Irrigation Management
Colorado State University
United States of America

The problem of unequal access to and use of irrigation water by canal and ditch "head enders" and "tail enders" in small-scale irrigation systems is addressed. A paradigm is proposed that sets forth the minimum requirements necessary for these farmers to organize and to work together in sharing irrigation water and maintaining, to both their satisfaction and that of the government agency, the physical facilities under their control. The minimum components of the paradigm are that farmers:

- have an agreed upon and written social contract;
- have knowledge of the economic costs of over-using water and the economic gains of using adequate amounts of water; and
- have technical knowledge on how to maintain conveyance channels and structures.

Poster Abstract No. 10

Some Aspects of Community Participation in Rural Development in Sri Lanka: Implications for Small-scale Water Resource Development

Anada Wanasinghe
Consultant
Ministry of Lands, Irrigation, and Mahaweli Development
Colombo, Sri Lanka

Small-scale water resource development (SWRD) with community participation is a favorite program for rural development. Some important implications for community participation in SWRD and similar programs are discussed on the basis of experience in a major rural development program in Sri Lanka.

Although community-oriented projects like SWRD schemes demand action compatible with the aspirations of the beneficiaries, they are usually first mooted by Government agencies which then confront the community with proposals. The community is unable to respond effectively due to its socio-cultural characteristics. Rural people also have difficulties in identifying and utilizing the best opportunities that could result from the proposed intervention by the Government agencies.

Advantages from community participation often fall short of expectations due to inability of the community to comprehend related technical, economic, and organizational issues. People can participate in development only when there is consensus about the program. This is difficult to attain as some people perceive relative disadvantages from these projects. Irrigation works are more susceptible to such constraints than rural water supply schemes as they raise issues relating to riparian rights and may disturb existing power structures.

Effective participation can be achieved by careful planning and detailed preparatory work with the community which can lead to a partnership between the community and the implementing agency. This requires officials to act as motivating agents. Furthermore, when SWRD projects are part of a wider package of components, such partnership may be easier to achieve.

Poster Abstract No. 11

Women, Water Supplies, and Sanitation: A Case Study of Domestic Shallow Well Water Supplies in Thailand

Kamontip Khatikarn
Associate Professor
Department of Social Sciences
Faculty of Social Sciences and Humanities
Mahidol University
Nakornpathom, Thailand

The main objective of this research was to explore the feasibility of promoting domestic shallow well water supply through the development or improvement of existing dug wells or drilled wells together with handpump installation on the basis of self-help through women's organizations in villages. Data were collected by interviewing the wives of the heads of households in four regions of the country. The heads of households or adults within families who could make decisions in household activities were interviewed in the absence of housewives. The total sample size was 3,363 households. In addition, other persons concerned with water supply were also interviewed, and the target population was divided into seven subgroups.

In all the households surveyed, 53.3% had private wells. Of those who did not have private wells or who had private water source but were not yet satisfied and frequently used neighbors' wells, 81.8% wanted to get private or new wells.

In relation to expressed needs and desirable types of pumps in the study area, 45.9% wanted electric pumps, while 9.3% and 2.4% wanted hand pumps and motor pumps respectively.

Moreover, a majority of respondents agreed to support women's participation in water supply and sanitation. In particular, women should be assigned the responsibility for loan management.

It is recommended that women's development organizations should be encouraged, particularly at the village level, by providing training so that rural women could gain knowledge, understanding, and awareness of the significance of water supply and sanitation, and the know-how to manage revolving funds.

Poster Abstract No. 12

Factors Determining the Development of Shallow Dug Well as Safe Drinking Water among Women in Five Villages of Viengpapao District, Chiangmai Province, Northern Thailand

Putsatee Agamanon
Assistant Professor

Subarn Panvisavas
Associate Professor

Kamontip Khatikarn
Associate Professor

Praphaphan Oon-ob
Faculty Member

Department of Social Sciences
Faculty of Social Sciences and Humanities
Mahidol University
Nakornpathom, Thailand

Utis Gerdpial
Technical Consultant
Ministry of Public Health
Bangkok, Thailand

It is generally known that in rural areas most women and children are responsible for fetching water for their families. Usually, unprotected shallow dug wells are the most common source of drinking water for villagers in the Northern part of Thailand.

Five villages in the Northern region were selected by deliberate sampling based on six criteria which were: (1) village population of 500-2000, (2) no piped water service within the village, (3) year-round availability of water in the village wells at depths not exceeding 10 m, (4) presence of a strong women's organization in the village, (5) village located outside the municipality or sanitary district, and (6) the district to which the five selected villages belong are located within 40 km from town.

The female heads of all households in the 5 villages of Viengpapao District, Chiangmai Province were surveyed regarding their water utilization and needs. The village headmen were also interviewed concerning the water supply problems of the community. The objectives of this study were to identify the factors affecting the development and improvement of shallow dug well water supplies in serving as adequate and safe drinking water source. This problem is related to the local needs and customs of the villagers.

