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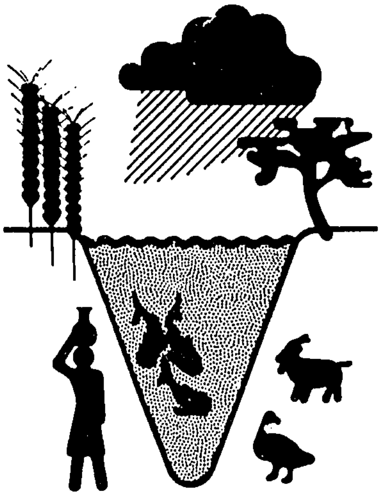
PVO/University Collaboration In Action

THE WATER HARVESTING/AQUACULTURE PROJECT
Cooperative Agreement with AID, FVA/PVC:
PDC-0204-G-SS-4085-00

FINAL REPORT
(October 1984 - September 1989)



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**Give a man a fish and you feed him for a day;
teach a man to fish and you feed him for a lifetime.**

.Chinese Proverb

Photo courtesy of CARE/Bangladesh.

Through the six participating PVOs–Catholic Relief Services, CARE, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children–technical assistance in water harvesting and integrated agriculture and aquaculture was made available to existing projects around the world.

At a refugee camp in Sudan, Save the Children requested technical assistance in water harvesting.

Photo courtesy of SCF Field Staff.

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List of Acronyms

A I D:	Agency for International Development
C R S:	Catholic Relief Services
C W S:	Church World Service
H P I:	Heifer Project International
I C A:	International Center for Aquaculture, Auburn University
L O E:	Level of Effort
L O P:	Life of Project
L W R:	Lutheran World Relief
P V O:	Private Voluntary Organization
S C F:	Save the Children Federation
T A:	Technical Assistance
W H A P:	Water Harvesting / Aquaculture Project
W H I A A:	Water Harvesting and Integrated Aquaculture / Agriculture

Providing five to six day trainings to introduce the concept of collecting water into ponds and exploiting this new resource in an integrated way was the foundation of the Water Harvesting/Aquaculture Project.

This participant in the 1985 Latin America regional training held in Panama displays a sizable catch.

Executive Summary

This report fulfills the final reporting requirements of the Center for PVO/University Collaboration in Development's (PVO/University Center's) Cooperative Agreement with A.I.D., FVA/PVC: PDC-0204-G-SS-4085-00. This five-year activity (October 1984 - September 1989) was undertaken to introduce the technology of collecting rainfall run-off into ponds and exploiting this water resource through fish culture, garden or fruit tree irrigation, livestock rearing, and other appropriate activities which improved the diet, livelihood, and/or environment of the beneficiary population. Perhaps even more fundamental than introducing this technology, however, was an underlying motivation to determine whether the Center could link the technical expertise, research and training capabilities of universities with the community development focus of private voluntary organizations (PVOs).

The Water Harvesting/Aquaculture Project (WHAP) allowed six PVOs to access water harvesting and integrated agriculture/aquaculture technology from Auburn University's International Center for Aquaculture (ICA) through technical assistance and training visits from ICA consultants. In varying degrees, Catholic Relief Services, CARE, Church World Service, Lutheran World Relief, Heifer Project International, and Save the Children, applied this technology to their development interventions in 44 developing countries around the world.

The Center for PVO/University Collaboration in Development (formerly the Joint PVO/University Rural Development Center) was the project holder. The project grew from the interest of the ICA in seeing its technical capabilities applied at the grassroots level to the benefit of the rural poor in the developing world and the PVO/University Center's desire to foster collaboration between universities and PVOs by delivering appropriate technical assistance at the village level. Working together, the PVO/University Center, Auburn and the member PVOs, developed and submitted an unsolicited proposal to A.I.D. which was funded beginning September 1984.

WHAP gradually introduced or expanded on the technology via six four-day to two-week familiarization training sessions during the first two years of project operation. Initial trainings were designed to introduce concepts to decision makers and planners at headquarters, then field staff through regional trainings, and later, project participants looking for answers after having worked with trial ponds. The WHAP Director and Technical Coordinator from Auburn followed trainings with programming visits to inform PVO staff in-country of the benefits available to them through WHAP. Meanwhile, as field projects committed to integrating water harvesting and/or integrated agriculture and aquaculture into their projects, technical experts from Auburn made site visits to conduct feasibility studies and to identify in-country resources for information and backstopping. Field projects were invited to request small project grants of up to $15,000 during project years two and three to integrate the technology into their programming. Once ponds were sited and constructed, consultants returned as needed to train, evaluate, and/or make suggestions for improvement.

WHAP conducted an internal self-evaluation at project end; a report on this final evaluation is

supplied as a companion to this report. When asked what the advantages and disdavantages of having the PVO/University Center facilitate and administer WHAP were, an advisory council member responded as follows:

> "The Center created the mechanism for collaboration in this type of program. ...Coordination and collaboration at the levels achieved in this project are almost impossible to achieve without a catalyst in spite of the rhetoric of most institutions regarding their commitment to collaboration."

WHAP's uniqueness lies in the roles developed for its eight major organizational participants. Each participant had a voice on an advisory council which met as needed and provided major policy guidance. But how the technology was applied was at the discretion of the individual PVOs. The project rested on the assumption that PVOs would adopt the technology, once headquarters staff were introduced to it at trainings, and that eventually, projects in the field would avail themselves of it in the form of feasibility studies, program design, staff and beneficiary training, and ongoing monitoring and evaluation. Auburn University backstopped the project technically under a subcontract from the PVO/University Center. Consultants located at Auburn (or other universities) had the responsibility of corresponding with PVOs and field projects and making site visits as needed and feasible. Their reports were distributed to the field, headquarters, and the PVO/University Center for project tracking. The PVO/University Center served as project holder: it facilitated the collaboration; administered project funds; had responsibility for all information collection/dissemination, monitoring, and evaluation; and provided day-to-day management of overall WHAP activities.

If meeting targeted outputs and inputs are indications of a project's success, WHAP fared very well with over 30,600 known direct beneficiaries, over 4000 persons trained, and over 1500 ponds constructed or improved at a cost of less than $1.5 million dollars over five years. That's an initial cost of about $47 per person if we count only the <u>reported</u> beneficiaries or $948 per pond/food production system if we count only the <u>reported</u> ponds. (Thirty-four projects were assisted to a lesser degree than the seventeen accounted for and did not report numbers of beneficiaries and/or ponds.) In terms of inputs, although only 24 1/4 years of full-time effort were paid for, over 34 person years of effort were leveraged directly by WHAP--<u>not including the manpower of the PVOs</u>. Seven per cent of WHAP funds went directly to field projects in the form of small grants. Technical assistance and training to field projects supplied by the Center and the ICA comprised 42% of WHAP expenses. WHAP spent 12% of its budget on documentation, information, and evaluation which included the costs of the external evaluation in the third year. Indirect costs to Western Carolina University (the home and administrator of the PVO/University Center) totalled 12% of the budget. The remaining 27% covered program development costs for travel to field projects by the project director, the Center's domestic travel to visit A.I.D. and participating organizations to facilitate the collaboration, salaries to support secretarial and budgetary functions, and office supplies and communications costs. Every field report indicated that fish production improved as a result of WHAP and thousands of families improved their diets and/or increased their incomes. Benefit streams from the project are expected to continue as projects expand to encompass new participants and as new water harvesting and integrated agriculture/aquaculture activities are undertaken.

The achievements of individual field projects described in this document are the result of complex collaboration between rural families and several development agencies and institutions. Unlike the more common type of A.I.D.-funded project which is designed to begin and conclude an intervention, WHAP contributed to many development efforts, each at a different stage of development with myriad philosophies and strategies, and supported, to various degrees, by community, national, and international groups. As such, the mathematical quantification of outputs, as a function of the relative impact of each collaborative group would be a laborious, if not impossible, task. We acknowledge that many of the "bottom line" figures cited in this report did not result exclusively from a WHAP intervention. However, we consider that PVO/university collaboration in WHAP brought about results that would not have happened otherwise and were cost-effective. The availability to PVOs of training and technical information on water harvesting/aquaculture reinforced "weak links" in many ongoing projects, and, in other instances, prevented costly and unproductive efforts where water harvesting/aquaculture technologies were desirable but technically unfeasible.

WHAP developed a collaborative management methodology and introduced a valuable technology to the PVO community that they can continue to interject into their programming in most regions of the developing world. The technology is low-cost and works on otherwise nominal or non-productive land. The project was a first, and as such, taught the PVO/University Center many lessons which will be applied to future projects. The final analysis is that formalizing PVO and university collaboration is very worthwhile.

WHAP emphasized flexibility. Some ponds were owned by single families, others by communities, and this one was run by community women to earn money for the primary school and women's health center.

Mirror carp fingerlings are stocked into a rearing pond at a Save the Children project in Bangladesh.

Photo by Alex Bocek, Auburn University

I. INTRODUCTION

The Water Harvesting/Aquaculture Project (WHAP) had its genesis in an unsolicited proposal submitted to and funded by A.I.D. It was designed to address a number of development needs: making available ongoing technical assistance in water harvesting/integrated aquaculture and agriculture to small projects across the developing world, accessing this technology to private voluntary organizations (PVOs); and developing a methodology to support this type of PVO and university collaboration.

The WHAP was managed by the Center for PVO/University Collaboration in Development, formerly the Joint PVO/University Rural Development Center, an organization dedicated to meeting the needs of the poor through collaborative activities. The Center was the project holder: providing management, documentation, information gathering, evaluation and general logistical back-up to the project.

The PVOs carrying out the projects which involved WHAP were: CARE, Catholic Relief Services (CRS), Church World Service (CWS), Heifer Project International (HPI), Lutheran World Relief (LWR) and Save the Children Federation of the USA (SCF). Training and technical assistance were provided by the International Center for Aquaculture of Auburn University. The PVOs and Auburn constituted an Advisory Council for the overall project and the Center provided staff support for this Council.

The scope of the WHAP reached into Africa, Asia, Latin America and the Middle East. Its applications varied according to the needs, environment and capabilities of the beneficiaries. In five years of service WHAP made some type of contribution--training, technical assistance, partial funding or programming help--in 44 countries.

All field projects developed or assisted under the WHAP were funded and managed by the sponsoring PVO. WHAP, through the International Center for Aquaculture of Auburn University (ICA), provided training and technical assistance to the projects as requested by the PVOs. Technical assistance was ongoing and lasted for the life of the WHAP.

The technical assistance, training, management, information and documentation services were funded by A.I.D. All other funding resources for field project implementation came from the PVOs and participating local groups, communities, and host governments. Both Auburn University, through the ICA, and Western Carolina University, through the Center for Improving Mountain Living (the administrative body for the Center) contributed substantial staff time and facilities in support of WHAP. This support was in addition to the funding provided by A.I.D.

The strategy developed by WHAP paid off in substantive field project development. The training and technical assistance plus the excellent support from the PVOs encouraged the development of new projects and the strengthening of existing ones. After five years, eighteen WHAP-related field projects are in operation and 37 others have received feasibility studies, training, project design or short-term assistance.

II. BACKGROUND

In 1981 only 11% of the rural population in 91 developing countries had adequate water supply--a prime requisite for daily life and food production. Yet in many countries, water that could be utilized was wasted and poorly managed. Moreover, up to 30% of rural women's time was spent in the acquisition of water, a heavy burden in time and effort with negative consequences on health and productivity. These statistics were compounded with a generally poor track record in bringing appropriate water-utilization technologies to the village level. The project developers sought to relate the various interests of the participants in addressing the problems of water supply and utilization through the introduction of a well-tested, appropriate water resources development-multiple use strategy. They saw this as an important key to improving village-level conditions and the quality of rural life.

Water harvesting, or the process of collecting and storing water from a variety of sources--mainly rainfall runoff--in ponds for beneficial use, seemed to be a simple way to increase water supply. Pond construction is a practical, relatively inexpensive means, under many Third World conditions, to collect and store water.

A major concern was that the newfound water be exploited to its greatest potential for food production. Long-time advocate of fish as an excellent source of protein, the ICA recommended teaching villagers how to raise fish in the ponds built to collect water. They stressed the flexibility of aquaculture; it may be as controlled or uncontrolled as dictated by the situation.

Some benefits and advantages water harvesting and aquaculture provide are:

- the potential to produce high quality food on poor agricultural land;
- effective water conservation and use;
- low feed requirements relative to those required by other livestock;
- production of a high quality protein source;
- acceptability of a broad range of nutrient sources to fish;
- valuable agricultural commodities;
- drought-proofing irrigation sources;
- raising the water table and enhancing domestic water supplies; and
- integrating fish production with the production of other agriculture and livestock.

Fairly early in the project's implementation, Auburn and the Advisory Council agreed that water harvesting and aquaculture alone were too limiting. With the availability of water, much more than fish culture became possible. Auburn encouraged the adoption of a more integrated approach to include agriculture and livestock raising: the fertile water of the fish ponds being excellent for growing vegetable gardens and the manure of the livestock grown in close proximity to the ponds, an excellent source of nutrition for the fish. This approach was dubbed "WHIAA" (Water Harvesting and Integrated Aquaculture/Agriculture).

A. Circumstances and Conditions Giving Rise to Project

1. PVO Participants - The six PVOs participating in WHAP are recognized within the development community for having excellent skills in grassroots rural development. Though each PVO is unique and has its own mandate, they are all known for their nonpolitical character and long-term commitment especially at the village-level, to the countries in which they operate. Long-term commitment has built trust levels which are essential to project success. Cultural sensitivity, an understanding of the beneficiary populations, hands-on experience, and a willingness to work where it is not always comfortable are all strengths these PVOs bring to the WHAP.

The WHAP grew out of the need expressed to PVOs by people across the world for water supplies to support food systems. Rainfall run-off was a source of water which was not being used to its fullest potential. This water could be harvested and used in a variety of ways which could provide support for food systems. The PVOs lacked sufficient technical expertise needed to either harvest the water or maximize its use. They needed assistance that could be applied flexibly to a diverse set of conditions and project opportunities in a great number of developing countries. Technical assistance (TA) obtained through traditional contracts is often too costly for many PVOs. In addition, this type of consultancy is usually limited to a short time span when what is needed is ongoing TA and guidance. It was recognized that appropriate technical assistance was essential if local capacity and skill were to be mobilized toward designing and implementing multipurpose water and rural development projects.

2. The International Center for Aquaculture of Auburn University (ICA) - At the same time, the conclusion reached by the ICA after 25 years of experience in international development work was that the harvesting and storage of water in ponds and its multipurpose use, particularly in relation to food production systems, is an effective and manageable technology for assisting rural people. The ICA had come to recognize that village-level water harvesting/aquaculture projects with technical assistance provided to grassroots beneficiaries in the context of long-term PVO support were more likely to be self-sustaining and replicable than those initiated at the ministerial or provincial level.

3. The Center for PVO/University Collaboration in Development (Center) - The Center was organized in 1979 to bring about collaboration in development between universities and PVOs. Its institutional membership was comprised of fourteen PVOs and nine universities at WHAP's outset, all committed to collaboration in rural development. Each member brings special strengths to the network. The staff of the Center, widely experienced in international development, understood the strengths characteristic of both communities and contributed conceptual and proven management skills. A series of meetings between interested PVOs, ICA and the Center, in which the Center acted as facilitator and catalyst to explore ways of working together as partners in a collaborative project, resulted in the development of a proposal for A.I.D.

4. The Agency for International Development - The Office of Private and Voluntary Cooperation of the Bureau of Food for Peace and Voluntary Assistance and the Bureau of Science and Technology were interested in the benefits of PVO and university collaboration, the improved extension of aquaculture technology to the local level, and improving the development impact of PL 480 (Food for Peace) resources. They saw WHAP as an innovative way to use PL 480 resources to support the development of field projects.

B. Issues, Questions and Conditions for Project Development

Some of the issues which surfaced in the early meetings were:
(1) How to address the critical need for new water resources for household and productive use across a wide variety of countries, regions and environments in the developing world;
(2) How to maximize the use of scarce resources to provide for technology transfer where it is most needed, on the village or "primary use" level;
(3) How to manage a collaborative project in which it is essential that the PVOs and the universities relate as peers with all parties having equal input into strategy and implementation;
(4) How to inform PVO personnel in the field of this useful integrated water harvesting/aquaculture system so they would consider it a developmental tool in their countries and areas of activity; and
(5) How to demonstrate that it is both feasible and practical to use the expertise available in universities to provide technical assistance to PVO projects at the local level.

C. Expressed Needs of Participants

First, the participants in the planning meetings recognized that the ICA offered the kind of expertise in water resources development and multipurpose water use, especially relating to food production systems, that could be applied as a practical strategy for rural development.

Second, there was an expressed intent of the group to maximize resources already available from each participating organization. They decided funding from WHAP would be used only to meet critical areas of need, such as training, technical assistance and facilitation of field projects.

Third, there was a need for an orientation program for PVO decision makers and program personnel both to give them an understanding of water harvesting/aquaculture as a strategy for development and to seek their support for the proposed collaborative effort. An orientation program was carried out along with subsequent training programs for PVO headquarters staff and field personnel.

D. Project Planning and Organization

The group collectively developed a plan and proposal for a project called "Water Harvesting/Aquaculture--A Core Intervention in Rural Development" (WHAP). An Advisory Council, made up of representatives from all the participating organizations, was established. The Center was designated as manager of the project, ICA as primary technical assistance provider and the PVOs as the implementers and managers of the field projects. The Cooperative League of the USA (CLUSA), now the National Cooperative Business Association, and SECID-CWID (Southeast Consortium in International Development-Center for Women in Development) were participants in the project at the outset. CLUSA's role, in addition to having field projects, was to provide training of village groups/cooperatives in project management. CLUSA in cooperation with HPI did develop two projects in Indonesia but the management training was never realized and CLUSA never became a full-fledged member of the Advisory Council. SECID-CWID agreed to assist in the gathering of gender-specific, baseline data for field projects in an effort to assure full inclusion of women in the project. Through SECID, Beth Schmidt, an intern from the University of Kentucky, provided 136 days of in-field service with an HPI project in Thailand testing the data collection instrument. With the data collection system under criticism by the Advisory Council, however, this component was eventually abandoned after the second year. (This will be discussed further in Section III. Monitoring and Evaluation.) Similarly, the use of PL 480 resources as incentive to participate in the project, another original component of the project, did not come to fruition.

E. Local Resources

The primary resources available locally for project implementation were those from the PVOs, local participants, and host governments. Both PVOs and host governments provided personnel, materials, equipment and finances. These would provide the bulk of the resources needed for project implementation. Communities and local groups provided labor, local materials, and some cash. In addition, the PVOs provided both field operational experience and the organizational network for field projects. Assigning a dollar figure to these inputs was nearly impossible since the field projects participating in WHAP were located in over forty countries and the levels of involvement were so diverse, and water harvesting/aquaculture projects were generally components of larger projects.

F. Funding

External funding was needed to provide support for the technical assistance, training and other support and a mechanism for their delivery to a wide range of participants. An unsolicited proposal was developed and submitted to the Agency for International Development. Funding was approved and provided jointly by the Office of Private and Voluntary Cooperation (Bureau for Food for Peace and Voluntary Assistance) and the Bureau for Science and Technology. WHAP as a funded activity began in October of 1984 although the effective date of the grant was July 1, 1984. The funding was for three years with two more years of funding possible following an external evaluation. That evaluation was conducted in the third year and as a result the project was funded for another two years. At that time, the funding status was changed from a grant relationship to a "cooperative agreement."

III. APPROACH

A. Collaborative Management Methodology

The most novel feature of the Water Harvesting/Aquaculture Project is its approach to combining diverse but complementary resources in a collaborative mode that would be sustained throughout the life of the project. The project's aim was to use these resources to address, effectively and efficiently, problems of rural development.

