



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Small Dams and Social Capital in Yemen

How Assistance Strategies Affect Local Investment and Institutions

Douglas L. Vermillion and Said Al-Shaybani



Research Reports

IWMI's mission is to improve water and land resources management for food, livelihoods and nature. In serving this mission, IWMI concentrates on the integration of policies, technologies and management systems to achieve workable solutions to real problems—practical, relevant results in the field of irrigation and water and land resources.

The publications in this series cover a wide range of subjects—from computer modeling to experience with water user associations—and vary in content from directly applicable research to more basic studies, on which applied work ultimately depends. Some research reports are narrowly focused, analytical and detailed empirical studies; others are wide-ranging and synthetic overviews of generic problems.

Although most of the reports are published by IWMI staff and their collaborators, we welcome contributions from others. Each report is reviewed internally by IWMI's own staff and Fellows, and by external reviewers. The reports are published and distributed both in hard copy and electronically (www.iwmi.org) and where possible all data and analyses will be available as separate downloadable files. Reports may be copied freely and cited with due acknowledgment.

Research Report 76

Small Dams and Social Capital in Yemen: How Assistance Strategies Affect Local Investment and Institutions

Douglas L. Vermillion and Said Al-Shaybani

International Water Management Institute
P O Box 2075, Colombo, Sri Lanka

IWMI receives its principal funding from 58 governments, private foundations, and international and regional organizations known as the Consultative Group on International Agricultural Research (CGIAR). Support is also given by the Governments of Ghana, Pakistan, South Africa, Sri Lanka and Thailand.

The authors: Dr. Vermillion is a Principal Researcher for IWMI and Mr. Al-Shaybani is a staff member of Hydro-Yemen, a consulting firm.

Acknowledgments: Field work for this study, implemented in 1998, was conducted with financial support from the FAO for field research.

Vermillion, D. L.; Al- Shaybani, S. 2004. *Small dams and social capital in Yemen: How assistance strategies affect local investment and institutions*. Research Report 76. Colombo, Sri Lanka: International Water Management Institute. (IWMI).

/ dams / development aid / investment / water stress / domestic water / water delivery / water development / groundwater / water resource management / irrigated farming / crop production / water supply / case studies / soils / organizations / irrigation systems / water policy / development projects / water rights / water distribution / water allocation / water users / institutions / Yemen /

ISSN 1026-0862

ISBN 92-9090-537-9

Copyright © 2004, by IWMI. All rights reserved.

Please send inquiries and comments to: iwmi@cgiar.org

Contents

Summary	v
Introduction	1
Development Assistance, Investment and Social Capital	2
Irrigated Agriculture under Stress	3
Development of Small Dams in Yemen	4
Case One: Bait Abdullah Dam, Shibam subdistrict	5
Case Two: Bait Fakhar Ad-Den Dam, At-Tawila subdistrict	8
Case Three: Al-Ma'mar Dam, Bait Al-Ma'mar village	12
Case Four: Sahib Dam, Al-Khyat village	14
Case Five: Al-Makik Dam, Hobah village	15
Case Six: Zeham Dam, Zeham village	17
Development Assistance, Social Capital and Results	19
Conclusion and Recommendations	22
Annex: Tables	25
Literature Cited	27

Summary

This report examines the development of eight small dam projects in the mountainous province of Al-Mahweet in north-central Yemen. The report also investigates how external assistance affects incentives for local people to invest in dam development and water delivery systems and also to create rules, property rights and institutional arrangements to manage the dam and water. The development of small dams is a current priority of the Government of Yemen and foreign development agencies and banks. The objectives of the government and aid organizations in developing small dams are to provide sources of water for domestic use, create new irrigated areas, and recharge groundwater.

This study indicates how assistance strategies and agreements between external agencies and local communities may be designed so as to inhibit or facilitate local investment, development of social capital and achievement of favorable outcomes.

This study shows how external assistance is designed and arranged and how it can have a substantial effect on the motivation of local people to make investments and build social capital to manage and benefit from the new infrastructure.

When villagers build a dam, those who invest in its construction consider it as their own property. The group of investors defines their own criteria for membership and identifies rules for investment, water extraction, water distribution, silt removal and canal maintenance. Initial or founding investors set themselves apart from late-coming investors. They assign themselves lower water fees and restrict others from becoming shareholders. This serves to protect their prior water rights and the value of their shareholdings.

The cases support the view that the method of assistance and the incentives they generate may be more important than the social context in building local organizational capacity and producing synergy from joint state and community investment.

Evidence suggests that cases with high proportions of external assistance tend to also have poorly developed rules for investment, water rights and irrigation system management. The report provides recommendations on how assistance strategies may be designed in order to stimulate local investment and facilitate the development of social capital.¹

¹Field work for this study, implemented in 1998, was conducted with financial support from the FAO.

Small Dams and Social Capital in Yemen: How Assistance Strategies Affect Local Investment and Institutions

Douglas L. Vermillion and Said Al-Shaybani

Introduction

This report examines the development of eight small dam projects in the highlands of the north-central Al-Mahweet region in Yemen. It investigates how external assistance affects incentives for local people to invest in dam development and water delivery systems and to create rules, property rights and institutional arrangements to manage the dam and water. The development of small dams is a current priority of the Government of Yemen and of foreign development agencies and banks. The objectives of the government and aid organizations in developing small dams are to provide sources of water for domestic needs, create new irrigated areas, and recharge groundwater.

This study highlights each of these problems and indicates how assistance strategies and agreements between external agencies and local communities may be designed in order to facilitate local investment, development of social capital and achievement of favorable outcomes. The purpose of this report is to improve understanding about the following questions:

- 1) What is the relative importance of social context versus design of assistance strategy, for building social capital and producing favorable outcomes?
- 2) How should external assistance for the development of water resources to serve the rural poor be designed in order to produce local social capital and favorable outcomes?
- 3) Can “state/society” synergy be created in the short-term in most contexts or does it depend on deeply embedded, long-term traditions?

The case studies were selected to represent two types of small dam development: 1) cases where the majority of investment was from local villagers and 2) cases where the majority of investment was from external aid agencies. Each case is discussed and the general findings are summarized.

Development Assistance, Investment and Social Capital

By now it is conventional wisdom that local institutions are essential for the effective development and management of natural resources (Carney and Farrington 1998; Ostrom 1990). The concepts of “public/private partnerships,” “state/society synergy,” and “good governance” are widely espoused (Rogers and Hall 2002; Siamwalla 2000; Smith 2000; Tendler 1997). Even so, many governments and development agencies persist in providing assistance in ways that fail to build viable local institutions and “social capital” (UNDP 1997). This is partly due to perverse incentives and vested interests (Huppert et al. 2001; Williamson 1996). It is also due to the lack of awareness of what is needed to build local institutions and how synergy between development agencies and local communities can best be created (Evans 1996).

Following Ostrom, et al. 1992, social capital is defined as, “the body of shared knowledge on how to organize people in a productive manner,” “the self-organizing capabilities of people,” and “the people and the patterns of regular, repetitive interactions among them that transform inputs into outputs” (Ostrom et al. 1992, pp. 6, 190, 191). After an earlier period of pessimism about the limited potential for collective action (Hardin 1968; Olson 1965), recent literature documents the emergence of social capital and synergy between state and society in a wide range of contexts and circumstances (Baland and Platteau 2000; Bromley et al. 1992).

Recent research by the International Forestry Resources and Institutions Research program supports the view that:

The design of institutions that help a group distribute the benefits and costs of their efforts in a way that is perceived to be legitimate, effective, and fair to that group is more important than the particular attributes of the group itself.
(Poteete and Ostrom unpublished).

Research on development assistance is increasingly emphasizing the importance of how development assistance is designed and what kinds of incentives it creates for local people to invest in physical and social capital (Shah 1996).

Principle-agent theory provides a theoretical basis to better understand the contractual hazards and incentive deficiencies that often arise because of information asymmetries between external agents and local communities in the context of joint ventures and agreements between the state and local communities (Wolf and Huppert 2000; Williamson 1996). Information asymmetries enable three kinds of contractual failures to happen: 1) adverse selection; 2) moral hazard; and 3) hold up.

Adverse selection happens when one of the two parties to an agreement makes a suboptimal selection of a good or service (or the service provider) due to inadequate information. The moral hazard problem arises when suboptimal services or investments are made due to opportunistic behavior of one of the parties to an agreement, in circumstances where the client cannot hold the agent accountable. The hold up problem occurs when a client in a service agreement is constrained to make a suboptimal choice of a service or service provider because the client is unduly dependent upon the agent (or service provider). This is because of previous investments and obligations made by the client that would make it costly or difficult for him or her to select other options.

This study, conducted in 1998, finds examples of each of these problems and indicates how assistance from external agencies to local communities may be designed in order to inhibit or facilitate local investment, development of social capital and achievement of favorable outcomes. This report examines eight cases of small dam development in the highlands of the north-central Al-Mahweet region in Yemen.

Information was gathered mainly from group and key informant interviews with knowledgeable farmers who were involved directly in the development of their dams.² The Yemeni villages vary by ethnic or tribal groups, proximity to markets, but each was basically dominated by the same local ethnic group, which generally comprised of mostly poor,

smallholder farmers. The case studies were selected to represent two types of small dam development: 1) cases where the majority of investment was from local villagers; and 2) cases where the majority of investment was from external aid agencies. Each case is discussed below and general findings are summarized.