Results revealed that convenience, modernization, dignity, prestige, generosity, imitative behavior among the villagers, other religious beliefs, as well as the influence of other social groups were the most important factors which determined the acceptability of new methods for transporting well water for drinking purposes. The use of electric pumps was found to be popular among the villagers because it is in consonance with these factors. There was also no risk of contamination due to direct handling or usage of unsanitary water containers.

Poster Abstract No. 13

U.S. Peace Corps (Thailand) Water Resources Development

U.S. Peace Corps
Thailand Water Resources Development
Thailand

The U.S. Peace Corps recruits graduate applicants with civil, environmental, and water resource engineering backgrounds for placement in its water resources development program. Volunteers perform a wide variety of engineering and development related tasks during the two years that they are assigned to the Local Administration Department, Ministry of Interior. They assist in surveying village needs and identifying potential water resource development projects funded by the Local Administration Department and other cooperating Thai Government agencies. A major component of their scope of work emphasizes the transfer of basic engineering skills to District Technicians who have vocational school training but do not possess civil engineering degrees or sufficient technical backgrounds. Some of the structures that volunteers design and construct include: small dams and reservoirs with concrete or grassed spillways, delivery systems, steel reinforced concrete diversion weirs, rainwater cistern systems, shallow and deep wells, and village domestic water systems. Peace Corps Volunteers in Thailand assist in all phases of the "People's Volunteer Weir Program" initiated in 1987 by the Local Administration Department and Khon Kaen University. Volunteers provide feasibility reports, watershed surveys, and supervision for the construction of diversion weirs with the assistance of District Technicians and volunteer village labor.

Poster Abstract No. 14

Strategies for Operation and Maintenance of Rural Water Supply Systems in Zaire

Kasongo Ntambwe
Chief
Infrastructure Division

Franklin Baer
Project Manager

Duale Sambe
Project Director

Kalonji Nsenga
Water/Sanitation Engineer

Itoko Y'Olunki
Water Sanitation Training Coordinator

Soins de Sante Primaires
en Milieu Rural (SANRU)
Zaire

Many water supply systems have been built in Zaire which are no longer functional. The reason usually given is the lack of community organization to operate and maintain the systems. In reality, however, it is the vertical nature of water projects which see community participation as something to promote only after the water supply system has been built, that is often the problem.

In May 1989, Zaire's National Committee for Water and Sanitation Action organized a round table discussion of the problems involved in the operation and maintenance of water supply systems. Participants came from three major national programs, four governmental ministries, and six international agencies involved in water and sanitation projects in Zaire. Eight of twenty recommendations addressed issues related to the empowerment of the communities to operate and maintain water supply systems. The group recommended that:

1. Community animation is essential to promote community participation before, during, and after the construction of the water systems.
2. The type of water system chosen should be appropriate to the capacity of the community to operate and maintain it.
3. The community should organize a village development committee with members chosen from and by the community.
4. A public contract defining responsibilities should be established between the community and any outside technical service.
5. The community should be aware of the estimated construction, operation, and maintenance costs before the installation begins.
6. Training key members of the village development committee in issues such as mobilizing community financial resources is necessary.
7. A community representative, preferably a woman, should be designated to supervise the operation and maintenance of each water supply unit.
8. Regular supervision of the water systems and the village development committees should be the responsibility of the district health zones.

Many of these recommendations are not new to Zaire. They represent, rather, a confirmation at the national level of ten years of grass roots rural health zone efforts to include water and sanitation as part of the national primary health care effort. Water and sanitation activities with appropriate community participation represent, therefore, an excellent multi-sectoral catalyst component of primary health care which can contribute to the operation and maintenance of not only water supply systems, but also of the entire health supply system.

Poster Abstract No. 15

Appropriate Well Drilling System for Northeast Thailand

Vichai Sriboonlue
Assistant Professor
Department of Agricultural Engineering
Faculty of Engineering

Chalong Buaphan
Assistant Professor
Department of Geotechnology
Faculty of Technology

Prakob Wirojanagud
Associate Professor
Department of Civil Engineering
Faculty of Engineering

Khon Kaen University
Khon Kaen, Thailand

Optimum utilization of the groundwater resources of Northeast Thailand will help alleviate water scarcity problems that are experienced every year during the dry season. This can be achieved by using village self-help programs. Khon Kaen University has initiated one such program in which there are three components. The first is the development of appropriate drilling rigs; the second, a compilation of knowledge on suitable well design and construction techniques; and the third, to provide rigs and knowledge to the rural communities and local officials.

Two drilling rigs have been developed, a hand-operated rig and an engine-driven rotary rig (TR-60). Essential information for water well construction in the Northeast has been gathered and compiled, and to date, two training programs for disseminating this knowledge have been held. The first one, which was for hand-operated rig, was provided to every village technician in two provinces. The second was for all district technicians from every province in the Northeast and covered topics in groundwater hydrology and development, including the principles and operation of the TR-60 rotary rig.