The collaborative process involved the assistance of experts from Auburn University as well as other universities. Much of Fred Bates' (the University of Georgia) and Beth Schmidt's (an intern from the University of Kentucky) support was supplied on a volunteer basis. These two consultants were instrumental in developing the baseline data collection and evaluation systems. Nancy Glover of the Nitrogen Fixing Tree Association at the University of Hawaii piggybacked a trip to CARE-Bolivia's project onto a trip to Costa Rica for another project to consult on nitrogen-fixing trees; and several consultancies were supplied by the University of Arkansas at Pine Bluff through a memorandum of understanding with Auburn University.

Over five years of collaborative management, the participants learned a great deal from one another and developed a respect for each's mandates and styles. The Center's approach of ensuring the participants the freedom to make decisions seemed to be the key to building mutual trust and a sense of project ownership. The Advisory Council provided a forum for discussion of project direction by those most involved. Frequent consultation with the Council assured the participants that it was, in fact, they who guided the project. Equally important, an unwillingness on the Center's part to make decisions for the Advisory Council served to insure WHAP's collaborative nature. The Council will be discussed further in Section V. E.

We have been told many times that decision by Council does not and will not work. This was not the case in WHAP. Now the Center can plan future projects knowing that the methodology will work if all involved are committed. We firmly believe that managing projects in a non-participatory manner would alienate project partners and preclude any true collaboration. That management style creates a "buyer/seller" mentality which is completely foreign to the Center's mandate of bringing the university and PVO communities together in a peer relationship. The collaborative management methodology is discussed further in Section VII. G. Policy Implications.

B. Project Design Strategy

In keeping with WHAP's collaborative management focus, the project was designed to be responsive to the requests of the participating PVOs in the field and to coordinate or relate those requests to the specific abilities of the ICA. This allowed the project to react quickly and efficiently. The Advisory Council was central to stimulating and reviewing field requests and, afterwards, monitoring the responses.

WHAP orientation trainings were implemented at the outset of the project specifically to introduce the WHIAA concept into the PVOs' programming spectrum. This training was the prerequisite to designing field projects. From top PVO officers, programming policy makers, to field staff--the goal of the training was to generate an understanding of the technology of the project so that requests for technical assistance were informed and appropriate. The strategy was to educate PVO staff at every level to ensure ongoing understanding and best utilization of the project's resources.

Once informed, PVO participants were encouraged to seek TA to determine the feasibility of using water harvesting as a means of providing new water resources to support food systems. The Project Director made many programming visits (75 person days) to inform PVO field offices of the availability of assistance. They were encouraged to request training and technical assistance from ICA for rural projects, a resource to which they would not ordinarily have had access. PVO projects were required to have the support of local organizations and groups to be considered eligible for WHAP assistance. Lastly, a way to monitor and self-evaluate the WHAP effort was designed.

C. Goal and Purposes

The original project goal was to improve the quality of rural life in selected developing countries through the introduction of improved technology in ways that will balance the local capacity for development with community needs and potentials. Sub-goals were (1) To design, implement, and evaluate a process and strategy of development using water harvesting/aquaculture as the core intervention and accelerator of rural development, and (2) To design, implement, and evaluate a collaborative management methodology involving PVOs and universities in the development of new techniques and strategies for delivering technical, organizational, and material resources for development.

Although the concept of "core intervention" did not persist in the project, the idea that water resources development and mulitpurpose strategies for its utilization would act as facilitators and accelerators of a sequence of rural development activities and generate other projects was given root in the opened-up characterization of the project as "Water Harvesting and Integrated Aquaculture/Agriculture." The idea that the introduction of new and/or improved water resources could serve as the catalyst for new food production, conservation and natural resource management, and income-generating activities--a core intervention in the language of project planners--proved too difficult to demonstrate given the operational demands on the PVOs and their project partners and the limited resources available for evaluation in the project budget. A streamlined baseline survey was in process when the evaluation budget was cut back further. An additional complication was that many of the projects assisted by WHAP were already in a mulitpurpose stage, a type of core process already, and the WHAP elements represented only another component.

The following purposes are taken directly from the original logical framework:

- To design and implement a series of field projects that would be directed toward:
  a. Moving villages toward self-sufficiency in water for household use, stock watering, garden irrigation, and where appropriate, drinking.
  b. Villages developing fish production through aquaculture for family consumption and marketing to:
    - Provide effective delivery and utilization of water harvesting/aquaculture technical assistance and other resources by linkage with PVOs and local groups to stimulate local resource commitment and participation and skills acquisition.
    - Identify and develop new and innovative strategies/methods of utilizing technical assistance, management, and material resources, including Food for Peace resources, to solve key development problems.

D. Inputs and Resources

Complementing the A.I.D. funding, the following types of resources and organizational structures were part of the WHAP:

1. <u>PVOs</u>
The six private and voluntary organizations (PVOs) had grassroots, firsthand knowledge and long-term commitment to working at the local level in organization, project management and stimulating local resources. This included financial, material and human resources. They had

networks of institutional arrangments with host governments, local groups, organizations and communities that facilitated the identification, design, and implementation of field projects. Each of the participating PVOs committed their funds and personnel to WHAP. Although expenditures specific to WHAP were difficult to extract from records of combined projects, all PVOs expended tens of thousands of dollars in per diem and travel costs for sponsoring trainees (sometimes staff, sometimes not), in-country costs for the ICA technical consultants, and the costs of field project preparation and implementation and support. (PVO costs are discussed further in Section VII, A. 2. PVO Costs.)

2. <u>The International Center for Aquaculture, Auburn University</u>
The International Center for Aquaculture had the technical knowledge, international experience and commitment to assist PVOs in rural development projects. In addition to the funds committed to ICA by WHAP subcontract, ICA used its Cooperative Agreement with A.I.D. and a Memorandum of Understanding with the University of Arkansas at Pine Bluff. Funds from these and other sources supplemented the WHAP funding. Auburn estimates that over the life of the project, it contributed up to $90,000 in matching funds.

3. <u>The Center for PVO/University Collaboration in Development</u>
The Center for PVO/University Collaboration in Development had the administrative capability, linkages with PVOs and universities and the experience necessary to administer WHAP. The Center managed the overall project, maintained the WHAP Project Office and provided staff and logistical support. In addition, it was able to leverage technical resources from other universities.

4. <u>The WHAP Advisory Council</u>
The Advisory Council, made up of members from each participating organization, provided for information exchange, input, and guidance in the project. With very few exceptions, Council members paid their own expenses to attend the fourteen meetings held during project operation. The same was true of the many meetings held for project development.

5. <u>Community/Local Groups</u>
The community and family pond owners participating in WHAP made considerable inputs in land, labor, local materials, cash, and organization through village development groups, cooperatives and development committees. These organizations provided day-to-day management of the project, encouraging project sustainability and replication.

6. <u>Host Governments</u>
Host governments provided extension services, allowed agents to attend trainings as participants or assistant trainers, and provided land for pond sites.

7. <u>PL 480</u>
During the WHAP design phase it was assumed that there would be a significant role for the use of PL 480 resources through Food for Work activities to construct ponds, dig wells, build irrigation facilities, plant trees and carry out other conservation activities. The principal programmers of food assistance such as CARE and CRS indicated strong prospects for using PL 480 as a project resource. At the same time, both the A.I.D. bureaus involved in WHAP, Food for Peace and Voluntary Assistance and Science and Technology, expressed interest in developing new and innovative ways to employ PL 480 resources. The decision to use PL 480 rested with the individual PVOs participating in WHAP. However, as WHAP projects were implemented there proved to be only minor, occasional use of PL 480. The PVOs preferred to wait and see how projects developed, to see how best to use it. Most PVO field project managers concluded it was not needed as an incentive.

IV. MONITORING AND EVALUATION

A. Monitoring

It was originally intended that field project monitoring and evaluation be carried out by the PVOs on their own projects, using their regular processes with minor adjustments. These adjustments were not expected to require additional PVO funding or staff. However, their monitoring methods were tailored to meet their needs which were not always compatible with those of WHAP. In addition to A.I.D.'s standard reporting requirements, even more detailed data was desirable if the project was to serve as a model for similar endeavors in the future.

Project activities were monitored by the following means: advisory council meetings were minuted; records of WHAP were stored in a data base providing project inputs including training and site visits for programming, technical, or evaluation purposes; field office progress reports were solicited; the external evaluation conducted in the third year contributed information; and the final collaborative evaluation provided qualitative reactions from Council members and selected field projects. Trainings were in almost every case followed up with trainee evaluations. These monitoring records and evaluation reports provided nearly all the information for this report. (Project results are largely summarized in Section IV. Review and Analysis of Project Results.)

The critical indicator of effectiveness is the response shown to the project in the field. PVOs with no past experience with water harvesting or integrated aquaculture and agriculture implemented WHIAA projects, and in some cases, hired specialists exclusively for this new intervention (HPI-Indonesia, Thailand and Sierra Leone and CARE-Guatemala).

An effort was made to have field projects complete a three-page progress report (See Attachment A) on a semi-annual basis which received sporadic responses at best. Collecting baseline information and monitoring outputs, such as number of beneficiaries and kilos of fish produced, proved to be an equally difficult task. Our final analysis is that degree of reporting was simply an unreasonable request to make of field project staff given the, relatively, modest level, for most, of WHAP input into ongoing projects. Out of 56 projects visited, thirteen received three or more visits from WHAP. Those projects that received no more than two technical consultations generally did not feel compelled to spend a great deal of time on reporting detailed project progress, regardless of how they benefitted from the visits. Furthermore, the tiers of communication from the Center to field projects proved too removed for the Center to pose many demands on these projects. Those projects which adopted the technology wholeheartedly and received more inputs, as a result, were more cooperative in providing information. WHAP interventions were combined with many other projects further complicating the challenge of reporting outputs. Solutions to this problem are discussed in "Section VIII. Recommendations."

B. Evaluation

In all, 217 person days of effort (not including staff and volunteer time at the Center) were contributed by the Center and volunteers in evaluation during the first two years of project operation.

The initial grant required a third year external evaluation of WHAP. A team comprised of Dr. Anson R. Bertrand and Dr. John Oleson working for Checchi and Company Consulting, Inc. conducted the evaluation and the Project Director, Nancy Blanks, acted as facilitator. The evaluators met with all participants, visited the Center and the ICA, and spent a week visiting a project in Indonesia and five days visiting a project in Guatemala. They paid particular attention to the attitudes of the participants toward the overall WHAP effort and attitudes toward PVO/university collaboration. They also assessed WHAP's effectiveness in meeting the needs of the PVOs and future needs for training and technical assistance.

A major outcome of their evaluation was the elimination of the evaluation component of the project. Considerable effort had been asserted in developing a baseline data collection system which would aid in assessing the project's impact at the end. The general conclusion of the participants and the evaluators was that such an extensive data collection effort was unwarranted given the extent of WHAP's involvement with most field projects. Another recommendation of the evaluation team was that if further funding cuts had to be made that the Project Support Fund be discontinued.

Because of the Advisory Council's desire to have some kind of field impact study despite the discontinuation of funding for the evaluation component, they proposed a collaborative internal, final evaluation. Each thought such an assessment could go further than merely determining the value of WHAP to the field project being reviewed, to assess the impact on the entire organization involved. They believed that allowing one another's organizations to participate in standard evaluations and seeing firsthand how other projects are managed would be valuable in and of itself. To both the Center and the Council, this decision represented a show of trust, further validating that effective collaboration had taken place.

A scope of work for the evaluation was developed and revised several times following its introduction to A.I.D. at a meeting on April 13, 1988. It reiterated project goals and purposes and outlined key issues the Advisory Council wanted to address.

The approach was not intended to a be a formal, thorough impact assessment of the total WHAP effort. Six field projects in varying levels of development ,which had received varying levels of assistance, were selected to conduct an evaluation of WHAP's impact on them. At the same time, the Advisory Council completed a brief questionnaire. The Center has now compiled the results in an orderly way and combined them with monitoring information collected over the years. (See companion report: WHAP Final Evaluation Report.)

V. REVIEW AND ANALYSIS OF PROJECT RESULTS

A. Training

Many four-day to two-week training sessions for participating PVO administrative and field program staff were held during the first three years of WHAP to acquaint them with the general concepts of water harvesting and aquaculture, and to give them the opportunity to interact with trainers and arrange for possible follow-up technical assistance at their sites. In fact, a pre-project training was held at the ICA in 1983 providing the impetus to begin planning WHAP. The target in the original logical framework was to train eighteen PVO international staff in the U.S. There were 35 participants in three U.S. trainings, 29 of whom were PVO international staff. There were also nine in-country sessions for field personnel and local leaders interested in the possibilities of water harvesting. Participants acquired the background information necessary to make preliminary project designs, site identification, and assessments. Training materials were developed by the ICA for each training including the training in French for francophone West Africa.

The original target for the first three years was to train 320 individuals, including village leaders, working at the country or field level in project countries. WHAP trained 14 U.S. PVO staff, 94 PVO field staff, 22 counterpart staff, 24 village trainers, and 10 individuals from Peace Corps, local governments, or other interested agencies for a total of 164 individuals. Additionally, short project-specific trainings were held upon request during technical assistance visits. These individuals went on to train over 4,000 others at the community or local level.

Forty countries were represented at WHAP's water harvesting, aquaculture and integrated agriculture trainings. Twenty-one of those countries were in Africa, eight in Asia, ten in Latin

America, and USA headquarters trainees bring the total to forty. Trainees attending from host countries were mostly persons who had supervisory or technical responsibility for water harvesting/aquaculture activities. Nine trainings were held overseas in Panama, Rwanda, Indonesia, Cameroon, Senegal, Bolivia, Thailand, Nepal and Morocco. Three trainings were conducted in the USA. At the request of SCF/Bangladesh, a special one-week course at the ICA was designed and executed in July 1987 for a Bangladeshi technical staff person. A WHAP consultant also contributed to two CRS trainings held in India.

It has become clear that almost without exception, the most vital WHAP field projects were under the leadership of staff who were introduced to the WHIAA concept at a WHAP training. The major output of this project was intended to be the formation of human capital for the improvement of human life. Training and technical assistance were at the center of the project, complemented by the implementation and project delivery capabilities of the PVOs. Over the life of the project, the ICA provided 198 person days of effort in training (not including preparation time). A summary of WHAP-sponsored trainings follows.

TABLE 1: WHAP-SPONSORED TRAININGS

REGIONAL TRAININGS	Trainees	WHAP P. Days	Participating PVOs	Countries Represented
South and Central America/Caribbean (PANAMA 85)	18	12	CARE, CRS, HPI, LWR, SCF	10
Asia/Pacific (INDONESIA 85)	17	15	CARE, CLUSA*, CRS, HPI, LWR, SCF	7
East Africa (RWANDA 85)	15	26	CCF*, CRS, HPI, LWR, SCF	6
West Africa (CAMEROON 86)	15	30	CARE, CRS, CWS, HPI, LWR, SCF	8
Francophone W. Africa (SENEGAL 87)	13	18	CRS, CWS, HFH*, HPI, LWR	4
CRS N. Africa and MiddleEast (MOROCCO 89)	10	5	CRS	5
COUNTRY-SPECIFIC OR U.S. TRAININGS				
US 83	12	30	CARE, CCF, COMP.*, CRS FAR.*, HELP.*, HPI, MFM*, NEF*, SIFAT*	5
US 84	13	24	CARE, CCF, ECHO*, HPI, SBC*	6
US 86	8	10	CARE, OICI*, SCF	3
US 87	1	6	SCF	1
BOLIVIA 88	23	6	SCF	1
NEPAL 88	8	12	SCF, CARE	1
THAILAND 89	11	4	SCF	1
13 Trainings	**164**	**198**	**18**	**40**

** "CLUSA" is the Cooperative League of the USA; "CCF" is Christian Children's Fund; "ECHO" is Educational Concerns for Hunger Organization; "HFH" is Habitat for Humanity; "COMP." is Compassion; "FAR." is Farallones Institute; "HELP." is Helping Hand Rescue Mission; "MFM" is Meals for Millions; "NEF" is Near East Foundation; "SBC" is the Southern Baptist Convention; "SIFAT" is Servants in Faith and Technology; and "OICI" is Opportunities Industrialization Centers International*

B. Technical Assistance

One hundred and fourteen visits were made to 56 field projects in 29 countries either for programming, evaluation, or technical assistance purposes involving 937 person-days of effort. This is the equivalent of over four person years of effort in direct technical assistance (using 232 as the number of working days in a year). This does not include the level of effort applied for project support at Auburn or at the Center for PVO/University Collaboration in Development. At the PVO's request, TA from the ICA was designed as a backstop to provide PVO field staff with skills and knowledge necessary to advance beyond project preplanning and preliminary site assessment. The assistance normally consisted of visiting field sites with local PVO staff, farmers, and other interested local people. Based on observations and on-the-spot analysis, the ICA experts prepared trip reports, containing site descriptions and background information and summarizing observations and recommendations made in the field by ICA consultants, which were shared with colleagues at ICA, the Center, PVO headquarters, and PVO representatives concerned in the developing countries. Technical information in the form of publications, reprints and other materials was also included. To use funds in the most efficient manner possible, visits were almost always "piggy-backed."

In each case a trip report with the recommendations for the project was prepared. TA visits to a given country often represented a follow-up of a visit made during previous years. In contrast, some TA visits were made to determine the feasibility of initiating a water harvesting project. If an area were deemed unsuitable for physical, technical, or cultural reasons, of course a follow-up visit was unnecessary. Being advised not to initiate an inappropriate project was just as important as receiving advice on project management.

All participants agreed that the possibility for ongoing technical assistance, often from the same consultant, was a significant benefit of a long-term collaborative project. The following chart more graphically illustrates the project's efforts to provide on-site assistance.

TABLE 2: TECHNICAL ASSISTANCE VISITS

VISITS/LOE:	Technical	/P. Days	Prog.Dev.	/P. Days	Eval.	/P. Days	Total Visits	/P.Days
CARE								
Bangladesh	1	10					1	10
Bolivia	7	71	1	9	1	12	9	92
Congo	1	10					1	10
Dominican Republic	1	6					1	6
Ethiopia	1	7					1	7
Guatemala	5	54			1	5	6	59
Kenya	1	13	1	3			2	16
Lesotho	1	2					1	2
Nepal	2	24	1	2	1	12	4	38
Peru	1	8					1	8
Somalia	1	7	1	2			2	9
Sri Lanka	1	19					1	19
12 countries	23	231	4	16	3	29	30	276
Catholic Relief Services								
Dominican Republic	1	8					1	8
Ecuador	1	1					1	1
Egypt	2	21	1	4			3	25
Guatemala	1	1					1	1
Honduras	2	16					2	16
India	3	34					3	34
Indonesia	2	5	1	3			3	8
Kenya			1	3			1	3
Panama(2)	1	8	1	9			2	17
Senegal	2	10	1	2			3	12
Somalia			1	1			1	1
Thailand			1	5			1	5
12 countries	15	104	7	27	0	0	22	131
Church World Service								
Indonesia	1	2					1	2
Kenya			1	2			1	2
Lesotho	1	7					1	7
Senegal	3	12	1	2			4	14
Somalia			1	2			1	2
Zaire			1	2			1	2
6 countries	5	21	4	8	0	0	9	29
Heifer Project International								
Cameroon			1	2			1	2
Indonesia(2)	6	52	1	3	2	47	9	102
Sierra Leone	2	20					2	20
Thailand	5	28			2	130	7	158
Uganda	1	10					1	10
Zaire	1	13	1	3			2	16
6 countries	15	123	3	8	4	177	22	308

VISITS/LOE:	Technical /P. Days		Prog.Dev./P. Days		Eval./P. Days		Total Visits/P.Days	
Lutheran World Relief								
Kenya			1	2			1	2
Papua New Guinea	1	9					1	9
Tanzania*	1	12					1	12
3 countries	2	21	1	2	0	0	3	23
Save the Children								
Bangladesh	3	14					3	14
Bolivia	2	13					2	13
Cameroon			1	1			1	1
Indonesia	1	2	1	2			2	4
Nepal	3	40	1	2	1	12	5	54
Somalia	1	5	1	1			2	6
Sri Lanka	1	7					1	7
Sudan	2	24					2	24
Thailand	3	27					3	27
9 countries	16	132	4	6	1	12	21	150
Other								
Africare/Somalia	1	3					1	3
ECZ/Zaire			1	2			1	2
FPP/Indonesia	1	1					1	1
LP3ES/Indonesia	1	2					1	2
OICI/Ivory Coast	1	4	1	5			2	9
OICI/Togo	1	3					1	3
5 organizations	5	13	2	7	0	0	7	20
TOTAL	**80**	**645**	**25**	**74**	**8**	**218**	**114**	**937**
56 projects								
29 countries								
11 organizations								

* *Tanzania was not an AID-funded country, hence, LWR paid the cost of this consultancy.*

C. Project Support Funds

The Project Support Fund was devised to fill funding gaps insuring that high quality projects would not falter due to lack of relatively small amounts of money at critical times. Five simple criteria were developed in cooperation with the Advisory Council and A.I.D. for proposals requesting up to $15,000 in seed money:
(1) The proposal must be submitted by someone who had attended a regional WHAP training.
(2) The project had to have received technical assistance from WHAP.
(3) Water harvesting and integrated activities were central to the project.
(4) The project was comunity-based and directed toward low-income families.
(5) The project was likely to promote further development activities.