Irrigated Agriculture under Stress

Yemen is a mountainous and arid country with a population of 18 million, located in the southwestern part of the Arabian peninsula. Annual rainfall in highland areas varies between 400 and 760 mm. Two peak rainfall periods provide potential for double cropping of short-season crops in some highland areas that are irrigated, during the eastern monsoon in April/May (*seif* season) and the western monsoon in July-September (*kharif* season).

Of Yemen's 55 million ha of land area, only 1.1 million ha is cultivated, of which 671,000 ha is rain-fed and 429,000 ha is irrigated. Approximately 2.2 million ha is under agro-forestry. Eighty percent of the cultivated area is planted with cereal crops, such as wheat, sorghum, maize, millet and barley. Irrigated areas have higher cropping intensities and more diversified cropping, including vegetables, fruit, cotton, coffee, tobacco and qat.³

For centuries the resilient people of this mountainous southwestern part of the Arabian peninsula have developed highly sustainable farming systems, which include indigenous methods of water harvesting, water spreading and construction of small dams and irrigation

systems. Centuries of incremental exertion have resulted in spectacular terracing of numberless escarpments throughout the region.

But, today, the sustainability of irrigated agriculture and even food security in Yemen are under threat for at least the following five reasons.

1. *Availability of water for agriculture is decreasing.* This is due to drawdown of groundwater aquifers because of overuse and loss of soil water retention capacity in upland areas, increasing competition for water, and an apparent recent trend in decreasing rainfall. Yemen's total average annual renewable water supply is about 2.1 billion m³. It is estimated that by the year 2010, the total annual demand for water will be about 3.3 billion m³, if current trends continue. Availability of water in Yemen is only about 130 m³ of water per capita per year (compared with an average of 1,250 m³ for the Middle East).⁴ However, it is estimated that in Yemen 90 percent of the population has less than 90 m³ of water per

²Interviews were held on site, complemented by inspections of dams and water delivery systems. Staff of local MAI (Ministry of Agriculture and Irrigation) offices were interviewed separately.

³The leaves of the qat plant are a popular stimulant used mainly by Yemeni men. Qat is profitable and its requirement for water has not been established yet. Approximately 30 percent of water used for agriculture is used for qat production.

⁴The international average per capita water availability is 7,500 m³ per year.

capita per year. Only 69 percent of the population has access to an “improved water source,” most of whom are not in the upland areas.

2. *High growth rate of an impoverished population is outpacing growth in agricultural production.* Yemen has a high population growth rate of 2.8 percent per annum. About 75 percent of the population lives in rural areas where 61 percent of the population is employed in agriculture. Gross net income per capita is only US\$450 per year and 46 percent of children below 5 years of age are malnourished.⁵ Yemen is one of the poorest countries in the world and its population is highly dependent upon a relatively fragile agriculture.
3. *A trade deficit is making importation of food increasingly difficult.* Yemen had a trade deficit of US\$104 million in 2001. Exports are

projected to decline while demand for imports is rising (with food being the main import).

4. *Soil erosion is increasing while the water retention capacity of soils is decreasing.* Widespread deterioration of terraces, soil erosion and desertification are reducing the water retention capacity of soils.
5. *Relatively low productivity and profitability of irrigated agriculture.* This is making it increasingly difficult for rural families to support themselves in agriculture. Many men migrate from rural areas in search of jobs. In many cases this leaves the task of local farming to women and children. Because of the ability of irrigation to increase cropping intensity and diversification, it is the main way to increase the productivity and profitability of agriculture and, thereby reduce the need for men to leave their village homes to seek other sources of income elsewhere.

Development of Small Dams in Yemen

The development of small dams in the mountainous regions of Yemen is a priority of the Government of Yemen (GOY) because of its potential to provide sources of water for domestic use, creating new irrigated areas and recharging groundwater aquifers. A variety of programs, funding sources and procedures are used by external organizations to develop small dams in Yemen, including the Agriculture and Fisheries Production Promotion Fund (AFPPF), Ministry of Agriculture and Irrigation (MAI), Social Development Fund, the European Union, USAID and other providers of bi-lateral assistance.

At the national level, the National Water Resources Authority, which has the mandate to

develop a water policy and strategy, and the General Directorate of Irrigation are relatively new organizations that have critical shortages of skilled staff and resources. At the governorate (province) and district levels, the Ministry of Agriculture and Irrigation and its Irrigation Department generally have little, if any, funds for development, operations or maintenance of dams and water delivery systems. In general, they lack the capacity to provide support to avert rapid deterioration of irrigation systems, to regulate over-extraction of groundwater or to plan small dam development according to basin level analysis and planning for integrated water resources management.

⁵Figures taken from “Yemen Republic at a glance,” at www.worldbank.org

Case One: Bait Abdullah Dam, Shibam subdistrict

Development and Investment

More than 30 years ago a man in Bait Abdullah village piled stones in the wadi⁶ near the village to collect water for his family's use. In the 1970s some engineering technicians visited the village and said that the stone weir would be a good site for a small dam. Other villages proposed that the small stone weir be made into a small dam for the benefit of the whole village.

Representatives of the village group appealed to the Ministry of Agriculture and Fisheries (MOAF) to provide the necessary resources for this proposal. The MOAF agreed to provide the village with 1,000 bags of cement.⁷ The MOAF informed the villagers that they would have to provide all the rest of the materials and the labor required at their own expense. Convinced that no other assistance would be given, 72 of the 120 families in the village agreed to provide the additional 3,000 bags of cement required and the necessary labor. Families could join the project and become beneficiaries by providing either cement or labor, or a combination of the two. The remaining 48 families did not support the project either because they did not believe that the project would be successful in providing enough water for everyone or they did not have sufficient money or adequate labor to contribute.

The MOAF agreed to the location and design of the two dams that were proposed by the village (a member of the village committee was experienced in construction) however, construction took 2 years. The small upper dam and larger lower dam were 100 meters apart, therefore two pumps were needed. The villagers

approached the Ministry of Agriculture and Water Resources (MAWR) in 1994, which agreed to give one 15-hp diesel pump to the village,⁸ and left the villagers to purchase the other pump. Water is pumped 25 meters out of the canyon to where it is distributed through an open channel network. After construction, the villagers were generally satisfied with the construction of the dam, but could see water regularly spilling over the sill of the lower dam, so they proposed that the height of the sill be raised from 9 to 13 meters. It was estimated that this improvement would increase the storage capacity of the lower reservoir from 24,000 m³ to 48,000 m³ (table 1 in the annexure). The upper dam was 8 meters high and had a storage capacity of 27,000 m³. The village did not plan to upgrade the upper dam, but the Ministry of Agriculture and Irrigation (MAI) insisted on increasing the thickness of the dam at the base from 2 to 5 meters, for safety reasons. The village planned to increase pumping capacity after the upgrading was completed.

In 1996, the villagers requested additional assistance from the government and this was accepted. The MAI designed the upgrading and the new AFPPF fund agreed to finance the project on a 50/50 cost sharing basis. The villagers argued that their previous investment in the first phase of work should be considered in the cost sharing, so the AFPPF agreed to a 70/30 cost sharing formula for the upgrading (i.e., 30 percent to be borne by the villagers). The AFPPF refused to provide assistance for obtaining another pump or pipes for the distribution system.

⁶A wadi is a small seasonal river that goes dry each year.

⁷One bag of cement = 50 kgs.

⁸The pump has a 2-inch pipe outlet and a capacity of 2.5 l/s.

Building Social Capital

As is the case in the other villages of these case studies, Bait Abdullah village consisted primarily of a single tribal group of relatively poor people. There is not much socioeconomic inequality among the villagers. The villagers estimated that their fields would need water at least once in every 18 days, and they divided the 72 members (who were the initial investors) into 18 rotations of one day each, with each rotation irrigating four farms per day. The founding members of the dam association decided that the water charge to the founding members should be YR (Yemeni Riyal) 100/hr (US\$0.71) for water pumped, while other users, which were the 48 families that did not invest in construction would pay YR 200/hr (US\$1.42). Founding members who wanted water beyond their normal allotment would then pay YR 200/hr (US\$1.42) to receive water outside of the normal 8-hour pumping day. The water charges were used for fuel, oil and spare parts for the pumps, salary for the pump operator and de-siltation of the reservoir (in addition to silt taken voluntarily). The founding members allowed open access to the reservoir for anyone to remove silt, since this helped sustain the functionality of the reservoir and it encouraged incremental expansion of the irrigated area because villagers used the silt for topsoil. Both water and fertile topsoil were constraints on the area that could be irrigated.

During the second phase of development, large trucks were needed to enter the area for construction. Construction occurred during the rainy season and the road that passed through five villages needed to be repaired. The main beneficiary village agreed to pay half the cost of road repair and the other four villages agreed to pay the other half of the cost. The total cost of road repair was YR 400,000 (US\$2,860), done in 1998. A bulldozer and driver were hired to do the work and they shared the cost according to the size of the village and distance of the village from the road. The beneficiaries made these

unanticipated expenditures and then did not have enough left to cover their 50 percent share of the project. This was part of the reason the village pressed the AFPPF for a 70/30 cost sharing arrangement. Sometimes villagers or farmer-groups got involved in disputes between farmers over accusations that some were working less than others. This could stop farmers from providing their share of the investment.