The Department of Local Administration, Ministry of Interior, has recognized the potential of this program and has set up the People's Well Drilling Program, to provide a TR-60 rig to every district in the Northeast and provide funds for 2,530 wells to be sunk in 1990.

Poster Abstract No. 16

The Khon Kaen University - New Zealand Type 2 Weir: A Weir Design for Everywhere

Kevin Smith
Technical Advisor

Kraiwudth Uttrahong
Project Manager

Sakchai Tongsuk
Field Engineer

Thai-New Zealand Watershed Development Project
Faculty of Engineering
Khon Kaen University
Khon Kaen, Thailand

The Khon Kaen University-New Zealand type 2 weir design (KKU-NZ Type 2) was developed for use in the watersheds of Northeast Thailand but its applicability is far more wide reaching. Its simple design, economic cost, ease of construction, and low maintenance make it an appropriate design for use as a diversion or storage structure almost anywhere.

Suitable for rivers or reservoir sites up to 6 m in depth and 40 m in width, and incorporating timber stop-logs (or drop gates) to facilitate water management and silt gates for sediment release (where needed), it provides a safe and durable but above all manageable facility for small or large irrigation systems.

This paper discusses the design, its applications, costs, construction methods (including labor requirements), and overall project implementation guidelines.

Part 6:

Symposium Recommendations

Symposium Recommendations

After reviewing the drinking and domestic water supply and irrigation sectors, as well as the assessment of technology management, training needs, people's participation, institutional aspects, and planning associated with these types of small-scale water resource systems together with the analysis of the pitfalls and approaches in dealing with them, the *International Symposium on Development of Small-scale Water Resources in Rural Areas* recommends that:

1) Small-scale water resources have an impact on the daily lives of the majority of the people in developing countries by affecting the availability of adequate water supplies for potable and/or domestic water as well as for irrigation. Target groups that will benefit from, as well as contribute to, water resource development projects must be clearly identified.

2) In developing such resources, all potential sources must be evaluated with an emphasis on low-cost, appropriate, and sustainable options.

3) Schemes must be implemented on the basis that both social and economic benefits or trade-offs are fully incorporated. This should be the basis of some form of project assessment statement.

4) Community participation is necessary in all phases of project realization and must be encouraged. Communities must also make a commitment with a view towards accepting ownership responsibility for the project. Efforts are needed to prepare communities before implementation.

5) Community participation through both formal and informal education and other media is necessary. Community development requires considerable resource inputs (finance and time) and budget must be properly allocated and used. A bottom-up and top-down approach should complement each other, coupled with adequate institution building efforts.

6) Women should be equally and actively involved in all stages of the project realization.

7) A partnership between government agencies and NGOs must exist. The role of NGOs is important and can be visualized as one which promotes awareness and which can facilitate governmental agencies to direct resources into the proper channels.

8) Projects must address all inter-disciplinary elements such as technical, social (public health), cultural, financial, and environmental components. An integrated approach is therefore needed in planning and management. Wherever possible, it should include sub-projects that complement their effects (especially health and sanitation with domestic water supply and agricultural support services with irrigation).

9) More research and development are needed in some areas of technology applications and must be strongly encouraged.

10) Information dissemination is vital. Promotion of an information network which encompasses all aspects of development in small-scale water resources in rural areas is needed.

11) Project monitoring and evaluation are needed to determine if objectives have been met and if projects can be replicated for the benefit of others. Pilot projects and model cases can be used, and lessons should be learned from failures. Assessment of failures ("failure criteria") is invaluable for future project formulation and implementation.

12) More emphasis should be given to rehabilitation and maintenance of existing water resource facilities.

13) Management must allocate resources optimally against specific needs. Also, technology information and hardware should match the software requirements to meet development goals.

14) Problems of management in the sector are widespread and, at a project level, need to be addressed at all participatory stages for continuity and sustainability of project results.

15) Technology application has many constraints which must be identified as they vary with location, needs, and resources.

16) All available technologies should be considered as long as they serve the goal of fulfilling project objectives and project criteria. Adaptation of technology can play a major role in project acceptance by a community.

17) Management of small-scale water resource projects should promote self-reliance and should be decentralized.

18) Training to improve the knowledge, skills, attitude, and confidence of both project users and technical staff involved in projects, should, where needed, include training for decision-making and management as well as hands-on training. Training by doing is best.

19) Identification and assessment of training needs and target groups at all levels (including user groups, community leaders, technicians, and managers) are essential. Training materials need to be more readily available, carefully selected, and widely disseminated.

20) Policy makers at all levels should give priority to investigating the role and contribution that small-scale water resource development can make in meeting the needs of rural people. Commitment should be given to establish village level institutions in order to support small-scale water resources development.

21) To keep the momentum going, as generated through this international meeting, it is strongly suggested to organize similar events every three years.