In FY 85-86 and 86-87, nine projects were awarded project support funds totalling $98,635. The external evaluation in the third year recommended discontinuing the project support grants due to funding reductions. An account of how grant monies were used follows.

FY 85-86

($15,000) CARE-Bolivia used its grant to support Phase I of a community-based technical assistance pilot project in renewable resource management. The project area, Tarija, is in a semi-arid mountain valley where rainfall is seasonal and erosion is a severe problem. This project promoted integration, including: aquaculture, duck-raising, irrigating fruit trees and brick-making. Funds were used to build four ponds in three communities, to hold a staff workshop, and to hire a promoter to provide TA and extension to existing water harvesting projects.

($5,341) CRS-Honduras assisted the community of Muyen, department of La Paz, located about 280 km west of Tegucigalpa in an area primarily suited to coffee production, to revive an aquaculture project. Their objective was to improve the nutritional level of the local population as well as to make the community more self-sufficient. Funds were used for the first year's fish food concentrate and to cover construction and equipment costs to reconstruct two 20,000m^2 ponds for 365 beneficiaries (43 families). These villagers were virtually isolated from other work and food sources due to their mountainous location.

($7,100) CRS-Panama assisted a pilot aquaculture and integrated agriculture project at the Tole Missional Center. Funds were requested to help replicate an existing, successful project at the community level. Tole is one of Panama's most backward districts; income is low and malnutrition and poor health conditions are serious problems for this region largely inhabited by Guaymi Indians. The project was directed at 240 families in 20 communities. Funds were used for hiring a technician and start-up costs. As a result of this initiative, 225 family ponds were constructed.

($7,042) CRS-Panama also requested and received a grant for another project in the Province of Veraguas. The land there is poor and semi-arid and many men are forced to become itinerant laborers for part of the year because they cannot make the land support their families. CEPAS, a local organization, used funds to implement a project in an area where they had previously provided educational and technical assistance. Ten communities, comprised of 150 families, were targeted to raise tilapia, pigs, and ducks in an integrated system. Tilapia ponds were constructed in each community totalling 24 ponds while two larger ponds (1,500m^2 each) were constructed for demonstration and training. After two years, over one hundred people were instructed at the Center.

($14,500) SCF-Nepal received funds to provide training, construct two ponds, and expand existing irrigation facilities as part of their ongoing water-harvesting project in the Ghorka District. Three new irrigation projects were completed using these funds. Four-hundred and seventy-one people have benefitted directly from this project. Twenty-three hectares now receive irrigation and are able to produce a broader array of crops.

($5,285) SCF-Zimbabwe assisted the impact area of Muusha, located in the highlands south of the capital city of Harare. Funds were granted to revive two abandoned fish ponds where a community cooperative was already active and simply awaiting financial assistance to begin work. Funds covered the costs of training, storeroom construction, consultancies and start-up. They established cooperative fish ponds and provided training in fish pond management and in integrated agricultural methods. Twenty families participated with indirect beneficiaries numbering 160. Ponds have a total surface area of 980m^2.

FY 86-87

($15,000) The HPI-sponsored project in Thailand for the Karen people had received technical assistance from WHAP the two previous years. Funds were used to pay the salary of a temporary full-time consultant for village aquaculture and integrated agriculture projects. Six ponds at the

Center for the Uplift of the Hill Tribes (CUHT) are used for aquaculture training. Both long courses (six weeks) and two-day seminars were provided there. Four hundred and forty-seven students attended trainings and many other families received consultant visits.

($14,867) SCF-Bangladesh sponsored the Kunda Pond Cultivation project in the Nasirnagar District. Funds were used to develop a two hectare community pond for fish culture which provides protein, income, and an area training site. The Boriachong Aquaculture Project funds a health center which serves a population of 8,500 villagers and a primary school which serves 1156 families. Villagers in this area also benefit by the employment generated by the ponds. On-going training is also being provided in anticipation of transferring total responsibility for the ponds to the villagers in a few years.

($14,500) CRS-India assisted approximately 118 landless families in the Vaivaka area of Manuguluru, state of Tamil Nadu, who organized into cooperatives to manage ponds on land leased from the Bishop of Vijayawada and donated by the state government. The project area is located in the low lying coastal area near the Bay of Bengal. The fish culture project utilized funds to build and support two ponds during the first year of operation.

D. Field Projects

The first project purpose was to design and implement a series of field projects which would increase the quality and quantity of water and food supplies. It is important to note; however, that WHAP cannot really take credit for <u>any</u> field projects. They represent the resources and labor of many families and communities, many committed field staff, and PVO headquarters staff. WHAP's role was to strengthen the weak links. Assistance at a critical point could have been the push a project needed to be a success.

Field projects took on many forms: from training centers in Thailand and Sierra Leone (HPI) and Zimbabwe (SCF); to individual ponds for small farmers in Nepal (SCF); to a community project to earn money for a women's health care clinic in Bangladesh (SCF); to an integrated aquaculture program responsible for over 800 ponds in Guatemala (CARE); to a mulitpurpose project involving ponds, fish culture, fruit trees, watershed management, and brickmaking in Bolivia (CARE).

Defining a field project has not been easy. For example, with only one technical assistance visit to Lutheran missionaries in Tanzania and previous training of a Lutheran staff person at ICA, project reports indicate that constructing ponds and raising fish caught on. Diffusion of the technology occurred rapidly and spontaneously to adjacent villages without the intervention of the project technician. Monitoring project progress even by the missionaries on-site proved impossible. Accordingly, our definition of WHAP-assisted PVO field projects includes those projects in which there has been significant WHAP involvement, sustained and/or expanded operation of WHAP activities over time, and continuity in reporting and contact with the Center and/or ICA. The extent of WHAP inputs varies from project to project but will generally include a combination of two or more WHAP inputs (training, technical assistance, program support, and/or project support funds). Field-level activities which did not generate ongoing projects and which lacked sustained contact and reporting between WHAP and the in-country PVO and are, therefore, not considered field projects for the purposes of this report. Sites are communities, areas, or local groups participating in WHAP. A site may be a demonstration and training center, a cooperative, or communal undertaking, or individual farm families in a given area receiving project assistance. Several individual farms or households in a community or area are considered as one site. In general, a site would not be an individual household or farm pond unless it were the only one in the area.

In all, by August 1989, there were eighteen "field projects" and 176 "sites", substantially exceeding the planned targets of nine field projects and 27 sites. Over 1500 ponds were constructed or improved. Project beneficiaries to date have exceeded 30,000. These are conservative figures based on project and site visit reports and do not reflect fully the replication of WHAP activities to new areas or activities in countries for which we lack reports from PVOs. We have scattered reports of fish production. The training ponds in HPI/Sierra Leone's project report selling 1,561 kilos of fish in the 1988-89 year. That is about 104 kilos per each of their fifteen ponds. They report that 4000m^2 is now in fish production with more ponds planned or under construction. HPI/Thailand reported in the 87-88 year that their 38 group/family ponds produced an estimated 1688 kilos of tilapia and carp. Most of their ponds were in the first or second growing cycle at that report. CARE/Guatemala has more production data than any WHAP project and reports that at the project's close in 1989, the total fish production from all participating ponds (800+) was over 45 tons. Of that amount, 38% were sold, 48% were consumed by pond owner families, and the remaining 14% was either used for restocking or traded for work. All reports from field projects associated with WHAP consistently indicate increased production due to WHAP involvement and very little pond abandonment.

The following chart provides a summary of all PVO field projects which received technical assistance visits and/or training or support funds. The information supplied indicates to some extent what impact these projects are having in their communities and what input WHAP had into that contribution. Output information was drawn from progress reports, TA trip reports, and other documents.

TABLE 3: WHAP FIELD VISITS RELATED TO OUTPUTS

	Stage of Development[1]	Sites[2]	WHAP Visits	WHAP P.Days	Ponds Constructed or Improved[3]	Trained On Site[4]	Direct Beneficiaries[5]
CARE							
Bangladesh√	1	----	1	10	----	----	----
Bolivia†$√	3	7	9	92	8	600	3000
Congo√	1	----	1	10	----	----	----
Dominican Republic√	1	----	1	6	----	----	----
Ethiopia√	2	----	1	7	----	----	----
Guatemala†√	4	46	6	59	812	1227[6]	9000
Kenya	2	----	2	16	----	----	----
Lesotho	1	0	1	2	0	0	0
Nepal√	2	2	4	38	----	----	----
Peru√	1	----	1	8	----	----	----
Somalia	2	0	2	9	0	0	0
Sri Lanka	1	----	1	19	----	----	----
12 countries	NA	55	30	276	820	1827	12000
Catholic Relief Services							
Dominican Republic	1	----	1	8	----	----	----
Ecuador√	2	----	1	1	----	----	----
Egypt√	2	----	3	25	34	----	----
Guatemala	1	----	1	1	----	----	----
Honduras$√	2	1	2	16	6	40	365
India$√	3	2	3	34	2	118	708
Indonesia†√	3	1	3	8	8	60	300
Kenya	1	----	1	3	----	----	----
Panama√			2	17			
(Tole)$	4	20			225	240	1200
(Canazas)$	4	25			49	256	1280
Senegal√	3	----	3	12	----	----	----
Somalia	1	----	1	1	----	----	----
Thailand√	1	----	1	5	----	----	----
12 countries	NA	49	22	131	324	714	3853
Church World Service							
Indonesia	1	----	1	2	----	----	----
Kenya	1	----	1	2	----	----	----
Lesotho†	1	1	1	7	5	----	----
Senegal√	3	----	4	14	3	50	500
Somalia	1	----	1	2	----	----	----
Zaire	1	----	1	2	----	----	----
6 countries	NA	1	9	29	8	50	500

	Stage of Development[1]	Sites[2]	WHAP Visits	WHAP P.Days	Ponds Constructed or Improved[3]	Trained On Site[4]	Direct Beneficiaries[5]
Heifer Project International							
Cameroon	1	----	1	2	----	----	----
Indonesia†√			9	102			
(Klaten)	4	3			6	90	450
(Luwu)†	4	3			10	25	90
Sierra Leone†√	4	2	2	20	19	193	500
Thailand†$√	4	12	7	158	40	447	2235
Uganda√	2	----	1	10	----	----	----
Zaire†	2	4	2	16	74	30	333
6 countries	NA	24	22	308	149	785	3608
Lutheran World Relief							
Kenya√	1	----	1	2	----	----	----
Papua New Guinea√	1	----	1	9	----	----	----
Tanzania†*	4	31	1	12	154	111	888
3 countries	NA	31	3	23	154	111	888
Save the Children							
Bangladesh†$√	4	2	3	14	7	600	8500
Bolivia√	3	8	2	13	28	28	635
Cameroon√	1	----	1	1	----	----	----
Indonesia	2	----	2	4	1	----	----
Nepal$√	3	2	5	54	8	8	471
Somalia	2	----	2	6	----	----	----
Sri Lanka√	1	----	1	7	----	----	----
Sudan	2	1	2	24	----	----	----
Thailand√	3	----	3	27	15	6	----
Zimbabwe†√	2	2	0	0	2	20	160
10 countries	NA	16	21	150	61	662	9766
TOTAL: 51 projects 27 countries	NA	176	107	917	1516	4149	30,615

† These projects have a significant demonstration/training component.
$ These projects received WHAP grants.
√ One or more of this project's staff attended WHAP training.
** Tanzania was not an AID-funded country, hence LWR covered the cost of the WHAP consultancy.*
--- Data unavailable
1 Please see Attachment E for full explanation of development stages.
2 "Sites" generally refer to communities or training centers.
3 "Ponds" may be community or family owned or operated.
4 Virtually every field project included some training for the beneficiaries conducted or sponsored by the PVOs.
5 Direct beneficiaries are estimates based on information supplied by PVO field projects. Wherever numbers of families, rather than individuals benefitting, were supplied, we have multiplied the number of familes by 5.
6 This project had 29 local "promoters" who underwent extensive, long-term training. They, in turn, trained subsistence farmers. Most trainings were informal and undocumented. The number "1227" is a modest estimate.

E. Organizational Development

The establishment and strengthening of local groups and organizations to support and manage WHAP activities was also a projected outcome. These varied from large and small cooperatives to village associations and committees, women's organizations, pond committees, project committees, etc. Project data indicate that at least 131 formal and informal local organizations were established or were operationally involved in WHAP projects during the LOP.

F. Comparison of Planned and Actual Program Outputs

The following table provides a summary comparison of planned and actual outputs for the project. Data is based on analysis of PVO field project reports, evaluation reports, field trip reports by ICA consultants and Center staff, and other communications from PVOs in the field. The extent of the information provided from participating PVOs varies from project to project. Hence the project information presented here, on the whole, is an incomplete interpretation of project results. In some cases we had information from early stages of field projects but not from the later stages. In others, while we knew that WHAP activities had begun, we had insufficient or no project reports or reliable information. Some country project activity involved only training or initial technical asistance or program support visits and the extent of the water harvesting/aquaculture activity is not clear. These locations, of course, are not considered as WHAP field projects, which explains why the total number of country project activities is greater than the total number of field projects. Project accomplishments exceeded program output targets or were close to planned figures as in the case of beneficiaries. The major output of WHAP, although not quantifiable, was the important awareness it engendered for headquarters and counterpart staff concerning the multipurpose management of water resources through harvesting rainwater run-off. It also added new dimensions of technical skill and new or improved project components to the stable of PVO project interventions.

TABLE 4: PLANNED PROGRAM OUTPUTS COMPARED WITH ACTUAL PROGRAM OUTPUTS

Program Outputs	Planned	Actual	Comments
A. Field Projects			
1. Projects	9	18	
2. Sites	27	176	
3. Beneficiaries	32,500	30,615	Figure includes direct participants and family members but does not include data from WHAP activities not classified as field projects.
B. Training			
1. PVO international staff trained in U.S.	18	29	
2. Villagers, host government counterparts, PVO local staff trained in field; specific breakdown by category actually trained as follows:	320	4254	These training targets were lumped together in original program proposal--breakdown by category are indicated below.
a. Villagers		4143	Training of village and farm-level participants.
b. PVO in-country/local staff		79	Does not include 15 PVO international staff trained in the U.S.
c. Host government counterparts/others		32	Includes PCVs and miscellaneous individuals.
3. Village trainers/promoters	54	24	Most project information did not clearly distinguish between village trainers/promoters and other categories of village-level training.
C. Organizational Development Village committees, local organizations established or stengthened	27	131	Includes large and small cooperatives, village development committees, women's organizations, pond committees, and other local organizations managing WHAP activities.

G. Comparison of Planned and Actual Program Inputs

The following table provides a summary comparison of planned and actual inputs of person months of technical assistance, training, program support, and evaluation delivered by the project. Data is based on analysis of reports of technical assistance and training from ICA, trip reports from the Center covering program support and evaluation, and other technical assistance services, and estimates of staff time and services contributed by Western Carolina Universitry and Auburn University in support of the project. The latter were not covered by WHAP funds.

Because of the difficulties in obtaining adequate information on the monetized value of participant inputs from local groups and communities, host governments and PVOs and others into WHAP projects and related activities, we are unable to clearly report on these aspects of the project. Most PVOs did not keep records or make estimates, despite being requested to do so, of local participation. Indications are that the value of labor, material, and other resources contributed by local participants to WHAP projects is well in excess of the input target of $750,000. Many of the PVO inputs to WHAP were part of larger, more comprehensive projects. They reported difficulties in extracting the WHAP components. Thus we simply lack sufficient data to present useful information at this time. The same is true for host government inputs of technical assistance, personnel and other support. Examples for different field projects have been cited as illustrations of the kinds and levels of inputs made to WHAP.

TABLE 5: COMPARISON OF PLANNED AND ACTUAL PROJECT INPUTS

Person months of technical assistance, training, program support, and evaluation:

Program Inputs	Planned	Actual	Comments
1. ICA	70	124.3	Includes 30.7 months of technical assistance, training and other services provided by ICA outside of WHAP funding.
2. CLUSA (NCBA)	5	30	CLUSA (now the National Cooperative Business Association) was not part of the core project but NCBA participation in HPI-assisted projects in Indonesia was well over 30 person months.
3. SECID/Center for Women in Development	50	7.4	Provided in the first two years of WHAP to collect baseline information. When intensive evaluation component of WHAP was deleted, arrangements with SECID/CWID were ended.
4. Center for PVO/ University Collaboration in Development	222	247.3	179.8 person months paid by WHAP funds and 67.5 person months provided by WCU and/or generated by Center for WHAP.

VI. MANAGEMENT: REVIEW AND ANALYSIS OF PROJECT OFFICE SUPPORT

A. Project Planning and Design

Realizing that any increased interest and activity in the water harvesting and aquaculture sector would originate in the field, the Advisory Council devised a plan for sectoral promotion based on field training activities and the funding of pilot activities. Participating PVOs designed their own projects based on local needs, problems, and available resources. To qualify for WHAP assistance, those projects had to involve the harvesting and storage of water in ponds and the use of this water to support food systems with the majority of the projects involving aquaculture. Projects were often multipurpose with agricultural components. Some projects involved conservation, resource planning and renewable resource management as well.

Developed collaboratively, the Water Harvesting/Aquaculture Project essentially functioned as originally planned. The Center acted as a coordinating and facilitating mechanism for the support of PVO field projects, providing 75 person days of direct overseas program development assistance over the life of the project.

B. Staff Resources

1. Center for PVO/University Collaboration in Development

<u>Project Director:</u> Nancy L. Blanks (.50 LOE 84-87, .62 LOE 87-89)
<u>Evaluation Specialist:</u> Ralph Montee (.50 LOE, 84-87)
<u>Information Specialist:</u> Joyce Moore (.50 LOE, 84-87), Phyllis Stiles (Full-time LOE, 87-89)
<u>Administrative Assistant:</u> Mary Kay Cooley (.50 LOE, 84-87), Anne Loughlin (.75 LOE, 87-88), Marilyn Jarisch (.75 LOE, 88-89)
<u>Secretary</u> (Full-time LOE)

In addition, staff time not funded by WHAP was devoted to the project including the time of the Executive Director and Administrative Officer of the Center for Improving Mountain Living and secretarial and support staff.

2. International Center for Aquaculture, Auburn University

Over the life of the project, about 1.7 full-time effort per year was divided among these three people:
<u>Technical Coordinator:</u> Bryan L. Duncan, Ph.D.
<u>Technical Consultants:</u> Alex Bocek, M.S. and Thomas Popma, Ph.D.

Travel and per diem, but not salary, were paid for the following consultant's work for WHAP:
Randy Brummet, Ph.D.; John Grover, Ph.D.; Upton Hatch, Ph.D.; David Hughes, Ph.D.; Len Lovshin, Ph. D.; Jean Yves Mevel, M.S.; Ronald Phelps, Ph. D.; Rudy Schmittou, Ph.D.; R. O. Smitherman, Ph.D.; Kyung Yoo, Ph.D.