Water conveyance losses in the open channels were high but the farmers were optimistic that they could obtain assistance from some aid agency to purchase the required pipes for the distribution system. Hence, they decided not to purchase it outright but to search for assistance. By the end of 1998, farmers had not contributed their agreed 30 percent share for upgrading and had no plan to do so. Villagers said that they hoped to obtain assistance from other aid agencies for the pump, pipes and remaining 30 percent share of work for upgrading the dams. By the end of 1998, the contractor had finished 70 percent of his share of the work and refused to complete his full share (which was 70 percent of the total) until the villagers contributed their 30 percent share.

Both the contractor and sub-contractors lived in the village, as such, both were subject to some social pressure and monitoring by the villagers. After completion of the initial phase, MAI officers approved the quality of construction but believed that both dams were too thin and should be thickened during upgrading. Villagers did not agree and preferred to use more of the materials for increasing the height of the dam, rather than the thickness. But the AFPPF technicians prevailed and designed the upgrading according to the specified thickness. Villagers had the view that the process of developing the dam was too slow and required a lot of political lobbying and they needed political connections to get assistance. They said that they did not expect to receive any assistance to maintain or repair the dam, so they would have to do it themselves. Any future costs of development or

system extension would be shared equally among the 18 shares held by the 72 founding members and latecomers would not be permitted to invest.

The initial investment by villagers established a property right among the 72 initial investors to first access rights for water at reduced cost. Non-investors were obliged to pay twice as much for water, which subsidized the cost of O&M (Operation and Maintenance) for the initial investors. The initial subsidy of 1,000 bags of cement coupled with a clear signal that no additional assistance would be forthcoming, provided sufficient incentive for 72 of the 120 families in the village to mobilize 3,000 bags of cement and the required labor.

However, for the second upgrading phase of dam development, terms and conditions for assistance had changed. The AFPPF finally agreed to a 70/30 cost sharing ratio for upgrading, but the villagers failed to provide their share during the agreed schedule for construction. Although this cost sharing formula was much more favorable to villagers than was the initial one, and the likely benefits were much more visible than before the first phase of development, the political lobbying had made villagers more aware of various funding sources and they were inclined to search and wait for the best deals for obtaining another pump, several hundred meters of pipe and for alternative assistance to complete the upgrading. From the perspective of the AFPPF, they were reneging on their commitment to contribute 50 percent from their own resources (even though they had agreed to count previous local investment as part of the 50 percent village share, which made the local share really only 30 percent for the second phase). From the villagers' perspective, they considered alternative sources of funding largely as their contribution due to the considerable efforts they had to make in searching and lobbying for assistance.

The first phase of relatively high local investment and low external assistance resulted in considerable effort by villagers to develop water distribution, maintenance and investment rules. The second phase of development had relatively high external investment with a low level of local investment. However, the rules and rights were elaborated and membership was extended. Organizing and building social capital occurred through a process of, first, experimentation by a few villagers in building a temporary weir. This was followed by a relatively open process of village meetings, families freely opting in or out of the project, using investment in materials and/or labor as the basis for granting water property rights, negotiation between villagers and providers of assistance, searching and lobbying for additional assistance, and developing group rules for water distribution, maintenance and investment. The collection of water fees and construction of the dams established both social and physical capital simultaneously, but not for the village, rather for the social group that invested in the dam.

Outcomes

The technical staff of the MAI agreed with the location of the dam in the village, but said that there was a technically better site downstream (at a narrower part of the wadi, which would be cheaper to build and have better storage capacity), but the downstream village had not requested it.

Immediately after completion of the initial stage of dam development, the scheme was only able to irrigate 4.5 ha of land, mainly due to the small capacity of the two pumps. Before irrigation, farmers planted wheat and barley or sorghum and maize once a year. After irrigation, farmers planted these plus another cash crop season for alfalfa and vegetables (especially

garlic and onions). Water for domestic use was more important than irrigation. Before the project, villagers (mostly women and girls) walked 5 km to carry water for household use. After

completion of the dams, 800 people in the village and 1,200 people from other villages began to take water from the reservoirs for domestic needs, including washing of animals.

Case Two: Bait Fakhar Ad-Den Dam, At-Tawila subdistrict

Development and Investment

In the late 1980s, two brothers from Bait Fakhar Ad-Den village returned to Yemen from working in Saudi Arabia and visited the famous Marib Dam, which inspired them to try to build a small weir in their home village. In 1987, their two families built a small masonry weir and, after seeing that ponding was substantial and stable, they raised the height of the sill with the support of four other families. They tried to persuade other villagers to join in enlarging the dam further, but others lacked confidence in the project or thought it would be too expensive. The average landholding size in the village is less than 1.0 ha per family, with little variation in size between them. All villagers belong to the same tribal group. The first phase of construction took 6 months, during which time the six families rotated between a group of five working on site and the sixth preparing food and attending to the children. Women poured and carried cement. Work was intermittent since the group needed time to incrementally raise funds for more cement and materials and then needed to find time to do the work. After the first phase, the dam was only one meter thick at the bottom.

The next step was to build a second small weir downstream several meters from the first weir and then divert water to their fields via gravity pressure through a 2-inch metal pipe. They purchased pipes incrementally and tested the levels and slope of different routes to

determine which route delivered water most efficiently. At first they purchased 500 pieces of galvanized metal pipe (6 meters each for a total of 3,000 meters) at a cost of YR 200 per piece (for a total of YR 100,000 or US\$714). Two years later they purchased another 200 pieces. This was an indigenous effort without external assistance. Only the original group of investors was allowed to purchase and use the pipes.

After the first phase of development, four other families saw the benefit of the small dams and also wanted to divert water from the wadi. But the original group of six investor families refused them as they feared that there might not be enough water for all of them. The four “late-comer” families responded with a proposal to build another weir about 100 meters upstream. The original group (already a recognized holder of water rights by prior appropriation) agreed to their request on the basis that water was frequently overtopping the first dam. With this arrangement they were convinced that there would be sufficient water for the additional dam. The ten families altogether owned only 7.7 ha of irrigable land.

At this time, in latter 1992, a team from a GTZ (German Agency for Technical Co-operation) project visited the area and advised the villagers that the proposed additional weir would be feasible, and they agreed to share the cost of construction. The original group of six and the second group of four agreed to work together on the project. The GTZ staff and villagers also

agreed to raise the height of the first dam and build a fourth small dam another 50 meters upstream from the third one. GTZ provided 800 bags of cement and the villagers provided labor and other materials. Again, work was done incrementally and intermittently according to the availability of labor and money. They also increased the height of the first dam to 18 meters and the thickness to 5 meters at the bottom and 1.5 meters at the top (table 1 in the annex). Before the small dams were developed, the fathers of all 10 families were working in Saudi Arabia. Some returned to Yemen to help with construction, while some remained in Saudi Arabia to raise more funds to support continued construction of the dams.

When incremental development of the dams progressed to the point where the lands of all 10 families could be irrigated, the remaining fathers who were in Saudi Arabia chose to return to their village in Yemen to engage in irrigated agriculture. The now larger group of investors purchased an additional 300 pieces of pipe for distribution of water and continued to use them on a trial and error basis to identify proper routing of pipes to obtain a maximum service area. They installed a valve and 50-meter plastic hoses at the end of each metal pipe to rotate the water between fields. It was apparent that, had villagers received more technical support in the beginning, they could have designed and built a water delivery network with much less pipe than that was purchased.

In the latter part of 1994, villagers had heard that there were assistance programs for the development of small dams and irrigation networks, and representatives of the group of 10 shareholders visited the provincial MAI office in Al-Mahweet to request further assistance. An engineer from MAI visited the site and said that the weirs were too narrow and should be widened for safety reasons. He estimated that a fifth dam would raise the total storage capacity of all dams to 96,000 m³ and the improvements would cost YR 22.5 million (US\$160,714).

However, the engineer said that if they built the fifth dam only a few meters above the first dam, where the canyon was narrower, it would yield a total storage capacity of 73,800 m³ for both the first and fifth weir, and would cost only YR 16 million (US\$114,286). This indicated that if the villagers had technical support in the beginning they probably would not have built the first three dams where they did.

Thereafter, the 10 shareholders heard about the AFPPF fund for small dam development, which required 50/50 cost sharing. The farmers proposed that their previous investment be counted toward their 50/50 share, saying that if their new contribution (which they proposed to provide in labor and materials) was only 20 percent of the estimated cost of YR 16 million (US\$114,286) for the fifth dam, they could complete their contribution within one year, otherwise they would need more time. The AFPPF accepted this proposal.

Building Social Capital

In the early stage of dam development, the original shareholders began collecting silt and depositing it on unused village land that they reclaimed for personal use, obtaining about 1 ha from open-access village land. When other villagers saw the benefits that the shareholders were deriving from the land reclamation and irrigation, the village authorities stopped the shareholders from reclaiming village land and decided to allocate all additional reclaimable land equally among villagers. After holding negotiations between the village and the shareholders, a compromise was reached to give the shareholders some additional village land and to distribute the rest among the other villagers.

After the first weir was built to nearly 18 meters in height, the 10 shareholders agreed that 5 of the original shareholders would take water from the first (lower) dam and the other 5 would take water from the upper dam. They divided

water rights equally among themselves, based on their equal shares of investment rather than the share of land used by each. When the AFPPF fund required a 50/50 matching contribution, the 10 shareholders agreed to provide their individual contributions in equal amounts, thus retaining the principle of equal investments and equal rights between them.