ICA also provided staff time not provided for by project funds including technical staff and secretarial and support staff.

3. Personnel not salaried by WHAP from other agencies/institutions

<u>Other Technical Consultants:</u> Silvana Castillo, M.S., CARE/Guatemala Chief of Aquaculture Project ; Michael Cremer, Ph.D., Kentucky State University; Nancy Glover, Nitrogen Fixing Tree Association, University of Hawaii; Frank Meriweather, University of Arkansas, Pine Bluff; John Morrison, University of Arkansas, Pine Bluff ; J.R. Snow, Ph.D., Auburn University, retired

<u>Evaluation Consultants:</u> Frederick Bates, Ph.D., University of Georgia; Eloise Murray, Ph.D., Center for Rural Women, Pennsylvania State University; Mary Hill Rojas, Ph.D., Virginia Polytechnic Institute and State University; Beth Schmidt, M.S., University of Kentucky; Simon Williams, Ph.D., Center for Rural Development, Fort Collins, Colorado

<u>Advisory Council</u>: See Part E for Council Members

<u>Field Project and Overseas Staff :</u> All field projects and support staff for projects were funded and managed by the PVOs.

C. Training and Technical Assistance

The Project Office was responsible for supporting the efforts of the ICA in delivering the TA and training requested through WHAP. When technical assistance was requested and scheduled, the Center notified all other project participants in the region so that they could schedule visits in conjunction with the trip. The Center assisted in the organization, promotion and delivery of U.S. and regional WHIAA trainings. Also, the project office acted as the buffer between technical provider and receiver, sometimes interpreting communication. Occasionally, when a PVO project or the ICA lacked funds to do something out of the ordinary, as in the case of bringing Silvana Castillo of CARE/Guatemala or Nancy Glover of the Nitrogen Fixing Tree Association to Bolivia, the Center expended its project funds to cover the costs. The Center also aided the TA process by clearing upcoming consultant visits with PVO headquarters and A.I.D. missions.

D. Project Administration and Documentation

The Project Office developed an Operations Manual for project participants and maintained all project documentation. The Office, in cooperation with ICA, scheduled technical and other inputs for the project, had fiscal and program reporting responsibilities to the Agency for International Development, monitored field project development and the provision of TA and training, was the information and documentation entity, published the WHAP newsletter "Ponderings", arranged meetings of and staffed the Advisory Council, maintained liaison with participants in the project, addressed problems encountered, and, in general, provided the management of the WHAP. ICA trip reports and annual activity reports documented their activities and the technical assistance delivered.

E. WHAP Advisory Council

The Advisory Council was invaluable in shaping and guiding the progress of the Water Harvesting/Aquaculture Project. Fourteen meetings were held over the life of the project.

Advisory Council Members were:

Auburn University: Bryan Duncan, Technical Coordinator for WHAP, Associate Director of International Center for Aquaculture
CARE: Tom Zopf, Director of Program Support
Catholic Relief Services: Ray Victurine, Water Projects Manager, Latin America and the Caribbean (84-86), Jeanette North, Desk Officer, India and Pakistan (87-88), Gary White, Projects Specialist (88-89)
Heifer Project International: Robert Pelant, Asia/South Pacific Program Director
Lutheran World Relief: Neil Brenden, Assistant Executive Director (84-86), Tom Edwards, Director, Latin America Programs (87-89)
Save the Children Federation: Jeff Saussier, Technical Resources Unit, Program Development and Support (84-86), Jim Worstell, Director, Training and Technical Resource Unit (87-89)

Advisory Council members were the liaison between WHAP and the participating PVOs as well as the communication link between WHAP and the field, especially in the development of field projects and requests for technical assistance. They also acted as interpreters of each agency's policy and mandate, and provided guidance on overall project implementation.

F. Publications

Ten issues of PONDERINGS, the newsletter of the Water Harvesting/Aquaculture Project were published to inform the development community of project activities and to broaden the perspectives of the participants themselves. They are included as Attachment C.

As part of their subcontract responsibilities, Auburn University produced eleven loose-leaf technical booklets which were designed specifically after the needs of WHAP field projects were identified during the first three years of field visits. This informational series entitled "Water Harvesting and Aquaculture for Rural Development" was designed primarily for field agents, agricultural technicians and extensionists with little or no experience in water harvesting and aquaculture. The goal of this activity was to incorporate technical information into low cost, practical and easy to reproduce guides. Editorial backstopping was provided by appropriate faculty and staff of the Department of Fisheries and Allied Aquacultures and the International Center for Aquaculture at Auburn University. The following titles were prepared and distributed by the ICA under WHAP:

1) An Introduction to Water Harvesting
2) An Introduction to Aquaculture
3) Fertilizing Your Fish Pond: An Introduction
4) Chemical Fertilizers For Fish Ponds
5) Organic Fertilizers For Fish Ponds
6) Transporting Fish
7) An Introduction to Tilapia Culture
8) Reproductive Biology of Tilapia Nilotica
9) An Introduction to Tilapia Nilotica Fry and Fingerling Production Systems
10) The Net Enclosure System for Tilapia Nilotica Fry and Fingerling Production
11) Monosex Tilapia Culture

They were photocopied in small batches of one hundred to allow the opportunity for any revisions suggested by participants in field projects. The booklets are included as Attachment D. Twelve hundred copies have been distributed to the field. ICA plans to continue further development of this series with funding from other sources since the completion of WHAP.

VII. END OF PROJECT FINANCIAL REPORT

COST ELEMENT	EXPENDITURES
Administrative Direction and Support	$346.884
Program Development	30.708
TA/Training (non-ICA expenses)	48.108
Evaluation	90.264
Documentation/Information	89.375
Subcontract (ICA)	552.454
Project Support Grants	98.635
Indirect Costs	180.944
TOTAL	$1,437.372

VIII. LESSONS LEARNED AND LONG-TERM PROJECT IMPLICATIONS

A. Project Costs

1. A.I.D. Inputs

The total project cost was $1,437,372. Costs have been divided into major categories of administrative direction and support, program development, non-ICA technical assistance and training, evaluation, documentation/information, the subcontract to the International Center for Aquaculture for training and technical assistance, Project Support Grants, and indirect costs.

The subcontract to Auburn was rightly the largest project expense. The essence of WHAP was providing top-notch technical assistance, training, problem solving and backstopping to the field projects and the participating PVOs. The $552,454 when combined with the $48,108 for TA/training expenses brings the overall total for training and technical assistance to $600,562.

The next largest item was $346,884 for administrative direction and program support. This category covered costs for overall administration of WHAP including the full-time equivalent of staff salaries, office support costs, communication, some program development costs, domestic and international travel of the Project Director and other usual administrative costs.

Indirect costs were $180,944.

Direct grants to field projects totalled $98,635.

Documentation expended $89,375 including the salary, domestic travel expenses, and support for the Documentation and Information Officer and function.

Averaged out by year over the life of the project, WHAP expended about $288,000 per year.

2. PVO Inputs (Examples)

Costs to the field projects for technical assistance and training were minimal because only in-country transportation and, when possible, lodging for consultants were picked up by the PVO. However, expenses for field project implementation, in terms of personnel, materials, pond construction and supply costs, were the responsibility of the PVOs. Data is unavailable for all the projects but we have cited some examples of information on hand to demonstrate the broad diversity of funding levels provided by the PVOs:

CARE-Guatemala
The Family Fish Pond Extension Project began in 1983. Upon its completion in 1987, the Integrated Aquaculture Extension Project began which combined aquaculture with small animal production and diversification, emphasizing integrated pond culture. For the period FY 1986-1989, the project received support from U.S.A.I.D./Guatemala through an Operational Program Grant. Total A.I.D. commitments were $500,000. During that period, the host country agency DIGESEPE pledged $60,000 to CARE, and CARE matched with $75,000. The combined budget over the three year period was therefore $635,000. This does not include Peace Corps' contribution of more than $220,000 in in-kind services.

HPI-Zaire
By contrast, Heifer Project International supported a smaller-scale water harvesting/aquaculture component of a Habitat for Humanity project in Zaire with $9,650 in 1988.

CRS-Honduras
The total cost of this aquaculture project to CRS for 43 families was $8,373 which included a grant of $5,341 from WHAP.

3. Pond Owner Inputs

A premise of WHAP was that constructing and managing ponds and integrating aquaculture and agriculture were within the financial means of most subsistence farmers. Expenses for establishing and maintaining ponds varied. The major start-up cost is for labor and materials to construct the pond and for purchase of fish stock. Some factors that influence these costs are the location and size of the pond, the type of soil and the distance to and type of water supply. Maintenence costs include the restocking of ponds, if farmers do not reproduce their own stock, and the purchase of food. Food costs are minimal if farmers use locally grown vegetation and use manure from animals integrated into the fish production. Also, ponds are expected to last ten years without reworking. Two examples of costs to farmers follow:

SCF/Nepal reports that the average initial investment for a 500m^2 pond is approximately $350 and yearly operating costs average approximately $30. The farmers involved with this project took out bank loans and felt they would have little problem repaying them in the allotted time with the sales they would make on fish and other agricultural products associated with the ponds.

HPI/Thailand reports that village ponds cost about $156 each to start-up with maintenance (food, transport of supplies, etc.) totalling about $7 per year.

B. Institution Building

A basic objective of WHAP was to establish and to institutionalize PVO and university networks which would exist long after direct project activity ended. This aim arose out of the view that it was simply the lack of such a network and mechanism for interaction that had acted as a constraint on PVO-university collaborative activities in the past. An institutional setting was established within which to continue the collaboration between universities, with their specialized technical expertise, and PVOs, with their experience and skills in grassroots level development. Auburn University and HPI, for example, are currently developing a joint proposal to continue their collaboration.

Institution building in the WHAP took place in several ways. Within the participating organizations of the WHAP, the training and technical assistance strengthened the technical capacity of PVO staff both overseas and in headquarters. (One hundred and thirty-one PVO staff and counterparts were trained directly by WHAP.) Some PVOs (HPI and CARE) recruited aquaculture specialists as part of their field staff as a result of their involvement in WHAP. At the same time, Auburn acquired firsthand knowledge of rural development issues and challenges faced by the PVOs at the local level. Thus the technical assistance and training being provided by Auburn became more focused and relevant to local conditions. Many developing country aquaculturalists trained at Auburn were put into contact with PVOs working in their countries. These technicians can serve as ongoing sources of technical assistance for the PVOs. In turn, the PVOs can help them extend water harvesting/aquaculture technology to the village level.

Community organizations were formed to support pond/aquaculture development. Other organizations were expanded to include responsibility for WHAP activities. This grassroots institution building provided in large part for project sustainability.

Lastly, trainings provided networking opportunities for local technicians who had occasion to meet and share ideas and solutions with other people dealing with similar problems. Among them, government counterparts were invited to participate in WHAP workshops along with other in-country resource people, such as local extension agents, in an effort to institutionalize the new technology.

C. Local Participation

In order for a field project to have become part of WHAP, there was a stipulation that there be effective local participation in the management and implementation of the project. Emphasis was put on developing and assisting local organizations such as cooperatives, development committees, or pond committees to oversee WHAP projects. Field projects were given support and assistance by the PVOs, but basically belonged to the local community or families. The input of the beneficiaries included land for the construction of ponds, villagers trained in pond construction and management, labor for site preparation and pond construction, and materials and/or cash for project implementation. Host governments sometimes contributed as well by way of extension help or including agents in WHAP trainings or providing the land for pond sites. In some projects, as in the case of CARE/Guatemala, the government was an important participant in the project. (See the companion report: the Final Evaluation Report, for a detailed discussion of the CARE/Guatemala project.)

The following excerpt from a report from the CRS project in the District of Canazas in Panama is indicative of the kind of labor contributed by local communities:

"In 1987 twenty-six new fish ponds were constructed; fifteen are managed by the 135 families participating in the project. Twenty-four of the ponds are approximately 500m^2 while those of the communities of El Alto de Los Pajaritos and La Eulalia are 1500m^2. Most of the ponds were constructed using manual labor to avoid the expense of renting a tractor (US$45.00/hr.). The ponds were constructed by members of the participating communities who will be given a portion of the pond production as compensation for their labor. In addition to this initial investment of labor, each family will work an average of three hrs./day in the maintenance of these ponds."

The SCF project in Bangladesh offers another example:

"The community has contributed over 4,000 free hours of labor to construct and repair the infrastructure of these projects, and community members frequently contribute time to attend project meetings."

CARE/Guatemala has reported that an average family fish pond (about 120m^2) was hand-dug and required 29 person days of labor.

D. Sustainability

The ICA devised a "development stage" measurement tool, essentially beginning with "no development" and progressing to "maturely developed", specifically for WHAP to help all project participants assess individual field project progress. (See Attachment E.) Briefly, the stages are summed up as follows:
(1) Awareness of WHAP technology among PVO country missions and selected headquarters staff.
(2) Interest in including WHAP initiatives in country programs.
(3) Trial of water harvesting and aquaculture technology.
(4) Extension of water harvesting/aquaculture technology to intended beneficiaries of PVO field projects.

As the variety of project sites reached the third or fourth stage of development, the local community assumed more of the total responsibility for the project. Less technical expertise was required from the outside. Local PVO staff were trained and provided the back-up when needed, while ICA's experts remained available to assist with additional training, problem solving and technical advice as the project matured. Coupled with ICA's commitment to locating appropriate technical expertise in-country, this approach encouraged local project ownership and local technical support from the outset.

Furthermore, WHAP's emphasis was always on low-input interventions. Activities were intentionally on a small-scale and use of local materials and labor was stressed to encourage long-term sustainability.

E. Benefit Distribution

The benefits of WHAP were directed to subsistence farming families (women and men) and to a number of rural training centers in various countries, regions and environmental circumstances.

The benefits include:
- increased water supply;
- more convenient access to water for agriculture and livestock;
- acquisition of new skills;
- diversification of food supply;
- income generation from a variety of activities which take place around the new water resource;
- increased food self-sufficiency for community participants in the field projects;
- reduced soil erosion by controlling rainfall runoff;
- environmental renewal from the introduction of organic materials; and
- improvement of ground water reservoirs.

Collateral benefits also extended to PVO staff members trained by WHAP in that the experience prepared them to replicate the water harvesting/aquaculture/integrated agriculture technologies under a variety of circumstances and to share their knowledge with communities adjoining project sites, with government officials and with extension agents who can train others.

F. Innovation and Technology Transfer

A major strength of the WHAP lies in the flexibility of the technology and its applicability to diverse sites and circumstances. From arid and semiarid lands to the humid tropics, the technology and training has proven to be valuable to both local communities and to the PVOs attempting to develop strategies for coping with the challenging problems of harvesting water resources and improving food production systems. WHAP's mandate was to transfer WHIAA technology to villagers across the developing world. Structuring the project through the PVOs made that possible following a sequence of six main steps: (1) Involving PVOs in project development and management, (2) Raising consciousness of PVO headquarters staff through orientation seminars, (3) Informing field staff of technology through orientation trainings, (4) Following-up with site visits to provide feasibility studies, project planning, and design, (5) Providing ongoing TA as field projects develop, and (6) Locating in-country technical and material resources.

A boon of working with the International Center for Aquaculture is that more than 400 students from over 65 countries have graduated from the Department of Fisheries and Allied Aquacultures and the International Center for Aquaculture at Auburn University with advanced degrees. These international alumni are playing a significant role in the growth and development of water harvesting and aquaculture technology. They form a network of qualified people from which the ICA has provided PVOs with in-country contacts and staff for help in aquaculture and water harvesting. The ICA was recently awarded private funding to further develop that network.

G. Policy Implications

1. Strengthening Local Capacity

Across the developing world and in almost every development entity, there is new direction for development assistance. This new direction is the demand that citizens of a country be assisted in developing expertise to carry out their own training, extension, and technical assistance according to the needs of their specific region or country. There are fewer requests for expatriate personnel to live in a country and more requests for short-term and ongoing technical backstopping of existing resources.

The Water Harvesting/Aquaculture Project has demonstrated a way to: strengthen PVO personnel, both local and expatriate, without swelling the ranks of expatriates living abroad; provide ongoing technical expertise and backstopping to rural development efforts; and strengthen government personnel and rural individuals while leaving ultimate control of projects and development efforts in the hands of local residents, where it belongs.

Major funders, including foundations, international funding agencies and others, all agree this is the direction of the future. Therefore, it seems important that other efforts be made to answer the needs of developing countries in this way.

2. Enhancing Collaborative Capacity in Development

The development of the project was a synergistic process undertaken in partnership among many players. Consequently, diverse resources were leveraged to focus on common problems. The Council management philosophy was a natural outgrowth of this initial interaction. The Advisory Council met the need for cooperation and exchange in setting overall policy, approving field projects, supervising the project office, and providing ongoing guidance and reality checks. In the beginning, Council members were not compensated by the project except for travel and per diem expenses. Over the course of project implementation, however, even travel and per diem expenses were necessary only occasionally for members outside of the New York area. Meetings were hosted by each participating organization.

Substantial progress was made in the promotion of collaboration in other ways over the life of WHAP. PVOs shared the responsibility for planning and holding training seminars furthering the cause of in-country collaboration between PVOs. The Center provided travel funding to have an exceptional CARE-Guatemala project director travel with the WHAP consultants to Bolivia for her input on the CARE and SCF projects there--an excellent example of project to project collaboration. In addition, PVO WHAP projects strengthened cooperation with government agencies, NGOs in-country or other US PVOs operating in-country (as is the case in Zaire where HPI works with Habitat for Humanity). When a WHAP consultant visited a field project, he visited all agencies and personnel of potential use to the project, including the A.I.D. mission, as requested or suggested by the host PVO. The decision to conduct the field project evaluations as PVO teams is a further illustration of the collaborative concept.

A serendipitous outcome of the WHAP regional trainings was that, often for the first time, a PVO's staff from neighboring countries were brought together. This provided a forum for exchange within the organization as well as across organizations.

The WHAP can take credit only indirectly for many of the examples cited above. However, the project's flexible style and responsiveness to suggestions provided the medium necessary for collaboration to grow. The WHAP has successfully demonstrated the practicality of collaboration between universities and PVOs in the development process. Types of collaboration include:

a. the design of rural development projects involving local universities and NGOs working with U.S. and other international universities and PVOs, thus strengthening local capacity ;

b. projects which specifically address the use of resources in a collaborative mode to maximize the impact of PVOs and universities working in the same areas and/or in similar efforts; and

c. projects which bring together a variety of funding agencies to impact on development challenges. Very good examples of this shared funding approach are already underway in some WHAP field projects. In Sierra Leone, the Near East Foundation is paying the salary of an aquaculture specialist trained by Auburn University to work on an HPI-sponsored WHAP project which is actually the project of the United Christian Council of Sierra Leone.

IX. RECOMMENDATIONS

A. PVO/University Collaboration

WHAP has been a practical, working demonstration of collaboration in development. The Center will continue its commitment to linking the technical expertise, research and training capabilities of universities with the community development focus of PVOs. It is an alliance which is only beginning to be explored. It affords non-governmental organizations and their project interventions access to long-term, high-quality technical backstopping, which would otherwise be unavailable except to well-funded organizations able to contract indefinitely with firms for services. It also fulfills the hope of researchers and instructors to see their knowledge applied to people and environments in need. The collaborative process enables this knowledge to be more effectively translated into appropriate forms for development at the local level. Perhaps best of all, this institutional partnership allows projects to be responsive and flexible: a pool of consultants is available to a pool of projects belonging to a pool of organizations. The configurations these partnerships might take in the future are limitless. During the Advisory Council's investigation of the potential of a follow-on to WHAP, they suggested exploring relationships within regions or countries which were more intensive than WHAP had been and involved collaboration among universities, PVOs, and local organizations and groups.

B. Councils as Mechanisms for Collaborative Management

The WHA Project has disproved some old myths: a Council or forum comprised of representatives of a variety of organizations participating in a mutually beneficial project with an equal voice can function. Sometimes it is a slower method than more traditional approaches since there are so many entities to be consulted; however, decisions are well-thought out before they are implemented, funds are carefully expended, and the project is continually scrutinized to answer the question--are we best meeting the needs of the intended beneficiary population? Another myth is that a project of this scope requires a large funding base. By pooling resources, WHAP has impacted on 44 countries on about $288,000/year. Management by council appears to be essential to collaborative projects where there is a greater need for sharing resources than for individual agency control.

C. Importance of Seed Monies

WHAP was able to provide project seed monies for only two years of the five-year project. This was unfortunate since the basic project concept was to make PVOs aware of a sector which was extremely worthwhile for rural development projects, in order to add it to their ongoing programming. The difficulty arose when more and more project staff recognized its value, wanted to implement it, but had insufficient funds budgeted for staffing or execution. If a new technology is being introduced, seed grants must be made available to maintain momentum. PVO field directors need this cushion to locate sufficient complementary funds and to mobilize local resources.

D. Field Project Monitoring

Monitoring field project progress and assessing impact proved a challenge for WHAP. In similar future projects, there would seem to be two major options. First, visiting consultants would have the responsibility of collecting needed baseline or benchmark data, and input and output information. In addition, record-keeping (including methods for monetizing local labor) appropriate to the needs of a given project should be included as the subject of training just like the technology being transferred. A second option is to see that project budgets include the resources needed for the more extensive baseline, monitoring, and evaluation that seems to be demanded by donors including A.I.D. We cannot continue to expect a heightened level of reporting and evaluation from the field project staff without providing the resources in project budgets required to help them do the job. Otherwise, we may threaten the independence that allowed WHAP to succeed in other ways.

E. Role of the Project Holder

For the Center to perform well as a catalyst and clearinghouse for all project activities, it will have to communicate more closely with field projects in the future. A recurring problem, cited by the external evaluators of WHAP, was that field staff were unaware of the Center's role and were confused when the Center requested their assistance. Collaborative projects must have roles and expectations clearly defined at the outset for all concerned. A simple but effective tool for dispelling this type of malaise is to use project letterhead for all project related correspondence. Due to the frequency of staffing changes, both at headquarters and in the field, a brief but clear introductory project booklet should also be developed and distributed widely.

F. Follow-up

WHAP's most developed field projects should be followed up in two to five years to determine whether the methodology did effectively transfer and whether these projects did become self-sustaining and why. Otherwise, we will not know the full extent of WHAP's success.

Due to Auburn University's five year commitment to WHAP as primary technical provider, PVO field staff could request advice on anything from feasibility studies in preparation for a pond and/or an integrated agriculture and aquaculture activity, to data collection programming, to overall project evaluation. It was an all-purpose approach individually tailored to each field project's needs.

In northwestern Thailand for example, a demonstration center trains local farmers in, among other things, integrated agriculture and aquaculture. Heifer Project International requested WHAP assistance in periodically reviewing an extension program there.

Photo courtesy of Auburn University.

ATTACHMENT A. Progress Report Form

WHAP Progress Report

Please complete for each administrative or geographic "site."
Site designation is at your discretion.

Code ____________ **Reporting Period** ______ – ______

Site Name ____________

Location ____________

 # Households Involved ______ **# Beneficiaries** ______

If project personnel attended a WHAP training, please enter:

Name/Current Position ____________

Name/Current Position ____________

Please complete following charts with numbers unless otherwise instructed.

Local Organizational Efforts Relating to Ponds

		Committees	Meetings During Period	Average Attendance Men	Women	TOTAL
Pond Committees or WH/A Project Committees	Begun this period					
	Existing					
General or Multi-purpose Organizations or Cooperatives Related to Ponds*	Begun this period					
	Existing					

* Please describe "Organizations or Cooperatives Related to Ponds" on attached sheet of paper.

Utilization of Ponds

	Ponds: Community Number	Community Meters ²	Family Number	Family Meters ²	No. of Ponds Being Used For: Aqua-culture	Training	Watering Livestock	Irrigation	Domestic	Water Harvesting Only
Constructed during this period										
Improved during this period										
Existing, not improved										

Aquaculture Production

Community Ponds		Family Ponds		Name(s) of Fish Species	Harvested Weight in Kgs:		
Number	Meter ^{2}	Number	Meter ^{2}		Food	Commercial	TOTAL

Training

Courses		Trainees	
1 Day or Less	1 Day or More	Men	Women

Livestock Watering

Ponds		Stock						
Com-munity	Family	Cattle	Chickens	Ducks	Goats	Rabbits	Sheep	Swine

Irrigation

Has. Irrigated		Name(s) of Crop(s)	Harvested Weight in Kgs		
Comunity	Family		Food	Commercial	TOTAL

Domestic

Ponds		Households		Use (Indicate No. of Households)		
Community	Family	Number Served	Average Size	Cooking	Washing	Personal Hygiene

Cost Analysis To Date

Project Inputs–$ Value	Cash		In-Kind		TOTAL	
Local Communities (Estimate)						
US PVO						
PVO In-Country Counterpart						
Government Counterparts						
Other Sources						
Total						

Average Cost of 1 Pond To Farmer	

Background Information

(Note: "Site" refers to how you have decided to refer to your project whether it be designated by geography, activity, or administrative procedure.)

When did site first receive services (training, project support funds, or technical assistance) from WH/AP?

Did you participate in water harvesting and/or integrated agri/aquaculture projects prior to involvement with WH/AP? If so, when and where? Did you consider the experience successful? Please explain.

Did site have any aquaculture ponds prior to introduction of WH/AP? If so, were pond(s) in operation and/or production?

If ponds were in production, what was estimated annual output (kgs) prior to WH/AP involvement?

Before involvement with WH/AP, was this water used for any activity other than aquaculture? If so, what?

Have pond management practices changed as a result of interaction with WH/AP and if so, how (generally speaking)?

Were any community organizations an outgrowth of WH/AP involvement?

Please return to:
Phyllis Stiles
Documentation Officer
Water Harvesting/Aquaculture Project
Center for PVO/University Collaboration in Development
Bird Building
Western Carolina University
Cullowhee, NC 28723
USA

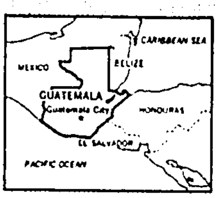
ATTACHMENT B. PONDERINGS (Project Newsletter)

PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Spring/Summer 1989

Women's Cooperative and Fish Farmers Join Forces



by Silvana Castillo, Coordinator of Aquaculture Project, CARE/Guatemala

In August 1987, a group of fish farmers from the Salama, Baja Verpaz CARE program decided to form a cooperative. Salama is a growing town with strong demand for meat, chicken and other basic foodstuffs. However, according to Guatemalan law, if there is a cooperative nearby with similar activities underway, a new cooperative cannot be formed, in order to avoid competition.

A cooperative called Salam-Ha had already been established as a consumer coop in 1985 by a group of 22 women teachers, nurses, and merchants. They had a store where they sold food and general household products. When the fish farmers found out about Salam-Ha, they decided to join the group. The fish farmers went through all the training required, and a group of 20 joined later that year.

It was a very heterogeneous group and everyone wondered whether or not it would work. The women were from town, educated and aggressive, while the farmers were from nearby rural communities, uneducated, poor and very shy.

CARE extensionist and member of cooperative with family at Salama. Note chicken shed perched over fish pond.

Photo: Silvana Castillo

The idea was that the farmers would be in charge of the production of fish, poultry and vegetables, and the women, sales. CARE's support was the donation of a refrigerator to the store, with the understanding that the cooperative would use the money earned from its sales to establish a revolving loan fund for credit for its members in complementary income generating activities. CARE also provides technical assistance in agricultural, fish farming and animal husbandry activities as well as in group organization.

continued . . .

PONDERINGS, *the newsletter of the Water Harvesting/Aquaculture Project, is issued quarterly by the Center for PVO/University Collaboration in Development, Bird Building, Western Carolina University, Cullowhee, NC 28723. Telephone (704) 227-7492; Telex: 493-2268. Inquiries and submissions are welcomed and should be addressed to Phyllis Stiles, Editor.*

The Water Harvesting/Aquaculture Project (WHAP) is an AID-funded endeavor begun in 1984. Six private voluntary organizations--CARE, Catholic Relief Services, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children Federation--manage and/or sponsor field projects around the developing world to which the WHAP supplies appropriate technical assistance and training through a subcontract with the International Center for Aquaculture at Auburn University. The Center provides overall project management and acts as the communications link with all project participants.

Nancy Blanks is Project Director and Dr. Bryan Duncan is Technical Coordinator.

Cooperative

Continued from page 1

The results of this economic marriage have been positive. They have had many new projects and good contracts in town as a result of their union. The co-op has a new, larger store and a greater variety of products. The farmers raise one-day old chicks and sell them at cost to members when they are two weeks old for fattening. As a larger market has developed, the farmers now feel the need to produce bigger fish and are starting to raise only male tilapia in their ponds. Jointly, the members have organized picnics, raffles and drawings for fund raising, and educational activities for members'. children. Now the Co-op's board of directors has grown to include representatives of the fish farmers.

CARE is conducting an Integrated Aquaculture Program in Guatemala which promotes and supports activities of organized fish farmers. WHAP has provided five technical assistance visits from 1985 to 1989 to this project. Also, CARE's Guatemala Director attended a WHAP introductory training in 1983, and in 1985, the Project Manager attended training. More than 500 ponds have been constructed as a result.

Training Held in Morocco for CRS Middle East/North Africa Staff

WHAP conducted a short course on water harvesting in Morocco in January. CRS staff came from Lebanon, Egypt, Jordan, Israel (West Bank), and Morocco to participate in the workshop.

The training lasted four days including three days of lecture and one day in the field. Afterwards, Dr. Kyung Yoo, the WHAP consultant who lead the training, visited sites in the area to give suggestions for improvement.

Participants included CRS staff and Peace Corps volunteers. Gary White, the CRS representative to the WHAP Advisory Council, also attended the training. White said, as usual, all of the participants wished the workshop could have been longer, but it was especially good for headquarters staff, such as himself, to experience the WHAP training firsthand. White would like to see CRS continue to include water harvesting and aquaculture in its programming.

Short Course Available

ISLRC

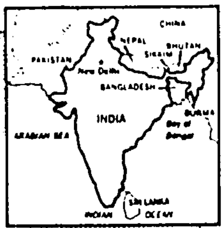
ANNUAL INSTITUTE ON LIVESTOCK IN DEVELOPMENT

Heifer Project International and the Alabama A & M University are co-sponsoring the Institute to be held August 6 - 11, 1989 on the Alabama A & M campus near Huntsville. It will combine HPI's annual Institute on Livestock in Development with the annual International Short Course in Small Livestock Production of Alabama A & M's International Small Livestock Research Center.

This Institute is for people who work, or hope to work, in rural development with low-income families, primarily focusing on developing countries.The program will include presentations on major issues in small-scale livestock development, small and large group discussions, practical hands-on experience with small livestock, and field visits to area farms which exemplify the innovative work being done.

Students can earn (2) credits by registering through Alabama A & M. A tour of projects will preceed the Institute. The cost is $345. For more information, contact Dr. James DeVries, Institute Coordinator at HPI, P.O. Box 808, Little Rock, AR 72203 USA. Telephone: (501) 376-6836. Telex: 4949415 HEIFER. The deadline for registrations is July 15.

Coping With Drought in Madras



by Dr. Kyung Yoo, WHAP Consultant from Dept. of Agricultural Engineering, Auburn University

The Madras Zonal Office of the Catholic Relief Service-USCC in India held a workshop in Salem, Tamil Nadu February 6 - 11. Dr. Kyung Yoo was invited to lecture on topics of water harvesting and soil conservation engineering. Experts in sociology, forestry and agronomy also lectured to the 33 participants present. The participants were staff or counterparts of either CRS or local nongovernmental organizations.

The workshop consisted of four days of lecture and two days of field trips to learn community organization and how to plan, design and implement structures for storing scarce water.

The zonal area has experienced several years of severe drought which has caused not only dried tanks but lowered water levels in wells. Water supplies for irrigation, animal watering, household use, and drinking water have all been impacted. In addition to the dry weather, sedimentation in tanks and excessive use of well water also contribute to water shortage problems.

The workshop was the second of its kind in this zonal area. Dr. Yoo also participated in the first workshop which was held in 1988 at the same location. There are several success stories from the participants of the first workshop. In fact, a week after the second workshop, there was a meeting by the participants of the first workshop to evaluate and exchange experiences. Unfortunately, the consultant was unable to attend due to a restricted travel itinerary. The zonal office has already invited the consultant to organize the third phase of the workshop in 1990. The consultant was very pleased to share his expertise and to help this group in their struggle for survival through the persistent drought.

Madras workshop participants inspecting tank construction: D. Theophilus, P. Ignatius Rosario, Leo D'Costa, Dalton Melder, Christuraj Puthotta, Fr. A. Arulraj, Reynald Vincent, J. C. Kerketta, Fr. Soosai. G., Job Thekkedath, C. J. D'Couto, Nikhil Hazra, C. H. Venkataratanam, Fr. P. C. Paul, Naodup Dorjee, P. Balaramnaidu, Lucas Babu, Zacharias Suriw, Fr. John Thayil, P. J.Varghese, Fr. Joseph Mangalath, Everest D'Mello, Valarian D'Silva O. F. M., Fr. Rayappa, S. Arul Raju, Fr. J. Antonysamy, Y. L. Jayaraj, Fr. P. Lourdusamy, C. Ganesan, D. Rajendran, K. Siva Prasad, Johny Padua, and A. Raja Mohammed. Additional trainers were Dr. M. L. Santhanam, Deputy Director of Psychology, N.I.R.D.; G. C. Siluvappan, C.B.C.I. Centre; P. Subramaniyam, Director, Center for Development Research and Training; T. Ganapathi, Additional Director of Agriculture; and G. Arumai Singh, Chief Engineer, Dept. of Agricultural Engineering.

Photo: K. Yoo

Auburn University Receives Endowment to Develop International Aquaculture Network

A worldwide database will soon be established to access aquaculture scientists (not limited to Auburn graduates) around the world, along with the latest research information useful for fish production in the developing world. This breakthrough for the International Center for Aquaculture will be made possible through an endowment established by an Auburn alumnus and his wife.

The ICA began work on this database in 1984 but it has remained in the early stages of development due to inadequate funding. Bryan Duncan, Professor, Associate Director of the ICA, and WHAP technical coordinator, says the funds will also be used to publish factsheets on the latest research and provide information to network participants. This information network should prove useful to development organizations, especially for identifying technical resources within their program countries.

PVO Field Projects Assess WHAP's Impact

Six projects have conducted field assessments of the Water Harvesting/Aquaculture Project's impact on their projects and their intended beneficiaries. The questions they were asked to answer were as follows:

Utility of Technical Assistance to PVOs and Villagers

• What evidence is there that technical assistance and training provided through WHAP is directly useful - for example, is the assistance oriented to practical needs of PVO field staff and counterparts; are types of interventions suggested by technical advisors feasible in light of budgets and technical capabilities; and are these interventions adapted to or consistent with social and cultural systems of client communities with which you work?

• What evidence is there that WHAP strategies have benefitted the target population, and that those benefits wil be realized equitably across the community (that is, both women and men benefit from and contribute to the activity)?

Monitoring Methods

• How practical is the three page progress reporting system disseminated in 1988—how well does the methodology work, is the system responsive to the needs and capabilities of those who are supposed to use it, and what alternative approaches might be preferable?

Sustainability of Intervention

• What evidence is there that water harvesting and/or aquaculture activities will continue once WHAP comes to a conclusion, or once the PVO leaves?

Economic Benefit, Food Security

• How many people were impacted by this pond project and what impact did it have on their food security?

• What economic value, if any, has been derived from this pond project by the beneficiaries?

• What did the beneficiaries have to spend to become involved in this pond project, and afterwards, to sustain it?

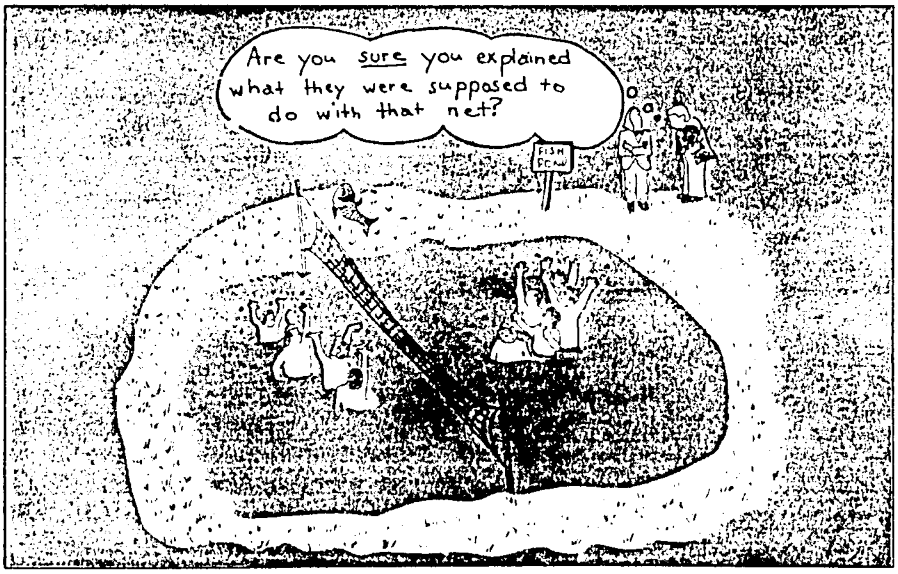
Three PVOs on three continents representing six projects at various stages of development each took several days to answer these questions. They were asked to have someone from another PVO assist them. CARE/Guatemala was assisted by LWR's headquarters representative to the Advisory Council, HPI/Thailand was assisted by SCF/Thailand, SCF/Nepal was assisted by CARE/Nepal, HPI/Sierra Leone was assisted by the United Christian Council of Sierra Leone, and SCF/Bolivia and Bangladesh conducted the evaluation alone.

In the next few months, the Center for PVO/University Collaboration in Development, with the help of the WHAP Advisory Council, will be assimilating these results and drawing some conclusions from the experience. WHAP has been a pioneer in terms of developing a structure for applying a particular university technical expertise to PVO projects in the developing world. As the project holder, the Center for PVO/University Collaboration in Development would like to submit definitive evidence that the cross-fertilization of university extension with the project implementation skills of private voluntary organizations yields great rewards to the population of the developing world.

Watch for the conclusion of this article in the next/last issue of **PONDERINGS.**

PVO Representatives to WHAP Advisory Council

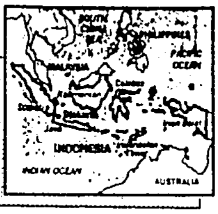
CARE
Sandra Laumark
Church World Service
Nancy Nicalo
Catholic Relief Services
Gary White
Heifer Project International
Robert Pelant
Lutheran World Relief
Tom Edwards
Save the Children Federation
Jim Worstell



Where in the World Is WHAP in 1989?

In 1989 WHAP consultants have provided technical and training consultancies to: CARE/Guatemala, HPI/Thailand, SCF/Thailand, CRS/India, HPI/Indonesia and CRS/Morocco.

Planning for Project Independence



The HPI/Indonesia project illustrates the total cycle a field project will ideally complete when it incorporates a water harvesting/aquaculture component.

PROJECT HISTORY

The PUSPETA Livestock, Poultry and Aquaculture Demonstration and Training Project is located in Klaten, Central Java. PUSPETA, a farmers service center, began in 1979. By 1982, Heifer Project International had recognized the outstanding training and extension work being done by PUSPETA through the Dairy Training Center in Jatinom and decided to support that work.

In 1984, HPI implemented a project which was to integrate several farming systems and to utilize knowledge gained by PUSPETA over the past five years. Emphasis would be placed on fattening bull-calves for beef with crop by-products; chicken-, quail- and duck-rearing; and using poultry manure as pond fertilizer for carp, tilapia and prawns. The plan was to conduct trials involving differing fish densities, species, and feeding programs. Villagers would be involved in the project at all levels but not on a large scale until PUSPETA had determined the most appropriate methods of integrated farming for this region. The government of Indonesia had agreed to provide credit for pond development to farmers selected for intial involvement in the aquaculture part of the mixed farming system. Success hinged on having expert consultations available at several key stages of the project at little or no cost to HPI or PUSPETA.