The shareholders installed a pipe that conveyed water from the upper reservoir down to just below the lower one, where water from both reservoirs was combined into a single main pipe that divided into several branches downstream. Two valves just below the lower dam enabled farmers to take water either from the upper or lower reservoir. The shareholders agreed to rotate water turns every two days for one day each, between the group taking water from the upper reservoir and that taking from the lower reservoirs. In the morning, the water users for that day must open the valve for the reservoir from which he or she is supposed to take water. The last user of the day must turn off the valve.

Eventually, additional families in the village requested to join the group of irrigators and offered to pay shares in the capital costs of construction that had been invested by the other 10 families up to that time. But the group of 10 refused the offer and decided that they would sell water to the “late-comers” at the rate of YR 200 (US\$1.42) per hour of service, compared to the amount of YR 100 (US\$0.71) that the 10 agreed to charge themselves. Shareholders and non-shareholders alike pay YR 200 (US\$1.42) per hour for water used during the reserve time. Fees collected were used for the repair of pipes, de-silting of the reservoir, to pay the salary of the pump operator, and for the purchase of more pipes to extend the delivery system. The dam is emptied every 2 to 3 years for de-silting. Silt is used for topsoil to reclaim land or is flushed down the wadi. On average, about YR 135,000 (US\$964) is collected in fees during the kharif season (which is about 90 days in duration). Fees collected in excess of the requirements for

O&M are divided equally among the original shareholders.

The shareholders and other villagers agreed to rotate water every other day between shareholders and non-shareholders. The original shareholders each received water for 8 hours every 16 days. Water allocations were determined on the basis of requests at the beginning of the season, except for multi-season crops like alfalfa (with rattoons), which were determined in the form of 2- or 3-year water allocation agreements. Water used during the extra 4 hours of reserve time for emergencies or other special requests was arranged on a first come, first served basis. Hence, water can be made available for up to 12 hours per day at any time of the year.

At the beginning of the season, non-shareholders who wanted water allocations for a coming season went to the most senior man of the original shareholders (the “water leader”) to request an allocation of hours per 16 days. The water leader, appointed by the initial group of 10 investors, scheduled irrigations. When requests exceed available time, late-coming requesters must wait for the next season for an allocation. Sometimes, non-shareholders rotate water among themselves between seasons. Original shareholders automatically receive their 8-hour allocation every 16 days.

Villagers invested considerable funds to reclaim 2.5 ha of land, by transporting silt from 5 km away by truck and depositing it on irrigable land at a depth of 35 cm. This was a group effort that cost YR 2,200 (US\$15.71) per truck load of silt for 1,130 truck loads to transport soil, for a total of YR 1.4 million per ha (US\$9,800).

For the most water intensive crops (like garlic and onions), farmers reported that they could irrigate 250 sq meters per hour, or one-fifth of a hectare in 8 hours, in which case some farmers wanted water every 8 days instead of every 16 days. Because of differing crops and planting schedules between farmers, some would trade unused time with other farmers in exchange for

water on a day that was not their normal rotation date.

In Bait Fakhar Ad-Den, the extensive amount of initial local group investment in dam development involved a parallel development of organization, property rights and management and financing arrangements for water delivery and system maintenance. The founding shareholders in the dam and water delivery system asserted their rights of prior appropriation to the water and their right to require “latecomer” water users to pay a higher amount for water services and to reimburse the shareholders their initial and subsequent investments. In effect, this reinforced their assertion that the dam and conveyance system belonged to the group of initial shareholders. Assistance from the government was minimal and required cost sharing, which stimulated local investment.

Social capital was built through the incremental process of experimentation and investment by the shareholders; rotational labor inputs; negotiations between shareholders, “latecomers,” village government, MAI and AFPPF; development of differential water rights between shareholders and latecomers, allocation and fee arrangements and water trading. All of this established social capital resided primarily in the group of shareholders rather than at the level of the village government.

Outcomes

After the first and second stages of development, the dams provided water to irrigate 14 ha, if

irrigation was the sole source of water. When there was rainfall and irrigation was used only for supplemental supply, 22 ha could be irrigated. Before the dams were built, farmers cultivated rain-fed wheat and maize. After the advent of irrigation, farmers cultivated potatoes, tomatoes, lentils, garlic, and apple and olive trees, partly for personal consumption and partly for the market. Wheat and maize were cultivated only on rain-fed land. After the introduction of irrigation, farmers coordinated crop patterns to minimize the risk of yellow and red rust attacks.

By 1998, there were 22 families or 102 farmers (about five persons per family) who farmed parcels of land irrigated by the dams (ten of which were the original shareholders). About 2.5 ha of the 22 ha of irrigated land developed were reclaimed by de-silting the reservoirs and depositing silt as new topsoil on barren land.

Before the first dam was built, only one of the shareholder families had a cow. After a few years of irrigation, each shareholder family obtained three to five cows and non-shareholder water user families had two to three cows each. Before the dam was built, the villagers had to travel 10 km to obtain water for domestic use and, as such, they could not carry enough water for the animals. The main limiting factors for raising livestock were lack of feed and water. Irrigation provided water to produce more straw and fodder and other animal feed, as well as drinking water for livestock.

Case Three: Al-Ma'mar Dam, Bait Al-Ma'mar village

Development and Investment

Before 1990, farmers in Bait Al-Ma'mar village irrigated small parcels of land along the wadi with about 80 small pumps of about 2-hp each and five tubewells (with 19-hp pumps). In 1990, a group of farmers from the village visited Bait-Fakr Ad-Den village and saw the benefits of its small dams. They returned and held several meetings with other villagers and identified which families were willing to invest in dam construction and become shareholders. The group reckoned that they could save about 50 percent on the cost of operations and maintenance if they built a dam, because they would no longer have to pump groundwater. A delegation from the shareholder group visited the provincial MAI office in Al-Mahweet to request technical and financial assistance. MAI staff visited the site, agreed on the location, provided technical advice and offered to provide 350 bags of cement if the villagers provided another 150 bags, other materials and labor. Twenty-five families agreed to become shareholders and invest equally in developing the dam. Shareholders hired laborers to build the dam and it was constructed in 4 months, at a cost of approximately YR 2.5 million (US\$17,857) or YR 100,000 (US\$714) per share for 25 shares. The dam was 14 meters high, 6 meters thick and 6 meters wide at the bottom, and 1.2 meters thick and 22 meters wide at the top. The storage capacity created by the dam was 40,000 m³ (table 2 in the annex). MAI staff noted that concrete was made manually (without cement mixers) and the walls of the wadi canyon were not excavated and smoothened, thereby causing seepage on the sides and making the dam not safe as it should be.

When the Minister of MAI visited the area, the shareholders asked him for a large pump to lift water 30 meters out of the new reservoir to a feeder reservoir. The minister requested the

AFPPF to provide it. The villagers and the AFPPF agreed that the latter would provide a 24-hp pump (with discharge capacity of 6.25 l/s) if the shareholders would obtain 3-inch metal galvanized pipes to convey water up to the feeder reservoir and to the fields. This was agreed and the pump and pipes were installed. However, the shareholders did not construct a flushing escape for silt and as a result the reservoir silted up within 2 years. As an immediate remedial measure they broke a hole in the dam to flush the silt (which, incidentally, took one month's work). Thereafter they decided to install a large pipe for flushing the silt once in every 2 years.

Building Social Capital

The dam supplied water to 75 family farms, which were divided into 25 equal shares between one and four farmers. In accordance with the national law for cooperative societies (Law 18, 1994), the shareholder group established themselves as a cooperative society and formed a committee and board of directors. The Cooperative agreed to arrange irrigations in intervals of between 12 and 16 days. In the beginning, the group estimated that the irrigation interval should be 16 days, so they started with 16 shares, but more people than expected wanted irrigation, so they increased the size of the Cooperative to 25 shares. They also reduced the duration for an irrigation to 6 hours (to be divided among all holders of the share) and allowed the pump to operate for 12 hours per day, which was enough to irrigate two shares per day. The more frequent the interval was the higher the cost of water became. The water charge rate varied between YR 250/hr (US\$1.78) and YR 400/hr (US\$2.85), depending on the estimated seasonal cost for O&M, level of demand, and frequency of a rotation interval for a

particular share. The fee was collected upon initial delivery of water. At the end of an irrigation season, the committee generally allocates between YR 100,000 (US\$714) and YR 150,000 (US\$1,071) for O&M costs for the next season. The rest was distributed among shareholders according to how many shares each obtained through their investment to develop the dam and water delivery system.

In 1998, farmers estimated that there was about 6,000 sq meters of topsoil inside the reservoir. They planned to remove and use most of it to reclaim land or add topsoil to farms, but they did not yet have the necessary funds and equipment to initiate this plan.

In brief, the amount of local investment relative to external assistance was very high, but the overall cost was relatively low. Water allocation and other rules were well developed. The allotment of shares was based on the proportion of the investment. As with the other cases, investment, shareholdings, search for and negotiations with parties providing external assistance, and trial-and-error investments were all important parts of the process. However, members of the new Cooperative complained that they need to go to the province and even to the national level to obtain information on dam assistance programs and lobby for assistance. They recommended that the process be decentralized to the district level. Elements of the process of building social capital in Al-Ma'mar were similar to the other cases.