TRAINING

Training was a key element in implementing the project. HPI's goal for the initial training was to "stimulate people to think about aquaculture projects." During the first year, it was focused on the staff. Directors became aware of WHAP technology. In late 1985, the PUSPETA Jatinom Dairy Training Center served as the site of a WHAP training for the Asia-South Pacific region. Five Indonesia staff attended that introductory training: Messrs. Muhammad, Sudadi, Wibisono, Azis and Wurjanto. Then, field trials were instituted and WHAP assisted the PUSPETA staff in designing a training curriculum. When results were accumulated and appropriate systems identified later, farmers were trained on their farms and at the pond demonstration site. Extension work, coordinated with the government fisheries office, began in year two.

An integrated tilapia/poultry system at HPI/Klaten. This is where the technology for extension to farmers was developed. Fish Project Coordinator, Bambang Wibisono, appears to be camera shy. *Photo: Thomas Popma*

TECHNICAL CONSULTATIONS

From 1985 to 1989 seven technical visits were made by WHAP consultants--four of them by the same consultant. The first visit occurred immediately before the 1985 training. The consultants worked with PUSPETA to develop a long-term pond management scheme including integrated agriculture/aquaculture and rice/fish production and modification of the pond complex at Jatinom to permit effective operation. The next visit, less than a year later, addressed issues of feeding, construction problems, and production trials. The recently hired aquaculture technician worked closely with WHAP consultants. In later visits, consultants reviewed fish production trial management strategies and developed a protocol for the next series of trials. As capabilities of PUSPETA's technicians grew, consultants introduced more advanced subjects like sex reversal and producing steady fingerling supplies.

WEANING

After four years of involvement with WHAP, it is evident that the HPI/PUSPETA program has gone through important logical steps in introducing aquaculture to the farmers of the Jatinom area:

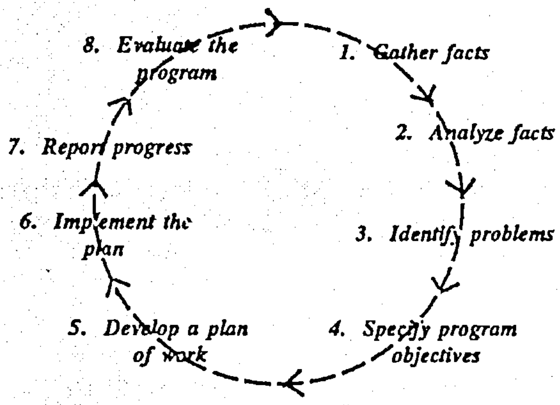
1. Directors became aware of the possibilities through training.
2. Infrastructure development received special attention.
3. Field trials were conducted to determine the approaches most suited to the region and culture.
4. Following successful tests, an extension program to farmers was implemented.

HPI has carefully laid the groundwork for the eventual weaning of this project from assistance once farmers have fully adopted the technology. WHAP, on the other hand, was able to increase HPI's capacity for providing assistance demonstrating the strength collaborative projects such as WHAP have in accessing resources as they are needed.

Technical Notes

by Dr. Bryan Duncan and Alex Bocek, Auburn University

During visits to many projects WHAP consultants have been asked to outline the steps required to implement a project or program in water harvesting/aquaculture. Program development involving an extension effort is a logical step-by step process. The following diagram outlines this process. When these steps are followed, all of the inputs required in a programmed effort can be identified and their timed application scheduled in an orderly fashion. This helps all involved parties understand their roles and provides a basis for them to evaluate their efforts.



Short manuals on extension programming and methodology which explain basic extension principals have been developed by many universities and extension services in the USA and should be useful for PVO program planners and field staff engaged in extension. Certain extension materials are available by writing:

Dr. Bryan Duncan
International Center for Aquaculture
Auburn University, AL USA, 36849

Peace Corps produces many useful publications including manuals, reprints, packets and case studies to service technical field needs. Development agencies may obtain copies free of charge. For more information write to:

Peace Corps Information Collection and Exchange
806 Connecticut Avenue, N.W.
Washington, D.C. 20526, USA

The National Academy Press publishes reports of relevance to development agencies. Reports are illustrated and contain references and contacts. Numerous titles are available. For information write to:

Commission on International Relations (JH-217)
National Research Council
2101 Constitution Avenue
Washington, D.C. 20418, USA

The Appropriate Technology Sourcebook: *Volumes I and II provides guides to practical books and plans for village and small community technology. These books are available at cost from:*

Appropriate Technology Project
Volunteers in Asia, Box 4543
Stanford, CA 94305, USA

PONDERINGS
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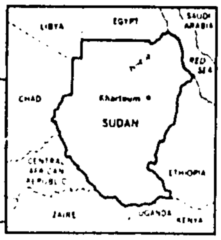
A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Summer/Fall 1988



New Water Resources for Sudan Refugees

People impound water for a variety of reasons but the two major motivations are: (1) an insufficient water supply, and (2) the control of destructive water. The Water Harvesting/Aquaculture Project has provided feasibility studies and technical backstopping to all kinds of ponds. In Bolivia, a CARE project prevents erosion and uses its new water resource for aquaculture, agroforestry and brickmaking. In Indonesia, an HPI project is raising fish in rice paddies. Chickens live in cages over ponds in Guatemala and their droppings feed tilapia. In other places, impounded water irrigates vegetable gardens, waters livestock and/or provides domestic water.

East of Khartoum in Sudan, 70% of the rainfall occurs from July to September, but the soils, once saturated, absorb little water. In the Karkora refugee settlement, a horse-shoe shaped diversion ditch has been dug around the village to prevent flood damage during the rainy season. Local technicians have recommended placing a hafir (a pond for harvesting runoff water) on the east side of the village to take advantage of this diverted water. Between 1917 and 1975, over 800 hafirs were construced in Sudan. Many are in critical use along nomadic routes as water sources for cattle. A major constraint on their use is that evaporation rates are so high that a year-long supply is not possible. In a country like Sudan where drought has been prevalent for several years, the most important factor to consider in designing a pond is the loss of water through evaporation from the water surface. By increasing depth, however, it is possible to reduce surface area.

There is always plenty of activity around the wells at Karkora. Photo: Save the Children

WHAP consultants Thomas Popma

continued . . .

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Sudan

Continued from page 1

and Jean-Yves Mevel visited this Save the Children project last May. To prevent the evaporation of the pond before the end of the nine-month dry season, they recommended parallel hafirs be built, given the water supply is sufficient. Drawing from the ponds sequentially— emptying the first one, then the second, and so on—reduces the amount of surface area and hence, loss of water through evaporation.

They also addressed water management considerations. If the water requirement is about 4 liters per person (for drinking) for 250 days of dry season, 11,000 m^3 must be stored. Assuming that at least 50% of the water is lost through evaporation, the total water storage capacity is 22,000 m^3. This means that three 10,000 m^3 hafirs are needed for the Karkora refugee camp to satisfy its domestic water needs. Obviously, a management strategy is essential to ensure a population of 11,000 people having enough water to last until the rainy season. During dry periods, villagers have traditionally relied on livestock sales to support their food needs; however, with refugees currently receiving only a minimum of water from the few wells at Karkora, there is almost no water left for livestock. The hafirs will alleviate that strain.

The principal function of all hafirs in this region is for water storage; however, the refugees of Karkora have expressed an interest in fish production for local consumption and trade. Consultants Popma and Mevel recommended stocking the hafirs with *Tilapia nilotica* for a number of reasons. It is endemic to the region and it reproduces freely in ponds. Furthermore, the hafir's four to five month growing season will provide fingerlings available for harvest and restocking the following year. Most interesting for Sudan, this species even tolerates slightly saline water. Unlike most markets, the refugees at Karkora said they preferred lots of small fish to less larger fish. Typically tilapia are managed to reach a larger size by preventing reproduction. With no natural enemies around, however, a mixed sex population of tilapia is very prolific and the pond tends to overpopoulate in a relatively short period of time. Since the Karkora hafir will be primarily for domestic use and cannot be fertilized, in 8 months 700-1000 kg/ha would probably be produced rather than the 1500-2000 kg/ha from a well fertilized pond. Taking into consideration the planned size of the first Karkora hafir, the refugees could expect 200-300 kg of tilapia in yearly harvest from the first pond alone.

Short Courses Available

Using Perennial Sesbania *Species in Agroforestry Systems*

The International Council for Research in Agroforestry and the Nitrogen Fixing Tree Association (NFTA) are co-sponsoring an international workshop on the perennial *Sesbania* species in agroforestry systems for March 27-April 2, 1989 in Nairobi, Kenya. The goal of the workshop is to set a course for future research and development activities for this valuable nitrogen-fixing species. Inquiries should be directed to Mr. Bill Macklin at NFTA, telephone (808) 259-8555 or telex 510-100-4385.

Desert Resource Integration and Utilization

The University of Arizona will offer an international short course designed for professional consultants, managers, architects, ministry employees and planners in arid and semiarid lands involved in the design and operation of systems for food production, alternative energy, shelter, water utilization, water conservation and waste recycling for family and small-scale village development. The course is scheduled for May 14-26, 1989 in Tuscon, Arizona at a cost of 5,000 US$ for all materials, lodging, food and local transportation. For further information call Dr. Kenneth Foster at (602) 621-1955 or telex: 156-1507 ARID UT.

WHAP Consultants Plan Full Year

The fifth and final year of the Water Harvesting/Aquaculture Project will be no less busy than the first four. Water engineering and integrated agri/aquaculture specialists from the International Center for Aquaculture, under subcontract with the Center for PVO/University Collaboration in Development, will be visiting project sites around the globe during fiscal year 88/89.

Their agenda includes both training and review of current project activities. They hope to prepare project participants for the weaning which will occur as of June 1989 when WH/A project funding ends. Arrangements must be made now if farmers and villages are to continue to improve their water harvesting and integrated agri/aquaculture methods. Consultants expect the transition will not be difficult since an essential element of each consultancy has always been identifying and encouraging communication with expertise locally available.

A tentative schedule follows. If you would like to request assistance, there may still be time. Please notify your WH/AP Advisory Council representative.

TECHNICAL ASSISTANCE SCHEDULE

AFRICA
Morocco(CRS)-February
*Sierra Leone(HPI)-May
*Zaire(HPI)-May

ASIA
India(CRS)-January
Thailand(HPI/SCF)-January/February
Indonesia(HPI/SCF)-February

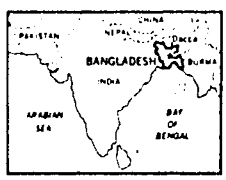
LATIN AMERICA
Guatemala(CARE)-January
*Bolivia(CARE/SCF)-March
*Ecuador(SCF)-March

* *STILL TENTATIVE*

SCF Impact Area Manager, Alamgir Bhuiya, holding mirror carp harvested from Kunda fish pond project. Banana trees growing near pond are integrated with papaya.

Photo: Alex Bocek

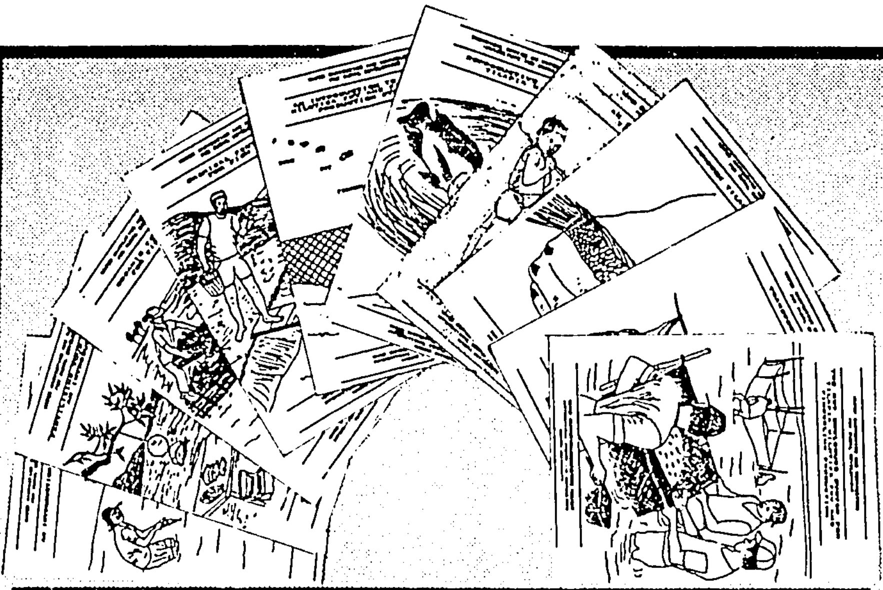
Save the Children Ponds in Bangladesh Destroyed by Flood



In August 1988, Bangladesh experienced record flooding which covered 75% of the country's landmass and left 25 million people homeless. Prior to this disaster, Save the Children Federation had some very exciting pond projects underway. In fact, during his last visit in April 1988, WHAP consultant Alex Bocek took part in a community pond excavation involving several hundred women who had come for a conference for women volunteers organized by Save the Children. It was an enriching experience for all those involved.

The Kunda project in Bangladesh received $14,867 from WH/AP project support funds in 1987 which were used to develop a 2-hectare community pond for fish culture. This pond had already been partly excavated during a one-week work camp organized by local youth groups in which over 1000 men, women, and children assisted in some way. The complete excavation required much more work. The pond was intended to provide a source of reasonably priced nutritious food as well as to create an income generating source from which the village of Kunda could independently finance programs in the health and education sectors. The project had expanded to seven ponds and completed its first production cycle before the devastating floods of the summer.

We regret what has happened to the Bangladeshi people and wish them every success in the rebuilding process. The picture shown here was taken in Kunda; we hope it will serve as inspiration to the Save the Children staff in Bangladesh and the people of Kunda.



Practical Booklets On Managing Fish Ponds Available

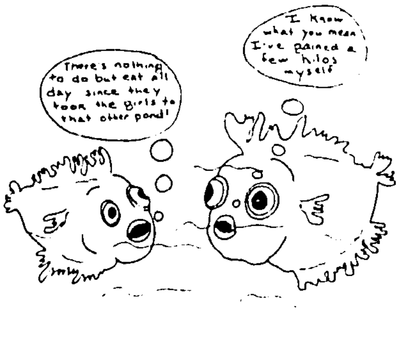
Over the course of the project, WH/AP has developed ten manuals specifically with PVO developmentalists in mind. Agriculturalists or natural resource technicians will feel very comfortable using these manuals with their non-technical approach. PVO field offices should direct requests for booklets by name to WH/AP representatives at headquarters offices in the United States or directly to Dr. Bryan Duncan at Auburn University.

TECHNICAL SERIES ON WATER HARVESTING AND AQUACULTURE FOR RURAL DEVELOPMENT

1. Introduction to Aquaculture
2. Fertilizing Your Fish Pond: An Introduction
3. Organic Fertilizers For Fish Ponds
4. Chemical Fertilizers For Fish Ponds
5. Transporting Fish
6. An Introduction To Tilapia Nilotica Fry And Fingerling Production Systems
7. Reproductive Biology Of Tilapia Nilotica
8. An Introduction To Tilapia Culture
9. Monosex Tilapia Culture
10. The Net Enclosure System for Tilapia Nilotica Fry and Fingerling Production

PVO Representatives to WH/AP Advisory Council

CARE
Tom Zopf
Church World Service
Nancy Nicalo
Catholic Relief Services
Gary White
Heifer Project International
Robert Pelant
Lutheran World Relief
Tom Edwards
Save the Children Federation
Jim Worstell



Monosex Tilapia Culture

WH/A Project Winds Down in Fifth Year

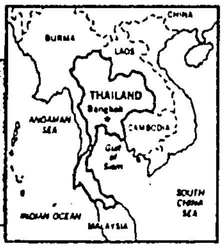
In the final year of any project, funders and participants alike are anxious to assess accomplishments. Did we do what we set out to do and was it done well? If the answer is yes, what elements made it successful? If no, what should have been done differently?

WH/AP is a collaborative effort involving the Center for PVO/University Collaboration in Development (formerly the Joint PVO/University Rural Development Center) as project holder, the International Center for Aquaculture of Auburn University as technical assistance provider (under subcontract with the Center), and six private voluntary organizations--CARE, Catholic Relief Services, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children Federation--as field project implementors.

Each member of the project is represented on WH/AP's advisory council which has the responsibility for making all programmatic decisions. When faced with the question of how this unusual project would be evaluated, it was the Council who suggested that the PVOs collaboratively evaluate WHAP's impact on their field projects. Hence, beginning in January 1989, selected projects will spend 2 - 3 days verifying the information collected on their respective projects by the Center and answering key questions about the suitability of the water harvesting and integrated agri/aquaculture technology to their villages.

By having a visiting PVO representative assist in the evaluation, it is hoped that the results will be more objective, that valuable knowledge of the potential for village level water harvesting and integrated agri/aquaculture will be shared, that field directors will gain new insights in evaluation techniques, and inter-agency collaboration will be further promoted.

Karen People Becoming Fish Farmers



The Karen (one of the "Hill Tribes") are a minority group numbering about 400,000 in the Chiang Mai province of Thailand. Unlike communities in other regions, the Karen have had little previous experience with aquaculture. They tend to be subsistence farmers with very limited resources.

The Center for the Uplift of the Hill Tribes (CUHT) is run by the Thailand Karen Baptist Convention which has been active in the northwest for over 30 years. They have several ponds at this training center which they are developing with the assistance of Heifer Project International and WH/AP.

The Center is an agricultural experiment and demonstration center, serving as the nucleus for an extensive village extension program and as a meeting place and training center for Karen adult leaders involved in community development. The Karen villagers began raising fish in ponds to supplement their incomes and nutrition several years ago but have had limited access to technical inputs or training until the project became involved with WH/AP. Village ponds, ranging in size from 100 m^2 to 1000m^2, have since been built in three major areas outside Chiang Mai. Almost all are family-owned.

Sunny Danpongpee is a Karen and manages CUHT for the Baptist Convention. He attended WH/AP's introductory water harvesting and integrated agri/aquaculture training held in Indonesia in 1985. He had had two years of experience with under-exploited CUHT ponds prior to the training. Bryan Duncan, WH/AP consultant, visited CUHT after the training and offered suggestions for improving the ponds' design and management.

That brief consultation laid the groundwork for a proposal for assistance from HPI to improve existing fish pond construction and management and to integrate swine and duck raising.

HPI approved the proposal because the technology would be transferred in three ways: 50 students annually would work directly with the ponds and then re-enter their communities with their acquired knowledge, the village development staff of nine at CUHT could incorporate the technology into the extension program, and the demonstration ponds would be clearly visible to several hundred Karen visitors to the Center each year.

Russell Gaulin, an aquaculture graduate from Auburn University, was hired by HPI in 1986 to assist the Karen Aquaculture Project and has been training his successor Porn Sak, a Karen extension worker, for about one and a half years. In 1987, the Karen ponds received $15,000 from WH/AP to partially cover the costs of Gaulin's salary.

CUHT has received 5 visits from WH/AP to date and Thomas Popma and Alex Bocek will be visiting the end of January. Gaulin reports a growing confidence in integrated agri/aquaculture in the region. He and Porn Sak have been mounting their mopeds religiously to deliver training and technical advice to over 12 villages throughout Chiang Mai province. Their topics range from composting, to pond fertilization, to harvesting techniques, to planting grass on banks to prevent erosion, to sealing ponds against leaks, to net making and repair, to record keeping. They find that villagers become interested as a result of farmer field trials. When the kilos of fish are weighed in, they become convinced that it's time to excavate a pond. CUHT, along with the Department of Fisheries Station at Mae Jo, has been the site of several 3-day seminars for farmers, providing excellent hands-on opportunities.