After the Al-Ma'mar Dam was completed in 1992, members of the Dam Cooperative Committee decided to form a regional committee to promote dam construction in other wadis in the region, as a business enterprise. Initially they selected five dam sites for development.⁹

Outcomes

About 63 ha can be irrigated from the dam for supplemental irrigation, when there is normal or above-normal rainfall. Without rain, the dam can irrigate 45 ha. About 400 sq meters can be irrigated per hour. During the seif season in 1998 (March-June), the Cooperative pumped water out of the reservoir for a total of 1,800 hours at the chargeable rate of YR 400 (US\$2.85) per hour. Approximately 33,000 m³ of water was extracted from the reservoir.

After irrigation became available, farmers started cultivating garlic, onions, tomatoes, potatoes, cucumber and apple trees. By 1998, farmers had converted 50 percent of the land to produce qat (which required less water and labor and was a good cash crop). Farmers reported that before the dam, the water table was 210 meters below the surface. After the dam was constructed, farmers reduced the depth of tubewell pipes to 200 meters and expected this to decrease further. Open wells had gone dry before the dam was constructed, but held water seasonally after the dam was built.

⁹This included the Sahib Dam site in Al-Khyat village, in the At-Tawila subdistrict.

Case Four: Sahib Dam, Al-Khyat village

Development and Investment

The Sahib Dam site, in Al-Khyat village, was the first site selected for development by the new regional Dam Development Cooperative (that was formed after the construction of the Al-Ma'mar Dam). It was selected first among the five villages because it had the largest estimated potential service area, the largest number of villagers who would be benefited and the lowest cost of construction per unit of service area. In agreement with local villagers, the Cooperative submitted a proposal for the project to the district MAI office in 1995. The Cooperative obtained an agreement with the AFPPF to share the estimated cost of YR 14 million¹⁰ (US\$100,000) on a 50/50 basis. For its 50 percent share, the Cooperative provided equipment, materials and labor and they became the contractor for construction, and the AFPPF paid its 50 percent share of the cost to the Cooperative (because it was the contractor). The Cooperative tried to persuade the AFPPF to provide assistance to purchase pipes for the conveyance network, but it declined since it was their policy to only provide assistance for the construction of dams.¹¹

The dam was completed in early 1997. It was 19.5 meters high, 65.5 meters wide, 8 meters thick at the base and 2.5 meters thick at the top. Storage capacity of the reservoir was 80,000 m³ (table 2 in the annex). MAI staff estimated that this could be increased to 120,000 m³ after silt was removed from the reservoir.

Building Social Capital

Water users included people from five villages, including some of the shareholders from the Ma'mar Dam project who were members of the regional Dam Cooperative Committee. A Sahib Dam development committee was formed with representatives from each of the five villages. A staff of the subdistrict MAI office also joined the Sahib Dam development committee. Representatives from each village met seasonally to decide on the water distribution plan and settle disputes. The representative from the MAI office acted as a mediator to settle disputes.

The regional Cooperative Committee planned to recover its 50 percent share investment in the Sahib Dam from the sale of water to the beneficiaries, who resided in the five villages. It was agreed that the water fee would be set on the basis of estimated costs of O&M of the dam and the delivery system. Everyone, both shareholders and non-shareholders, would pay the same price for water. Any funds remaining after the costs of O&M were paid would be shared on the basis of 75 percent to the Cooperative shareholders and 25 percent to all water users from the five villages.

Even 2 years after the dam was constructed, there was no irrigation because the Cooperative committee was still searching for additional sources of assistance to purchase a large pump and the conveyance pipes. They had not purchased any small pumps. The Agricultural

¹⁰The actual cost rose to YR 18 million (US\$128,600) because they discovered that the depth of soil at the dam base was 14 meters instead of 3 meters, so considerable extra excavation was required.

¹¹AFPPF staff said that AFPPF had this policy because there was such a large demand for assistance for dams and it wanted to respond to as many requests as possible.

Development Bank of Yemen charged between 7 and 12 percent service charge for credit purchases of items such as pumps or pipes. So the farmers decided to look for other sources of grant assistance.

The Cooperative estimated that 16 ha could be irrigated from the dam, which would serve approximately 400 farmers (including all family farm workers). They calculated that the main irrigation interval should be 18.5 days, based on an estimate that each village would need an irrigation turn of about 3.5 days.

Investment cost was very high and shared on a 50/50 basis between the government and the villagers. The development of rules and institutions was inhibited and it precipitated a dispute. Farmers said that they needed extension support for methods to distribute and apply water, cultivate vegetables, rotate crops and control pests.

This project was started by the new nongovernmental regional Cooperative and initiated a new regional scope for village-based development of small dams. It succeeded in

constructing the dam with a 50/50 joint investment involving the five villages, regional Cooperative members and a MAI representative, all of whom negotiated investments, fees, shares and profit-sharing among both shareholders and non-shareholders.

Outcomes

By the end of 1998, 2 years after completing the construction of the dam, water had yet to be diverted from the Sahib Dam reservoir, while cooperative members searched among government offices and aid agencies for grant assistance to purchase pumps and pipes. Farmers continued to cultivate wheat, barley and maize on rain-fed land, and they planned to cultivate vegetables on irrigated land. Farmers reported that springs located downstream of the wadi began producing more water after the dam was constructed. Farmers intended to use this water solely for irrigation.

Case Five: Al-Makik Dam, Hobah village

Development and Investment

The idea for building a small dam at Hobah village arose from a visit in 1987 by an officer from the provincial MAI office in Al-Mahweet. The officer observed the low discharge of wells in the area and noted the high cost of spare parts and maintenance. Farmers cultivated wheat, barley, corn, potatoes and vegetables (which were irrigated from open dug wells). The farmers of Hobah village began looking for financing, and in 1997, they finally obtained funding from an Agricultural Imports Fund, sponsored by the USAID and administered by the MAI. The donor

paid for 100 percent of the cost of constructing the dam, but no assistance was provided to install pumps or the conveyance network.

The first design specified that the dam should be 14 meters high at the spillway. This was later revised to 20 meters high. Project staff underestimated the depth of topsoil over the bedrock, which caused delays and search for more funds. The dam was 16.5 meters thick at the bottom and 3 meters thick at the top, and 25 meters wide at the bottom and 65 meters wide at the top. The total storage capacity was 200,000 m³, while the cost of construction amounted to YR 55 million (US\$393,000), (table 2 in the annex).

Building Social Capital

During the construction of the dam a conflict emerged between farmers who had 70 ha of potentially irrigable land upstream from the dam and farmers who had 17 ha that could be immediately developed downstream of the dam (which, they said, could be expanded to at least 70 ha). The upstream farmers argued that they should get 75 percent of the water because they had most of the land, but the downstream farmers thought that this was unfair since the upstream users would have to pump water out of the reservoir, while water could flow by gravitational pull to the downstream users. The downstream farmers were ready to start irrigating immediately after the dam was constructed, but the upstream farmers objected and said that the downstream farmers could not use water unless both groups used it together. It was apparent that the potential water supply was insufficient for all 87 ha and the upstream group did not want to risk losing the 75 percent share that they felt they should get, and could get if the downstream farmers began irrigating first. The upstream group was hoping to obtain a pump from the government.

The upstream group said that they should take 75 percent of however much water would be available and proposed that water be distributed to upstream users for 9 hours a day and to downstream users for 3 hours a day. The upstream group said that the downstream group should help them find funds for the pump and distribution system and that the downstream group should pay one-third of the cost of O&M (including the cost of pumping water to the upstream area), for the reason that both groups were going to be served by the one project. The upstream group said that they had already formed a cooperative organization to manage O&M for the whole project, but the downstream farmers reported that they did not know of such an arrangement. The upstream group emphasized that they were the ones who had

promoted the dam project, and exerted pressure on the government to approve it and even paid travel expenses for MAI staff to visit the area and prepare a design. (The downstream farmers said that they would pay their share of these costs after the dispute was resolved.) The upstream group asserted that the dam was the government's property and would be completed eventually.

The downstream group held the view that both upstream and downstream farmers should be beneficiaries, but priority water rights should be given to downstream farmers because they had used water from the wadi even before the construction work on the dam began. They said that the dam was located where it was in order to mainly serve downstream users and they argued that the potential irrigable area downstream was larger than the potential irrigable area upstream. Nevertheless, they proposed that the water be divided in 50/50 shares between the upstream and downstream areas in order to resolve the dispute. But they said they had no money to contribute to the purchase of a pump or conveyance pipes (which were needed by the upstream group). They said that they intended to specify a fixed time period after the construction of the dam to wait and not use any water from the reservoir so as to allow upstream farmers sufficient time to purchase a pump and pipes for their use. If after the lapse of this given period, the upstream group had not purchased a pump and the necessary pipes and started irrigating, the downstream group would be compelled to dig channels and start using the water downstream.

By the end of 1998, there had been several months of delay in further construction. The contractor had completed almost 80 percent of the work on the project when he discovered that the depth of the soil over the bedrock was greater than expected and that more funds were needed for the extra excavation. Because there was no agreement over how water would be shared between the upstream and downstream

areas, they were unable to identify what the service area would be and who would be the water users. The downstream group said that since the dam was the government's project, the government should resolve any problems related to the use of the dam.

During the planning and construction stage, the donor and government focused on the physical construction of the dam and provided 100 percent of the capital costs externally. There was no effort made to identify the service area and beneficiaries (because the project focused on the dam only). Absence of any prior agreement about who were the beneficiaries and the lack of investment by the prospective beneficiaries created the situation where neither

the upstream nor downstream group could assert a clear basis for water rights, obligations and rules. The different technical and financial requirements between upstream and downstream areas compounded the problem. The external financial capital was used in a way that prevented the development of local social capital—a critical element in enabling the dam project to have a lasting social value.

In brief, although Al-Makik had a high level of external assistance, it was handicapped by a major dispute between upper and lower end users over investment and water rights, which led to a poorly developed institutional basis for governing, managing and financing the new water supply.

Case Six: Zeham Dam, Zeham village

Development and Investment

In the early 1990s, residents of Zeham village made a request to the provincial MAI office in Al-Mahweet for a feasibility study to build a dam at their village. Farmers from the village visited the MAI for technical advice and for a supply of cement. They wanted to make a small dam, which would not be too expensive because they only had a limited amount of funds. The district MAI office did a study and submitted a request for cement to the MAI office at the national level (in Sana'a). A team came to the site from the national office of MAI and proposed to change the site to another location where the storage capacity would be larger. They recommended that the farmers submit an application for assistance through the AFPPF. Due to the high expected cost (YR 30 million or US\$214,300), the application was rejected by the AFPPF.¹²

After this they went to the Social Development Fund (SDF) and a SDF engineer also saw that the plan was too expensive. He went to the site with staff from the MAI and did another study and estimated what the service area would be. The SDF team found that the wells had very low yields and could only be operated about 2 or 3 hours at a time before they ran out of water. So they agreed with the original design but disagreed with the estimated cost. They revised the cost estimate to YR 28.7 million (US\$205,000) and proposed to go ahead with the project, with the SDF providing 85 percent of the financing and the villagers the balance 15 percent. The Cooperative agreed and decided to contribute its 15 percent share in the form of renting and providing heavy equipment for construction (such heavy equipment was owned by the members of the Cooperative).

¹²Generally, the maximum level of assistance allowable per dam was YR 15 million (US\$107,000).

The application was submitted to the SDF in September 1997, and was approved in November 1997. Construction began soon thereafter, with an estimated time of 24 months needed for completion. By December 1998, construction work was 80 percent completed. The dam was 18 meters in height and 62 meters wide at the top. It was 12 meters thick at the bottom and 3 meters thick at the top. The dam created a total storage capacity of 120,000 m³. The planned irrigated area was 30 ha, upon which were 30 farms serving a total of 1,875 beneficiaries (table 2 in the annex).

Building Social Capital

Before the project, the area depended on rainfall for a sufficient supply of water. Without supplemental irrigation farmers often experienced crop failure and had to cut the crop early and use it for livestock feed. Farmers intended to plant 100,000 coffee trees in the irrigated area.

In order to be eligible for SDF assistance, the farmers organized themselves into an Al-Faiha Agricultural Cooperative. Since it was a multi-purpose, profit-making cooperative, villagers could voluntarily invest as much capital as they liked and, thereby become shareholders in the Cooperative. They agreed to distribute dividends periodically to shareholders from profits made by the Cooperative. The dividends were based on original capital investment in the dam project.

Farmers calculated that during the two rainy seasons (seif and kharif) they could provide supplemental irrigation for 30 ha, providing two irrigations per parcel at 16 days apart at the latter part of the season. Between these seasons (when there was normally no rain) farmers expected to provide full irrigation to only 12 ha of the 30. During the supplemental irrigation period, farmers estimated that the irrigated area per

parcel that could be served would be about 1,000 sq meters. This would drop to about 640 sq meters per irrigated parcel during the full irrigation period. Annual rainfall in the area is 700 mm.

At the recommendation of the SDF (which has poverty alleviation as its main goal) the Cooperative decided to charge YR 10 (US\$0.07) per m³ to “normal” farmers and YR 5 (US\$0.03) per m³ to “poor” farmers. The definition for “normal” versus “poor,” according to the SDF, was to be based on the following criteria: total number of persons in a family, woman-headed household, number of old people in the household, socioeconomic status, total farm area owned, number of workers and handicapped people in the household. It was decided that the total water allocated at the rate of YR 5 (US\$0.03) should not exceed 50 percent of the service capacity of the dam.

Farmers of the Cooperative expressed their view that they fully owned the dam. They intended to distribute water on a demand basis, giving priority to farms that were nearest to the dam and only after their needs were met would the water be distributed to the fields that were further away. This priority-based system did not account for the “poverty” status of farm families. The poverty alleviation criterion for water charging of the SDF was therefore alien to local conceptions of how to allocate water equitably.

The agreement signed between the SDF and the Cooperative did not include anything about the development of the irrigation network, but a fixed pipe outlet was built into the dam. By the time of this study, the Cooperative had not yet planned how to develop the conveyance network.

In brief, the dam project in Zeham involved relatively high levels of external assistance and low levels of local investment. The development of institutions and rules to manage the water and apportion of water rights were poorly developed.

Development Assistance, Social Capital and Results

Assistance Strategies, Investment Arrangements and Social Capital

Literature on development and social capital, shows that researchers like Tendler (1997), Evans (1996), Fox (1992), and Moore (1989) note the importance of complementarity of the resources and strengths of the state in relation to society and the importance of close but transparent relationships between the state and local communities. This study shows that the way in which external assistance is designed and arranged can have a substantial effect on the motivation of local people to make investments and build social capital to manage and utilize the dam and the irrigation scheme. Small dam projects in Yemen normally include only the construction of the dam and not the irrigation network. When external assistance is provided only for the construction of the dam the work on the water delivery network and irrigation was often delayed. Where external providers of assistance took the lead in financing and constructing the dams, it was done without carefully specifying in advance what kind of water service would be provided, where the service area would be located and who would be the water users. Moreover, the case studies indicate that villagers are in need of technical assistance for dam site placement, proper excavation and thickness of the dam required for the safety of the dam.

The multiplicity of sources of external assistance and diverse terms and conditions for the provision of assistance created some confusion and stalling among village groups. Sometimes it encouraged a speculative, shopping mentality among rural people who responded by taking a lot of time to search and wait for favorable, or more favorable, low-cost terms of assistance. To an extent, this may be good because it could pressure the government to be

responsive to the needs of villagers. Too much of such a mentality, however, may create an excessive dependency of the people on the government, which can have a negative impact.

The study indicates that when villagers build a dam, those who invest in its construction consider it to be their own property. The group of investors defines the criteria for membership and identifies rules for investment, water extraction, water distribution, silt removal and canal maintenance. The initial or founding investors set themselves apart from late-coming investors, and the former assign themselves lower water fees and restrict others from becoming shareholders. This serves to protect their prior water rights and the value of their shareholdings. This is consistent with Ostrom et al. (1992) and Coward (1986), who have noted the importance of group investments in creating locally-recognized property rights and effective institutions to manage resources. Social capital emerges from a pattern of decisions, investments, and development of institutions (rights, rules and authority) that emerge incrementally. This is often prompted by a few enterprising individuals who persuade others to invest and experiment with small dams. At some point, the original group of investors and their corresponding rights and benefits are determined and distinguished from latecomers. People from the village government and/or MAI may facilitate the process.

If the government builds a dam at its own expense, villagers see it as the government's dam. If farmers are not organized as a group and invest cooperatively in dam development, they tend to be less motivated to use and maintain the dam than the village groups who are the major investors in their projects. They lack the "social capital" or organizational capacity to complete, operate and maintain the project. The study team observed several cases in Al-Mahweet, where extended time had passed after

completion of the dam and farmers had not developed the water conveyance and distribution network for the dam.

Table 1 in the annexure shows information on the levels of investment farmers provided in the Bait Abdullah and Bait Fakhor Ad Den small dam projects (cases 1 and 2). In both cases, in the first phase of development, where farmers only expected modest assistance from the government, villagers provided between 71 percent and 75 percent of the cost of materials and all of the labor. In the second phase of development, in both cases, after farmers became aware of other government assistance programs, their share of investment was dramatically less.

Table 3 in the annex shows a consistent pattern of large local investment where external assistance is small, and small local investment where external assistance is large, among the eight cases of small dam development activities. It also indicates that cases with high proportions of external assistance also have poorly developed rules for investment, water rights and O&M.

Al-Makik and Zeham received relatively high shares and amounts of external assistance. Both had poorly developed rules and institutions for managing water. Internal conflicts related to the external assistance arose in both villages. Al-Makik village had a serious dispute over water rights. Zeham village adopted a two-tiered water charge due to pressure from the project donor. It was a contentious matter for the villagers to define who was “poor” and who was “normal.” Several opposed the externally induced water charge rule, which was seen by villagers as incompatible with their conceptions of fairness.

MAI officers reported that in the beginning of dam projects farmers tended to agree to provide 50 percent of the total cost. Later they realized they could not invest this amount, often due to the occurrence of unexpected expenses, such as the need for more excavation or the building of

access roads. Sometimes farmland was lost to the dam or reservoir and no compensation was given by the government. So the farmer group paid compensation money to the farmer whose land was used in the project and this amount was subtracted from their intended 50 percent contribution to the core project. Also, sometimes a road had to be built or repaired, especially during the rainy season, which required extra work and a large truck to transport cement and materials, for which the farmers had to pay. Or sometimes farmers did not have the money to follow through with their cost sharing agreement. Also, if the village leader is not strong or is not supporting the project, it can be difficult for farmers to raise the agreed level of local investment.