Karen farmer feeds fish special treat of termites. *Photo: Auburn University*

Technical Notes
by Dr. Bryan Duncan and Alex Bocek, Auburn University

The Asian Institute of Technology (AIT) provides advanced education in engineering, science and allied fields through a variety of academic, research and special programs. An average of 120 combined faculty and research staff work at the institute. A brochure describing AIT's programs and admission procedures is available. Write to:

Division of Agricultural and Food Engineering
Asian Institute of Technology
G.P.O. Box 2754, Bangkok
THAILAND

The International Center for Aquaculture (ICA) at Auburn University has received numerous requests for information on aquaculture during the course of the Water Harvesting/Aquaculture Project. Many of these requests have dealt with courses and degree programs in aquaculture at US universities. The following publication lists the major US universities, their courses, facilities, degree programs and staff:

"Major Aquaculture Associations, Education and Research Resources in the United States"
Field and Special Programs Division, Room 300, National Agricultural Library
Beltsville, MD 20705

From Great Britain, the University of Sterling (Stirling FK9 4LA, GREAT BRITAIN) conducts research on a variety of aquaculture topics of relevance to developing countries.

One hundred and eighty-five ongoing global, regional and national aquaculture aid projects supported by 20 donor agencies are listed in the FAO publication, "Aquaculture Aid Profiles - February 1988". Copies may be obtained by writing to:

Food and Agriculture Organization of the United Nations
Publications Division, Via delle Terme di Caracalla
00100 Rome, ITALY

Specialized aquaculture equipment and chemicals are available from numerous companies. Comprehensive guides for categories of equipment and chemicals may be obtained in the following:

"Buyer's Guide"
Aquaculture Magazine
P.O.Box 2239
Asheville, NC 28802 USA

"European Aquaculture Trade Directory"
European Aquaculture Society
Prinses Elisabethlaan 69
B-8401, Bredene, BELGIUM

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Center for PVO/University
Collaboration in Development
Bird Building
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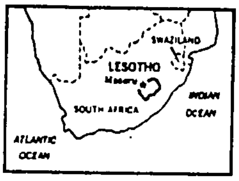
PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Winter/Spring 1988

Thaba-Khupa Doing Great Things In Lesotho



Imagine a community which produces its own fruits and fresh vegetables and meat supply, makes its own clothes and sandals, builds its own beds and school desks, and teaches health education.

Meet the Thaba-Khupa Ecumenical Center, a farm institute in Maseru, Lesotho. The Center is involved both in teaching and production comprising a variety of units: poultry, farm, health, metal working, home economics, leatherwork, dairy, and fish. The school has about 100 residential students in its two-year program and is forced to turn many more away each year for lack of facilities. Shorter courses are also offered.

Thaba-Khupa's philosophy is to cover as many topics as possible within a given subject during the two-year length of the course. Products are sold and profits reinvested into the school.

Integrated fish and duck production is an element of the school's program. Catfish and common and chinese carps are fed droppings from ducks and waste duck feed that falls through cracks in the floating feeding platforms. The students sell both fish and ducks on the local market which includes the many Chinese who live and work in Lesotho.

Headmaster, Mr. Mohau Mahase, hosts Duncan on extension visits to former students. Extension is an integral part of Thaba-Khupa's program. *Photo: Bryan Duncan*

Fingerlings are purchased from the Government's Fisheries section in Maseru and ducklings are purchased from South Africa. There are five fish ponds measuring from 1000 square meters to 4000 square meters. Thaba-Khupa is the single fresh fish vendor in all of Lesotho.

Fish in the Thaba-Khupa ponds have several obvious enemies including otters, clawed toads, and herons. Other less obvious enemies are the lack of a tradition of aquaculture, leaking pond walls, an insufficient food supply, and inadequate rainfall or inadequate

(continued on page 2)

PONDERINGS, *the newsletter of the Water Harvesting/ Aquaculture Project, is issued quarterly by the Joint PVO/ University Rural Development Center, Bird Building, Western Carolina University, Cullowhee, NC 28723. Telephone (704) 227-7492; Telex 493-2268. Inquiries and submissions are welcomed and should be addressed to Phyllis Stiles, Editor.*
The Water Harvesting/ Aquaculture Project (WHAP) is an AID funded endeavor begun in 1984. Six private voluntary organizations-- CARE, Catholic Relief Services, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children-- manage and/or sponsor field projects around the developing world to which the WHAP supplies appropriate technical assist-ance and training through a subcontract with the International Center for Aquaculture at Auburn University. The Joint Center provides overall project management and acts as communications link with all participants.

Collaboration Thriving in Sierra Leone

The United Christian Council of Sierra Leone appears to be doing something very right. The Near East Foundation (a member of the Joint PVO/University Rural Development Center network) has recently hired an aquaculture specialist and Auburn alumni, David Reside, for two years to work with the aquaculture project in Sierra Leone. NEF is also providing funds for supplies and the cost of training a Sierra Leonian at Auburn University.

Heifer Project International has sponsored this project for some time and has taken advantage of the expertise provided by WHAP.

At the Joint Center, we are extremely pleased to see this kind of cooperation between indigenous organizations/institutions and U.S. organizations/institutions. When the collaboration multiplies as it has in Sierra Leone, we are elated. Only by pooling our resources, our energies, our dreams, will we make an impact on the problems faced by the developing world.

Thaba-Khupa

Continued from page 1

water harvesting where rainfall is sufficient. Mrs. Koali, the Center's director, recently hosted Dr. Bryan Duncan of the Water Harvesting/Aquaculture Project on a technical assistance visit there. Duncan was asked by Thaba-Khupa's WHAP sponsor, Church World Service, to assess the aquaculture project's needs and to recommend improvements.

Duncan agreed with Koali that erosion of agricultural soils is a problem of emergency proportions. He saw oppportunities for improving the harvesting and storage of water which would increase the potential for agriculture and preventing further erosion. The government is making efforts to educate the public in soil conservation measures but is limited by resources and manpower. Unmanaged communal ponds built in 1964 by the Government Fisheries Section further testify to the same hindrance.

Duncan identified locally available supplemental and inexpensive feeds during his visit which could increase fish production if implemented. Blood and bone meal, leaves of the abundant willow and leguminous trees ground into meal, and flour sweepings and brewery wastes were offered as viable options.

There is an opportunity for aquaculture to be more profitable for Thaba-Khupa. To reach that goal, Duncan recommended increasing the price of the fish first of all. He felt that the current price was too low based on the evident demand and the price of frozen and canned fish. He also suggested a schedule of complete harvesting and restocking to provide the ponds with a manageable routine.

In view of the eroded condition of the watersheds which feed the reservoirs supplying the Institute's water needs, so basic to fish farming, Duncan recommended the addition of soil and water conservation into the curriculum. The first project in that area would be to draw up a plan and proposal for improving the catchment area by planting trees and cover crops, building a small dam, endorsing little or no-till farming and other conservation practices, and working with farmers on the watershed to accomplish this.

We hope to hear more from Thaba-Khupa-- doing great things in Lesotho!

Center Director, Ms. Violet K. Koali, and Headmaster in front of campus cottage.
Photo: Bryan Duncan

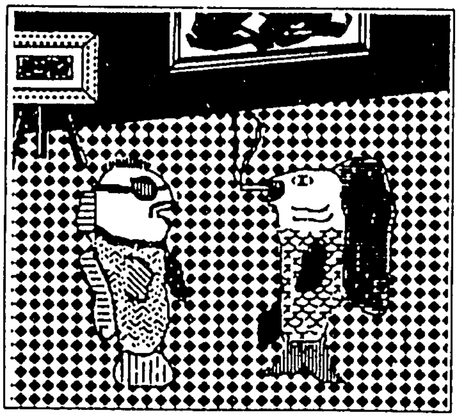
On The Road With The ICA

Technical consultants from the International Center for Aquaculture paid visits to Indonesia, Thailand, Zaire, and Lesotho in January; India in February; Bolivia, Bangladesh, and Nepal in April; and Sudan and Sierra Leone in May.

The WHAP Advisory Council requested these visits for their respective organizations last year after having been advised by field personnel of their needs. Once needs were identified, the ICA team scheduled trips to use manpower and funds as efficiently as possible.

The Council is currently comprised of Tom Zopf for CARE, Nancy Nicalo for Church World Service, Jeanette North for Catholic Relief Services (CATHWEL), Robert Pelant for Heifer Project International, Tom Edwards for Lutheran World Relief, Jim Worstell for Save the Children Federation and Bryan Duncan for the International Center for Aquaculture.

Scheduling for the 88/89 fiscal year is underway now. Participating PVOs should contact Council representatives if water harvesting/ aquaculture/ integrated agriculture advice is needed. Consultants are prepared to address issues ranging from prefeasibility studies to post-project impact assessment.



"Fish Culture"

From the desk of:

Nancy Blanks, Project Director

Recently, CARE's Tom Zopf, one of WHAP's original Advisory Council members, shared his impressions of what we have learned from the Water Harvesting/Aquaculture Project. Zopf confessed that in the beginning he, of all council members, was probably the most pessimistic about the potential of the project.

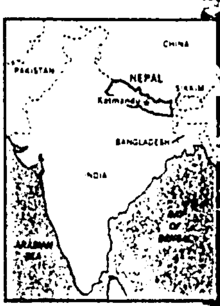
An interesting thing happened, however, which changed his attitude. The Advisory Council, made up of all institutional participants in WHAP, opened the door to true collaboration. Early on, the PVOs took the lead in the project through the Advisory Council. They spoke clearly to both the managers of the project (Joint Center) and to the technical providers (Auburn University). A decision to provide regional training for PVO staff members across the developing world was made at the wishes of the PVO participants at the first Council meeting held after notification of funding. Other decisions followed and WHAP became a process in the truest sense of the word. The novel project that almost everybody said would never work was on its way.

AID's Office of Agriculture of the Bureau for Science and Technology and the Office of Private and Voluntary Cooperation of the Bureau for Food for Peace and Voluntary Assistance funded the Water Harvesting/ Aquaculture project for five years through June 1989. Over that period 41 countries have received technical assistance and/or training through the project. One hundred and one PVO staff and their counterparts have been trained directly through the project and many more indirectly. And, perhaps most importantly of all, a systematic way of connecting technical expertise to PVOs at the grassroots level has been pioneered.

With WHAP's fifth year fast approaching, Zopf outlined the forms of collaboration he felt the universities, PVOs, and Joint Center could explore in the future . Universities can develop new sectors of interest for the PVOs--as proven by WHAP. The Joint Center can develop awareness of PVO work among the university community; promote cost sharing activities; develop a skills roster and act as clearinghouse for publications, collaborate in joint pilot projects; and promote grants for universities to provide technical assistance to PVOs. PVOs can help universities in their project design efforts to include such elements as community maintenance and management of development systems. They can jointly bid on contracts, share PVOs' existing host country infra-structures, and offer excellent sources for internship positions. PVOs can also collaborate by sharing technical expertise and project management skills.

The Water Harvesting/Aquaculture Project has been a great learning experience for all of us. The Advisory Council is currently discussing follow-on funding to allow WHAP to continue as is or perhaps in an expanded capacity. If you have benefitted from this project and would like to see it continue, please let us know by letter. Your input is very valuable to us.

Nancy L. Blanks



A birds-eye view of Nepal's heavily-terraced Gorkha District. *Photo: Gary White*

Aquaculture Goes To New Heights In Nepal

by Mark Williams, SCF/Nepal Program Advisor

Bank Approves Loans For Aquaculture Farmers In Gorkha

Until very recently aquaculture was not considered feasible in the middle hills of Nepal. The Government of Nepal initiated a large aquaculture project in the Terai Region (plains area bordering India), but no initiatives had been undertaken in the middle hills area.

Through the Water Harvesting/Aquaculture Project, Bryan Duncan visited Nepal in February 1987 and met with Keith Leslie, SCF Nepal's Director, and Bharat Sharma, Director of Nepal's Fisheries Department. A field visit was arranged to assess the feasibility and potential for aquaculture in certain areas of the Gorkha District, Gandaki Zone, the area in which SCF had decided to concentrate. It was determined that not only was aquaculture feasible, but it had tremendous potential to provide a substantial source of nutrition and income to the communities.

Both SCF/Nepal and Sharma became very excited about aquaculture projects in the area and initiated steps to promote the concept. Many farmers were interested. After surveying potential sites and interviewing farmers, two were chosen as the best candidates for first year pilot/demonstration projects.

All parties concerned felt it essential that a system be installed that would insure sustainability and the potential for expansion of aquaculture by interested farmers in the future. It was decided to try to create a linkage between farmers and banks. Aquaculture being a new concept, both farmers and lending agencies were reluctant to take the risks involved in loans. Banks in general were very hesitant to give loans to small farmers because of poor repayment percentages. The reasons for this varied, but the major reason was poor feasibility analysis and little to no follow-up assistance to the entrepreneur.

In an effort to improve the situation, the Department of Fisheries put together a complete feasibility and profit analysis for the farmers and the bank. It was agreed that SCF would provide technical assistance and the farmers would procure the loans.

Sharma and I accompanied the farmers, Rishi Ram Sharma and Kim Bahadur Adhikari to the Agriculture Development Bank in Gorkha. The Bank's initial response was negative. An hour's conversation ensued during which Sharma finally persuaded the bank to approve the loans. The farmers were required to put up portions of their land as collateral. I, as SCF Program Advisor in Nepal, found myself to be as nervous as the farmers. Sharma and I, after all, had initiated the idea.

Pond construction began in May 1987. Both SCF and the Department of Fisheries provided ongoing technical assistance. Because of initial delays in acquiring loans, the first year's growing season was shortened by almost four months. Despite the setbacks, the harvest was profitable, the demonstration was a success and the farmers are repaying their loans.

Currently, there are six ponds all financed by the bank--only one year after the project's conception. The two original farmers are integrating banana trees and pig raising with their ponds to increase profits.

We believe the impact of the aquaculture projects is twofold. First, aquaculture projects are providing an added source of nutrition to the community and a means of income generation. Second, the gap between Gorkha farmers and lending agencies has been bridged. Now *all* small-scale enterprise in this area has a better chance of finding funding.

Training participants interview private fish farmer in Kathmandu. Photo: Alex Bocek

CARE and SCF trainees guage stream to determine water volume available for aquaculture / agriculture. David Hughes, WHAP consultant, mans the stopwatch. Photo: Alex Bocek

SCF and CARE Administrative and Program Staff Receive WHIAA Training

Kathmandu was the site of a water harvesting and integrated aquaculture/agriculture training in April. The six-day course included the basics of selecting pond sites, actual visits to potential sites, and lectures and discussions on the multiple uses of harvested water.

Alex Bocek and David Hughes conducted the training, in this fourth WHAP visit since 1985, along with Bharat Sharma (Director), Sukra Pradhan (Fisheries Development Officer), and Deep Swar (Project Leader)-- all, of His Magesty's Government Fisheries Department of Nepal. Field trips included visits to the HMG Fisheries Station and a private fish farm in Kathmandu.

Participants from Save the Children were: Kamal Prasad Bhattarai, Huta Raj Tiwari, Surya Binod Pokharel, and Sita Ram Luitel. CARE's trainees were: Tilak Bahadur Bhandari, Dirgha Jibi Ghimire, Kedar Nath Bhatta, and Maheswar Ghimire.

WHAP consultants also made technical assistance visits to aquaculture farmers involved in the SCF program.

Technical Notes
by Dr. Bryan Duncan and Alex Bocek, Auburn University

"A Guide to Integrated Warm Water Aquaculture", by David Little and James Muir was recently published by the Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland. This book contains a wealth of information dealing with a wide range of activities which can be integrated with aquaculture. Aspects of waste utilization, irrigation water use, and complete integrated systems are discussed. A good book with practical considerations for those interested in integrated aquaculture.

"Fertilizing Your Fish Pond", "Chemical Fertilizers for Fish Ponds", and "Organic Fertilizers for Fish Ponds" are three titles now offered by he International Center for Aquaculture (ICA). The ICA has produced these technical booklets tailored specifically for the participants of WHAP. These are just the first in a series of publications to come in response to the need for technical literature expressed by the PVOs (CARE, Catholic Relief Services, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children Federation) participating in the Water Harvesting/Aquaculture Project. They are illustrated with line drawings and cover frequently questioned topics. If you do not already have cop(ies) and would like to obtain them, contact your PVO representative. The editor requests your input in order to make the booklets as functional as possible.

PONDERINGS
The Joint PVO/University Rural Development Center
Western Carolina University
Bird Building
Cullowhee, North Carolina 28723
USA

PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Fall 1987

Water Harvesting and Aquaculture Development In Guatemala

by Dr. Ronald Phelps, ICA

CARE/Guatemala began a family fish pond extension project in 1984. Currently it comprises over 550 family ponds reaching more than 1000 families in 26 communities within the Alta Verapaz and Chiquimula Departments. This successful collaboration of institutions provides an effective extension program reaching near subsistence level farmers. USAID has provided financial backing; CARE the managerial skills; and a government counterpart, DIGESEPE, and Peace Corps the personnel to conduct the extension activities.

The goal of the project is to improve the nutritional intake of the participants both directly through the addition of fish protein to their diet, and indirectly, through the income generated from fish sales intended to increase resources for buying food.

Environmental barriers include steep slopes which are not suitable for large ponds and are inaccessible to heavy equipment, temperatures which are not ideal for tilapia, and annual dry seasons that cause ponds to dry up.

Generally the ponds are stocked with tilapia or a combination of tilapia, common carp or snails.

WHAP has assisted CARE in evaluating past activities and developing a data collection and storage system that will enable CARE to assess the technologies being extended in terms of their appropriateness and impact. Assistance has been given to help identify bottlenecks in current activities and to propose possible alternatives.

Small-scale aquaculture development efforts worldwide tend to face a common set of problems. CARE/Guatemala's project is no exception. This project must contend with limited land and water resources. Individual farmers in the target group are rarely able to have over 1000 m^2 of impounded water. In Guatemala, the average pond size is slightly over 200 m^2 and few farmers have more than one or two ponds. The challenge is to make these small bodies of water as productive as possible when cash for purchasing feeds or fertilizers may be scarce.

The CARE project has approached the problem of nutrient scarcity by integrating other animal production with fish, including broilers and laying hens, pigs, and rabbits. San Carlos University in Guatemala is working with CARE to develop more practical approaches for livestock production for the participating farmers. DIGESEPE is helping by providing the livestock. This integration increases yields considerably while teaching the farmers to be better animal husbandrists. Moreover, such an approach provides additional income and nutritional alternatives on the farm while encouraging better farm management.

To date, ICA has made three visits and plans the next visit this December. WHAP's involvement over the next year will be to review the progress of various project activities, analyze field data, and help to solve technical problems.

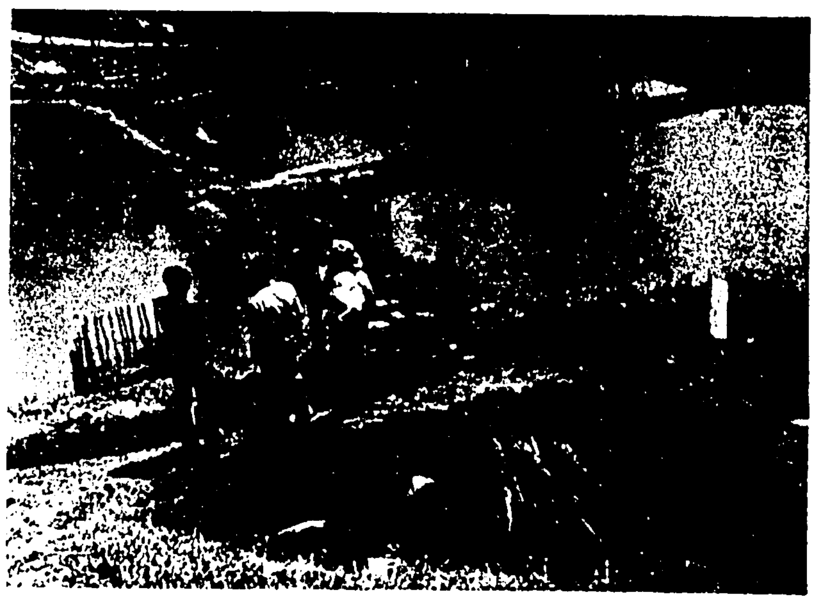


Photo: Bryan Duncan, ICA

CARE/Peace Corps fingerling production ponds. Grass bundles provide environment for spawning and compost corrals fertilize ponds. From left to right: Dr. Smitherman, ICA; Ed Brand, CARE/Guatemala Director, Peace Corps Volunteer, and Corinne Pingel Seltz, Project Manager.