These cases illustrate the fragile nature of incentives for farmers in Yemen to invest in the development of small dams and irrigation networks. Poorly planned subsidies and inconsistent approaches between development agencies can easily discourage local investment, create disputes and inhibit institution building. Often, the mere speculation that external assistance might be available on easy terms is enough to cause extensive delays in local investment. It is not the amount of external assistance that affects local willingness to invest. It is more how the assistance is planned in order to require local investment.

On the other hand, the cases support the view that the design of assistance and the incentives they generate may be more important than the social context in building social capital and producing synergy from joint state and community investment. This is seen in the different responses made by Bait Abdullah and Bait Fakhar Ad-Den between the first and second phases (where the social context remained the same) and by the general pattern of responses to dominating or facilitating modes of assistance. The Yemeni villages vary by ethnic or tribal groups and proximity to

markets, but each was basically dominated by the same ethnic group which generally had a large majority of poor, smallholder farmers. The cases also imply that state/community synergy can be created in the short-term by the design of assistance strategies and that such synergy is possible in settings with deeply embedded, long-term traditions.

Local investment is the key to building local social capital. Group investment builds trust and capacity among farmers to also invest in other areas, such as land reclamation, coordinating cropping patterns and pest control. When local people do invest, they tend to do it incrementally, through a process of trial and error and purposeful linking of investments to water rights. Water rights are defined in shares based on the share of investment made by the shareholder. Investment depends on people making a distinction between investors and “late-comer” clients, the latter which do not have durable rights, but only a temporary right of access, on a pay-for-service basis, that too only after the rights of shareholders are met first.

Principal Agent Problems versus Synergy

The manner in which the assistance strategies were designed and implemented, particularly those that were dominated by external investment, created significant risks of the three types of principal-agent problems as noted above (e.g., adverse selection, moral hazard, and hold up). These were evident in the case studies.¹³

Apparent examples of adverse selection problems are:

- 1) when villagers failed to select an assistance option after an extended period of time due to the expectation that they would find better terms from other donors (Sahib); and

- 2) when villagers selected a donor but found out later that it required water distribution rules that were locally unacceptable (Zeham).

Indications of moral hazard risks were:

- 1) the gateway role played by MAI staff who had knowledge of different donors, knowledge which villagers normally did not have; and
- 2) inability of donors to monitor the level of local investment and the ability of villagers to exaggerate claims about how much they invest in labor and materials (to enable their actual share of investment to be less than agreed amounts).

Apparent examples of the hold up problem were:

- 1) pressure on the government to increase funding for a project beyond agreed terms after the contractor finds out that the depth of the soil above the bedrock at the dam site (as in Al-Makik) was underestimated;
- 2) one-sided dependency of upstream farmers on downstream farmers to invest in pumps and conveyance pipes and the hydraulic ability of downstream farmers to wait them out (as in Al-Makik);
- 3) after the project begins and the donor has invested most of its share, villagers have leverage to persuade the government to agree to reduce their share of investment, because they know that the government needs to account for the successful use of its funds (Bait Abdullah second phase). This is a hold up problem in that villagers have leverage over the local government, which has already made an investment and may be persuaded to provide additional assistance to make the overall investment successful.

¹³These are only indicative of contractual failures. More information is needed to confirm and explicate these relative to actual agreements made between the stakeholders.

Results: Do Synergy and Social Capital Matter?

As was seen in table 1 in the annexure, in the cases of Bait Abdullah and Bait Fakhor Ad Den, development costs per m³ of water storage created (not including labor) varied from YR 21 (US\$0.15) to YR 763 (US\$5.45) per m³. This wide range in cost per unit of storage created reflects the relatively ad hoc and unsystematic nature of project selection among the providers of assistance. Also, in both sites the total cost per m³ of water storage created was substantially higher for the second phase of development, which received substantial government assistance.

Table 3 in the annex indicates that, where the share of farmer investment is substantial (in

Bait Abdullah Phase 1, Bait Bakhar Ad-Den Phase 1, Al-Ma'mar and Sahib) the total cost per m³ storage created tends to be lower (average of US\$ 0.73/m³ storage created) than in the other four cases where the external assistance constitutes a large share of the total investment (US\$2.50/m³ storage created). In other words, external assistance produces high-cost projects and discourages local investment. All three cases where the water users were the primary investors (Bait Abdullah Phase 1, Bait Fakhar Ad-Den Phase 1 and Al-Ma'mar) resulted in the rapid utilization of the dam (in terms of construction of the water delivery infrastructure and development of the irrigated area). In all cases where the government or donor was the primary investor, utilization was delayed or still pending at the time of the study.

Conclusion and Recommendations

In Yemen, the approaches for providing assistance to develop small dams are quite variable and subject to the influence of various international donors. There is a lack of a single basic strategy and terms and conditions. The incentives, pressures and support for village groups to get organized and build social capital are relatively weak. This study suggests that in order to ensure positive and sustainable results of water resources development projects, creation of local organizational capacity should be given at least as much attention as the construction of infrastructure.¹⁴ This study supports the views of Cernea and others (Cernea 1993; Cernea and Meinzen-Dick, ND) in saying that it is important to balance project

organizational intensity (the extent to which projects emphasize organization-building) with organizational density (the degree to which society is organized relative to the requirements for such organization, such as the need to develop and manage small dams). This study found both organizational intensity and density to be quite low in the beginning, but village groups in need of more water were quick to respond to opportunities.

Although social context (especially property relations, inequality, etc.) is important, the experience of these cases suggests that a consistent, effective strategy of joint investment may produce favorable results across different social contexts. Creating a local sense of

¹⁴Although this might seem like conventional wisdom, it is, in practice, still not the norm.

ownership by requiring substantial local investment in project development, is an essential part of developing local institutional, managerial and financial capacity (i.e., social capital) to use the infrastructure effectively and sustainably after completion. The study suggests that, prior to project implementation, prospective water users should be organized into groups and make agreements with the government to provide a significant share of the total cost of the project, through labor, material, equipment or other relevant contributions.

To ensure that both parties (government and farmers) fulfill their commitments, it is recommended that projects should be divided into stages, each with agreed targets and levels of investment to be provided by both parties. At each stage, each party can demonstrate that they are fulfilling their part of the agreement. If the beneficiary group fails to fulfill its part of the agreement, the government would be able to curtail the unproductive use of its funds. This would provide more incentives for farmers to fulfill their agreed share of investment.

This study suggests that donors should be cautious about imposing different terms for providing assistance for the development of small dams within a country. This may create local dependence on the government and encourage villagers to shop and speculate among donors and projects. However, as long as this doesn't place villagers in the role of mere supplicants, if they are organized, they can place pressure on the government to be responsive to the needs and capabilities of the villagers. In order to discourage dependency, it is recommended that governments consider adopting a consistent set of principles for assisting villagers to develop small dams and the requisite social capital to effectively and sustainably use them.

The incremental but relatively rapid reactions of the social groups to assistance options presented suggests that synergy between external assistance and local investment can be created relatively quickly and widely as long as an appropriate process and effective incentives and accountability mechanisms are applied.

This study suggests that the most important and effective role the government and development assistance agencies could play is to provide a single and consistent strategy to:

- 1) promote local investment in the development of both the dam and water delivery network; and
- 2) build local institutions to manage the dam and delivery system or create such managerial capacity in existing ones.

This would probably be accomplished most effectively with the following strategy:

- 1) external assistance is based on local requests, analysis of basin development potential and constraints and agreements about cost sharing and institution building;
- 2) clear and consistent policy for cost sharing;
- 3) facilitating the building of local institutions to govern, manage and finance operations and maintenance of dams and water delivery networks;
- 4) the provision of appropriate technical assistance (especially for dam site identification and safety requirements); and
- 5) phased parallel joint investments and monitoring by villagers and the assistance agency.

Annex: Tables

TABLE 1.
Development of Bait Abdullah and Bait Fakhar Ad-Den dams.

Item	Bait Abdullah Phase 1	Bait Abdullah Phase 2	Bait Fakhor Ad Den - Phase 1	Bait Fakhor Ad Den - Phase 1
Government's cost and share for materials	\$2,464* (25%)	\$44,978 (96%)	\$1,971 (29%)	\$114,400 (near 98%)
Beneficiaries' cost and share for materials	\$7,393 (75%)	\$1,928 (4%)	\$4,929 (71%)	(Small but unspecified)
Labor provided by (<i>number</i>)	Beneficiaries (72)	Government contract	Beneficiaries (12)	Government contract and beneficiaries
Year completed	c. 1990	Pending	1987	Pending
Height to dam sill (<i>meters</i>)	9 m (<i>upper dam</i>)	13 m (<i>upper dam</i>)	—	18 m
Thickness of dam at bottom (<i>meters</i>)	3.3 m (<i>upper dam</i>)	9.8 m (<i>upper dam</i>)	1m	5m
Area irrigated (ha)	4.5 ha	Pending	21 ha	Pending
Storage capacity created	24,000 m ³	48,000 m ³	75,000 m ³	21,000 m ³
Development cost per ha irrigated**	\$2,191	Pending	\$329	Pending
Cost storage created/m ³ (YR)**	\$0.41	\$0.97	\$0.15	\$5.45

Notes: *Figures are in 1998 US dollars. US\$1 = Yemeni rial 140. How material costs will be shared between government and farmers is still under negotiation. **Does not include costs of labor.

TABLE 2.
Development of Al-Mamar, Sahib and Al-Makik dams.

Item	Al-Mamar	Sahib	Al-Makik	Zeham
Government's cost and share	\$863* (2%)	\$50,000 (50%)	\$392,857 (100%)	\$174,059 (85%)
Beneficiaries' cost and share	\$44,588 (98%)	\$50,000 (50%)	0	\$30,716 (15%)
Total cost	\$45,450	\$100,000	\$392,857	\$204,776
Height of dam sill (<i>meters</i>)	14m	19.5m	20m	18m
Width of dam at top (<i>meters</i>)	22m	65.5m	65m	62m
Thickness of dam at bottom (<i>meters</i>)	6m	8m	16.5m	12m
Area irrigated (ha)	63 ha	16 ha	78 ha	30 ha
Storage capacity created	40,000 m ³	80,000 m ³	200,000 m ³	120,000 m ³
Cost per hectare	\$721	\$6,250	\$5,037**	\$6,826**
Cost per m ³ storage created	\$1.13	\$437	\$1.96**	\$1.70**
Year of completion	1992	1997	Pending	Pending

Notes: *All figures in 1998 US dollars, where US\$1 = Yemeni rial 140. **Figures are planned amounts, since construction was not completed at time of study.

TABLE 3.
Investment arrangements, institutional development and outcomes of eight small dam development projects.

#	Dam	Main Investor	Incentive for users to invest*	Development of social capital**	Cost/m ³ storage developed	Pace of utilization
1	Bait Abdullah Phase 1	Users	High	Well developed	\$ 0.41	Rapid
2	Bait Abdullah Phase 2	Government	Inhibited	Well developed	\$ 0.97	Delayed
3	Bait Fakhar Ad-Den Phase 1	Users	High	Well developed	\$ 0.15	Rapid
4	Bait Fakhar Ad-Den Phase 2	Government	Inhibited	Well developed	\$ 5.45	Delayed
5	Al-Ma'mar	Users	High	Well developed	\$ 1.13	Rapid
6	Sahib	50% Government /50% Users	Inhibited	Moderate	\$ 1.25	Delayed
7	Al-Makik	Government	Poor	Poor	\$ 1.90	Pending
8	Zeham	Government	Inhibited	Moderate	\$ 1.70	Pending

Notes: *As affected by awareness about terms and conditions for assistance. **This means the extent to which institutional, managerial and financial arrangements were in place for utilizing the dam at the time of dam construction. All figures are in US dollars.

Literature Cited

- Baland, J. M.; Platteau, J. 2000. Halting Degradation of Natural Resources: Is there a Role for Rural Communities? *New York and Oxford: Oxford University Press*.
- Bromley, D. W.; Feeny, D.; McKean, M. A.; Peters, P.; Gilles, J.; Oakerson, R.; Runge, C. F.; Thomson, J. eds. 1992. Making the Commons Work: Theory, Practice, and Policy. *San Francisco: ICS Press*.
- Carney, D.; Farrington, J. 1998. Natural Resource Management and Institutional Change. *London and New York: Routledge*.
- Cerne, M. M. 1993. *The Sociologist's Approach to Sustainable Development*. Finance & Development (December): 11-13.
- Cerne, M. M.; Meinen-Dick, R. ND. *Design for Water User Associations: Organizational Characteristics*. In: Developing and Improving Irrigation and Drainage Systems: Selected Papers from World Bank Seminars, ed., Guy Le Moigne; Shawki Barghouti; Lisa Garbus. *World Bank Technical Paper Number 178*. Washington, DC: World Bank. pp. 45-56.
- Coward, E.W. Jr. 1986. *State and Locality in Asian Irrigation Development: The Property Factor*. In: Irrigation Management in Developing Countries: Current Issues and Approaches, ed., K.C. Nobe: R.K. Sampath. *Studies in Water Policy and Management, No. 8*. Boulder, Colorado and London: Westview Press.
- Evans, P. 1996. *Government Action, Social Capital and Development: Reviewing the Evidence on Synergy*. World Development, 24 (6): 1119-1132.
- Fox, J. 1992. The Politics of Food in Mexico: State Power and Social Mobilization. *Ithaca, NY: Cornell University Press*.
- Hardin, G. 1968. *The Tragedy of the Commons*. Science, 162: 1243-48.
- Huppert, W.; Svendsen, M.; Vermillion, D.L. 2001. *Governing Maintenance Provision in Irrigation: A Guide to Institutionally Viable Maintenance Strategies*. Wiesbaden, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), International Water Management Institute, International Food Policy Research Institute and Universum Verlagsanstalt.
- Moore, M. P. 1989. *The fruits and fallacies of neoliberalism: The case of irrigation*. World Development, 17 (11): 1733-1750.
- Olson, M. 1965. The Logic of Collective Action: Public Goods and the Theory of Groups. *Cambridge, MA: Harvard University Press*.
- Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge and New York: Cambridge University Press.
- Ostrom, E.; Schroeder, L.; Wynne, S. 1992. Institutional Incentives and Sustainable Development: Infrastructure Policies in Perspective. *Boulder, Colorado and Oxford, UK: Westview Press*.
- Poteete, A. R.; Ostrom, E. (unpublished). *Institutional Mediation of Group Characteristics and the Consequences for Collective Action*.
- Rogers, P.; Hall, A.W. 2002. Effective Water Governance. *TEC Background Paper No. 7*. Stockholm: Global Water Partnership.
- Shah, T. 1996. Catalysing Cooperation: Design of Self-governing Organisations. *New Delhi, Thousand Oaks and London: Sage Publications*.
- Siamwalla, A. 2001. The Evolving Roles of State, Private, and Local Actors in Rural Asia. *Oxford and New York: Asian Development Bank and Oxford University Press*.
- Smith, L. D. 2001. Reform and decentralization of agricultural services: A policy framework. *FAO Agricultural Policy and Economic Development Series, No. 7*. Policy Assistance Division and Agriculture and Economic Development Analysis Division. Rome: Food and Agriculture Organization of the United Nations (FAO).

- Tendler, J. 1997. *Good Government in the Tropics*. Baltimore and London: The Johns Hopkins University Press.
- UNDP (United Nations Development Programme). 1997. *Reconceptualising Governance. Discussion Paper 2*. New York: UNDP, Management Development and Governance Division, Bureau for Policy and Programme Support. .
- Williamson, O. E. 1996. *The Mechanisms of Governance*. Oxford and New York: Oxford University Press.
- Wolff, B.; Huppert, W. 2000. *Governance by Contractual Rules – Improving Service Relations in Irrigation*. MAINTAIN Thematic Paper 10. Division 45, Rural Development. Eschborn, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

Research Reports

64. *Use of Untreated Wastewater in Peri-Urban Agriculture in Pakistan: Risks and Opportunities.* Jeroen H. J. Ensink, Wim van der Hoek, Yutaka Matsuno, Safraz Munir and M. Rizwan Aslam. 2002.
65. *Land and Water Productivity of Wheat in the Western Indo-Gangetic Plains of India and Pakistan A Comparative Analysis.* Intizar Hussain, R. Sakthivadivel, Upali Amarasinghe, Muhammad Mudasser and David Molden. 2003.
66. *Agro-Well and Pump Diffusion in the Dry Zone of Sri Lanka: Past Trends, Present Status and Future Prospects.* M. Kikuchi, P. Weligamage, R. Barker, M. Samad, H. Kono and H.M. Somaratne. 2003.
67. *Water Productivity in the Syr-Darya River Basin.* Hammond Murray-Rust, Iskandar Abdullaev, Mehmood ul Hassan, and Vilma Horinkova. 2003.
68. *Malaria and Land Use: A Spatial and Temporal Risk Analysis in Southern Sri Lanka.* Eveline Klinkenberg, Wim van der Hoek, Felix P. Amerasinghe, Gayathri Jayasinghe, Lal Mutuwatte and Dissanayake M. Gunawardena. 2003.
69. *Tubewell Transfer in Gujarat: A Study of the GWRDC Approach.* Aditi Mukherji and Avinash Kishore. 2003.
70. *Energy-Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability.* Tushaar Shah, Christopher Scott, Avinash Kishore and Abhishek Sharma. 2003.
71. *Policies Drain the North China Plain: Agricultural Policy and Groundwater Depletion in Luancheng County, 1949-2000.* Eloise Kendy, David J. Molden, Tammo S. Steenhuis and Changming Liu. 2003.
72. *Development Trajectories of River Basins: A Conceptual Framework.* François Molle. 2003.
73. *A Method to Identify and Evaluate the Legal and Institutional Framework for the Management of Water and Land in Asia: The Outcome of a Study in Southeast Asia and the People's Republic of China.* Ian Hannam. 2003.
74. *A Diagnostic Model Framework for Water Use in Rice-based Irrigation Systems.* Wilfried Hundertmark and Ali Touré Abdourahmane. 2003.
75. *Prospects for Adopting System of Rice Intensification in Sri Lanka: A Socioeconomic Assessment.* Regassa E. Namara, Parakrama Weligamage, and Randolph Barker. 2003.
76. *Small Dams and Social Capital in Yemen: How Assistance Strategies Affect Local Investments and Institutions.* Douglas L. Vermillion and Said Al-Shaybani. 2004.

Postal Address:

P O Box 2075
Colombo
Sri Lanka

Location

127, Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Tel:

+94-11 2787404

Fax:

+94-11 2786854

E-mail:

iwmi@cgiar.org

Website:

<http://www.iwmi.org>