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Leguminous Tree Specialist Visits WHAP-Assisted Project

by Ralph Montee, Joint Center

One of the Joint Center's functions in WHAP is arranging, through the Volunteer Consultant Pool and other sources, for technical assistance beyond water harvesting/aquaculture. One such request for a leguminous tree specialist came from the CARE field project in Bolivia.

The purpose of the CARE project in Bolivia is to help farmers make improvements in the sustainable use of their holdings by encouraging and assisting ecologically sound efforts to protect and utilize their watershed areas and land more effectively. Key activities are the construction of ponds to harvest runoff water for multipurpose use (including aquaculture and integrated agriculture), small rural industry, soil conservation, and the promotion of other environmental improvements such as the afforestation of water harvesting sites and watershed areas.

CARE-Bolivia is concerned with a number of technical needs in various geographic and climatic zones including:

(1) recommendations for improving forests and pastures in watershed areas combining grasses, shrubs and trees;

(2) a comprehensive technical design for integrating lowland agroforestry activities with coffee and other crop production;

(3) suggestions for changes in prevailing slope cultivation practices through new crop combinations and methods designed to control soil erosion and improve soil quality.

CARE sought someone who could identify reliable species, including native ones, which will serve multiple uses--fodder, soil conservation, timber--and which are adapted to local conditions. Nitrogen -fixing species have been identified as particularly vital.

With the help of the ICA, a specialist in leguminous trees and shrubs, Ms. Nancy Glover of the Nitrogen Fixing Tree Association was located. Arrangements were made for a two-week technical consultancy for the CARE WHAP field project in Bolivia July 1-14.

Glover's visit was well received by the project. After her visit, along with a report containing her recommendations for forestry activities, Glover prepared a slide show for CARE on shade trees with coffee and agroforestry systems and ordered a film from the International Research Development Center in Spanish which promotes the use of trees in farming systems. She also sent books in Spanish dealing with coffee management and took seed and rhizobium inoculent for those exotic species recommended.

The Nitrogen Fixing Tree Association

The Nitrogen Fixing Tree Association (NFTA) formed in 1981, is a PVO, not-for-profit association with about 1200 associates in 100 countries which the association serves through a program of communications and research and development. The NFTA is housed by the University of Hawaii. It is committed to the research of leguminous trees and shrubs and making that knowledge available to development organizations.

Why Nitrogen Fixing Trees?

Nitrogen fixing trees are fast growing multi-purpose plants that can thrive in infertile soils and provide products that people need, such as fuel wood, animal feed, fertilizer and timber. In a sense these trees are living fertilizer factories.

Dr. James Brewbaker is president of the NFTA. Although no training is scheduled at the moment, he invites WHAP participants to make requests for training or consulting known to the Association. NFTA's address is P.O. Box 680, Waimanalo, Hawaii 96795 USA. Telephone: (808) 259-8685 Telex: 510100 4385

Photo: Ron P..., ICA

Kirsten Johnson, formerly CARE/Bolivia staff, talks with other CARE employees and aquaculture workshop participants at water harvesting pond in Tarija. This pond was built about a year ago. Water harvesting is only one element of this natural resources management project.

WHAP: Delivering Technical Assistance and Training Around the Globe

If there was ever any question that PVOs would be interested in accessing technical assistance in aquaculture when the water harvesting project began in 1984, that question has now been answered with a resounding "yes." Here is the technical assistance and training response to date:

Visits Planned For This Year

In consultation with project participants, the WHAP technical team has tentatively scheduled the following visits for 1987-1988. In December, representatives will travel to Guatemala. January and February travel will include Indonesia, Thailand, India, Zaire, Zimbabwe, and Lesotho. In April Nepal, Bangladesh, Sierra Leone, and India are scheduled. (India has several PVO WHAP-assisted projects.) And in June, Sudan will be the site of a training.

Aquaculture Training Scheduled at Auburn

The Department of Fisheries and Allied Aquacultures will offer a 15-week Aquaculture Training Program March 26-July 16, 1988.

Lecture topics include principles of aquaculture, water quality, hatchery management, fish reproduction, pond construction, fish nutrition, fish health and aquaculture economics.

Major emphasis is placed on practical training in various techniques essential for successful rearing of aquatic organisms. Each participant gains experience in fish reproduction by spawning and rearing common carp, grass carp, silver carp, bighead carp and tilapia. Techniques for the larval rearing of channel catfish, striped bass, and freshwater prawn are demonstrated.

Each participant is provided a 200 m^2 pond to "culture" a crop of fish. The ponds are stocked with a species similar to those in the participant's area of the world and various pond management techniques are evaluated. Culture techniques to be experienced include use of organic and inorganic fertilizer, agricultural by-products and supplemental fish feeds and monoculture polyculture schemes.

Field trips are taken to government fish hatcheries, private fish farms, fish processing plants, and a feed mill.

Upon successful completion of the program, trainees receive a certificate of achievement in aquaculture training and a letter of evaluation is sent to the participants' sponsors and/or employers. This program is designed for foreign nationals in the developing country context.

Applications should be received by January 15 to receive first consideration as enrollment is limited to approximately 20 students. Cost is $3500 plus approximately $500-$700/month for personal living expenses. For more information, contact Dr. E. W. Shell, Aquaculture Training Program, Auburn University, Alabama 36849-4201 USA. Tel: (205) 826-4786 Telex: 5106002392.

Number of Visits:		85	86	87
1	Bangladesh (SCF/CARE)		1	1
2	Bolivia (CARE/SCF)	1	2	1
3	Cameroon (All PVOs)		1	
4	Congo (CARE)		1	
5	Dom. Republic (CRS)	1		
6	Equador (CRS)		1	
7	Egypt (CRS/CARE)	1	1	
8	Guatemala (CRS/CARE)	1	1	1
9	Honduras (CRS)			2
10	Indonesia (HPI/Clusa/ All PVOs)	1	2	1
11	India (CRS)			1
12	Ivory Coast (OICI)			2
13	Kenya (CARE)		1	
14	Nepal (CARE/SCF)	1	1	1
15	Panama (ALL PVOs)	1		1
16	P. N. Guinea (HPI/LWR)	1		
17	Peru (CARE)	1		
18	Rwanda (All PVOs)	1		
19	Senegal (CWS/CRS)		1	2
20	Sierra Leone (HPI)			1
21	Sri Lanka (CARE/SCF)		2	
22	Somalia (CARE/SCF)		1	
23	Sudan (SCF)		1	
24	Tanzania (LWR/HPI)	1		
25	Thailand (HPI/SCF)	1	2	1
26	Togo (OICI)			1
27	Uganda (HPI)		1	

Legend of PVOs:

CARE	=	Care
CLUSA	=	Cooperative League of the USA
CRS	=	Catholic Relief Services
CWS	=	Church World Service
HPI	=	Heifer Project International
LWR	=	Lutheran World Relief
OICI	=	Opportunities Industrialization Centers International
SCF	=	Save the Children Federation

A Historical Look at Auburn University's International Center For Aquaculture

Editor's note: WHAP's technical assistance and training component is the responsibility of Auburn University's International Center for Aquaculture (ICA). In this issue **PONDERINGS** takes a historical look at the development of the ICA in lieu of *Technical Notes*.

The ICA was established in 1970. In its dedication to international development , it has provided services to 91 countries on 5 continents with a total of more than 132 person years. Because of its affiliation with Auburn University, the Center has several resources including the academic, research and public service programs and professional staff of the Departments of Fisheries and Allied Aquacultures, Agricultural Economics and Rural Sociology, and Agricultural Engineering. Joint collaborative agreements with the University of Arkansas at Pine Bluff and informal agreements with other Institutions lend additional support to ICA programs.

ICA has increasingly become involved with private voluntary organizations (PVOs) in international development. ICA helped to develop and became the technical provider for the Water Harvesting/Aquaculture Project because of the common but unaddressed set of problems facing a number of PVOs and ICA. PVOs generally lacked sufficient aquacultural technical expertise and the ICA lacked the ability to deliver its technology to grassroots beneficiaries.

Auburn University's fisheries program began in 1933 under the direction of Dr. Homer S. Swingle. For 50 years, the University has been a leader in applied research in warmwater fisheries and aquaculture. The staff consists of 30 professionals in its Department of Fisheries and Allied Aquacultures and the International Center for Aquaculture. Facilities include a modern three-story building on campus, with offices, research and teaching laboratories, and lecture halls. Located near campus is a 900-hectare fisheries field research unit with approximately 600 experimental units having a total water surface of 100 hectares. These facilities provide good opportunities for students and staff to research aquacultural problems.

The graduate training program of the Department has an annual enrollment of 135 students in advanced degree programs, of which 48 or more normally are from the international community. Auburn has gained an international reputation because of unique field facilities and emphasis on applied research in developing improved methods of producing fish for food.

Through its International Center for Aquaculture, Auburn University has contributed substantially to international fisheries programs. More than 80 percent of its staff participate directly in overseas projects. Fishculture surveys and short-term studies related to specific fisheries problems have been carried out in 76 countries, most of them at the request of USAID misssions. ICA has cooperated with USAID misssions in providing long-term technical assistance for aquaculture programs in Egypt, Jamaica, Rwanda, Honduras, the Philippines, Indonesia, Columbia, Brazil, El Salvador, Nigeria, Equador, and Panama.

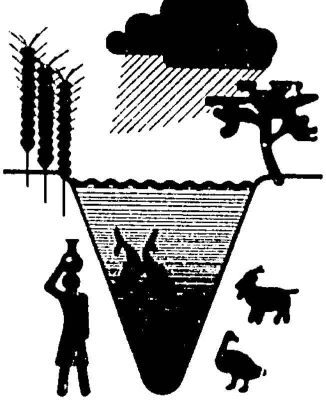
WHAP currently employs Dr. Bryan Duncan as Technical Coordinator, Alex Bocek as research associate, and utilizes the services of Dr. Tom Popma and Dr. Ronald Phelps.

PONDERINGS
Joint PVO/University Rural Development Center
Western Carolina University
Cullowhee, North Carolina 28723

PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Spring/Summer 1987



WHAP Continues For Two More Years

After an evaluation process that went around the world, the Agency for International Development (AID) has approved funding for the final two years (through June 1989) of the Water Harvesting/Aquaculture Project. AID evaluators Dr. Anson Bertrand and John Oleson visited with each of the U.S. agencies participating in the project and traveled to Guatemala and Indonesia to visit field projects operated by CARE and Heifer Project International.

The project, cofunded by AID's Bureau of Science and Technology (Office of Agriculture) and the Office of Private and Voluntary Cooperation , began in 1984 as a collaborative project involving the Joint PVO/University Rural Development Center, Auburn University's International Center for Aquaculture (ICA) and six PVOs--CARE, Catholic Relief Services, Church World Services, Heifer Project International, Lutheran World Relief, and Save the Children.

The extensive evaluation administered by a private consulting firm, reached several conclusions. Briefly, they are: the project has successfully linked PVOs to Auburn's ICA and fostered cooperation among PVOs involved in the project, ICA has provided excellent technical assistance and training, and all participants support the role of the Joint Center as coordinator.

Project Support Funds Strengthen Existing Projects

by Joyce Moore, Joint Center

In the Muusha Impact Area of Eastern Zimbabwe, Save the Children directs a project involving farmers who have organized into a Farmers' Collective. These farmers have small plots of approximately 5 hectares and grow sunflowers, corn, soybeans, and other vegetables that must be guarded, incidentally, from marauding baboons.

The Muusha area is mountainous with both gentle and steep slopes. Although rainfall is somewhat unpredictable, there are year-round streams that flow through the impact area.

For the 1985/86 fiscal year, Save the Children (SCF) received Project Support Funds to repair an aquaduct to an existing pond and to reactivate an irrigation system that had fallen into disrepair. This irrigation system lengthens the growing season and allows for greater crop diversity.

Five other projects associated with the Water Harvesting/ Aquaculture Project also received Project Support Funds to strengthen existing projects during the 1985/86 fiscal year.

For the 1986/87 year, the three following projects have been granted Project Support Funds:

1. Heifer Project International--Karen Aquaculture Project, Thailand--$15,000. This project, for the Karen people, has received technical assistance from WHAP for the last two years. The Karen people are a minority living in remote, inaccessible areas in northern Thailand where public services are generally unavailable. The Funds will go toward the salary of a full-time consultant who is working with the Karen people to design and implement integrated aquaculture/agriculture projects appropriate to their villages.

2. Save the Children Federation--Kunda Pond Cultivation, Bangladesh--$14,867. SCF will be using these Project Support Funds to develop a 2 hectare community pond for fish culture in the Nasirnagar district. Although Bangladesh has great potential for aquaculture, improved techniques are unknown to many villagers. This project is designed to provide a source of reasonably priced nutritious food and to generate income for the village of Kunda for independently financed programs in the health and education sectors. The site will also serve as a demonstration pond and training facility for other aquaculture initiatives in the area.

3. Catholic Relief Services (CRS)--Fish Culture at Vaivaka and Manuguluru, India--$14,500. This project area is located in the low lying coastal area near the Bay of Bengal. There are approximately 110 landless families in this area who, with the support of CRS, are organizing into cooperatives to manage ponds on land leased from the Bishop of Vijayawada and donated by the state government. Fish harvested from these ponds will provide both food security and additional income for families involved in the project.

At printing, these funds had not yet been issued due to a delay in the AID funding cycle.

Although budget revisions indicate that Project Support Funds will not be available for the final two years of WHAP, we look forward to hearing from those projects which have received support as they continue to build on the foundation that these funds have provided.

Trainees visit field project in Nianga where a Peace Corps volunteer checks fish weight gain.

Senegal Training

Under the auspices of participating PVOs, PVO project managers and indigeneous government administrators from Zaire, Niger, Guinee-Bissao, and Senegal gathered June 15-19 in St. Louis, Senegal (in the northwest corner near the coast) to acquire more knowledge about the principals and practices of water harvesting/aquaculture and integrated agriculture as mechanisms for rural development. As decision makers, it will be up to them to analyze the situation in their various countries as to the viability of instituting aquaculture projects there. This training session will provide them with the tools to do so.

One component of the training was visiting a functioning field project outside of St. Louis in Nianga. At that site run jointly by CRS and Peace Corps, participants were able to see pond management and ask questions about fish culture first-hand.

Catholic Relief Services and Church World Service were the hosts for this training session organized by Auburn University's International Center for Aquaculture (ICA). Dr. Bryan Duncan (Auburn University), Jean-Yves Mevel (Auburn University), John Morrison (University of Arkansas at Pine Bluff), and Abdou Rahmane Sarr (Church World Service) led the four-day course combining lectures and practical field work. Nancy Blanks, WHAP Project Director, was also on-site for this session. All training materials were translated and printed in French, marking the first training session not in English.

The governments of Zaire, Guinee-Bassao, and Senegal, the Peace Corps, and PVOs--Habitat for Humanity, Catholic Relief Services, Church World Service, and World Vision International--were represented at the training. Seven participants came from Senegal: Jeremy Freidmund, Marsha Lin, Abdoulaye Diallo, Assane Ndiya, Abdoulaye Sougou, Demba Ba, and Gregory Groth. Three attended from Zaire: Nita Kumba, Ir. Nkwer Kandol, and Ir. Manemodeke-Ndjuro. Niger and Guinee-Bissao each had one representative: Oumara Elysee and Jose Magalhaes.

Dr. Duncan said the participants were interested and enthusiastic about the potential of aquaculture and that he has already received one letter from a participant who was surprised to learn that this was the first training given in French, it had been executed so well.

ICA and the Joint Center are now discussing the next WHAP training, the first of the more technical training sessions. Just as the original project design outlined, future trainings will build on the interest generated from the first three years' more general sessions.

We would like to extend our thanks to Lionel Derenoncourt, Regional Representative for Church World Service, and Laverne Pierce, Country Director for Catholic Relief Services for making this training possible.

FROM THE EDITOR

This is the sixth issue of PONDERINGS which happens to occur at the beginning of the fourth year of WHAP. If you wonder why you never received your Winter 1986-87 issue, it is because there isn't one. Joyce Moore, previous editor of PONDERINGS and information officer for WHAP, has left the Joint PVO/University Rural Development Center to become the sage at "City Lights", her bookstore and local center for the intelligentsia. We, at the Joint Center, will miss Joyce not only because of her careful maintenance of the mounds of information generated by WHAP, but also because of her gentle, witty disposition.

As the new editor of PONDERINGS, I would like to make a request of all project participants. PONDERINGS serves as the telescope for all of us. It offers each of you a device for viewing projects that are similar to yours but geographically far away. Please share your experiences through a letter, an editorial cartoon or a photograph. Recounting your experiences could shed some light on a problem another project is having. Auburn University has been extremely dedicated in reporting on their technical involvement with the project. The implementation of the day-to-day field work is equally essential to project realization.

Here are PONDERINGS' deadlines for the coming year:

FALL 87 - AUGUST 24
WINTER 87 - NOVEMBER 9
SPRING 88 - FEBRUARY 1
SUMMER 88 - APRIL 2

A very special thank you goes out to the PVOs who have sent in their responses to the monitoring surveys.

Very best wishes,

Phyllis Stiles

Phyllis Stiles, Editor

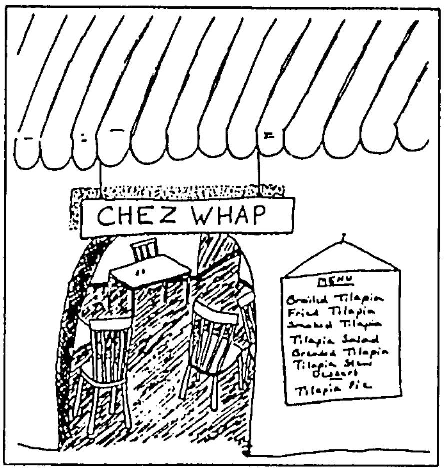
PONDERINGS is issued quarterly by the Joint PVO/University Rural Development Center, Bird Building, Western Carolina University, Cullowhee, NC 28723 (704) 227-7492. Address inquiries or submissions to Phyllis Stiles, Editor.

Harvesting Water, Not Always For Developing Aquaculture

During the first three years of the Water Harvesting/ Aquaculture Project, the emphasis has been on improving existing water sources and increasing their usefulness. The regional trainings held in Panama, Indonesia, and Africa stressed aquaculture and integrated agriculture. But as the project matures, participating PVOs are requesting information and assistance in developing new water sources especially in arid and semiarid areas. For many of them, aquaculture is a secondary consideration for harvesting water.

In many areas of the world, rainfall is inadequate or seasonal. By using the terrain to collect some of this rain into storage systems from a catchment area or by diverting seasonal stream flow, this water can be used during dry seasons. Since water is a basic need for humans, animals, and plants, there are many possible applications for this harvested water. Supplementary irrigation for gardens and trees, animal watering, and normal household uses--bathing, drinking, cooking--are obvious possibilities. The problem is not finding a use for the water but harvesting, storing, and apportioning the water optimally.

Dr. Kyung H. Yoo is a soil and water engineer from Auburn University's Department of Agricultural Engineering. He is working with Dr. Bryan Duncan and other technical experts from Auburn University's International Center for Aquaculture to expand the scope of WHAP. Last fall Dr. Yoo worked with Save the Children on a dryland farming project in Quoriyoley, Somalia where he proposed a water harvesting system for domestic and animal use, minimizing commuting time to remote crop fields. In February he consulted with Catholic Relief Services in Honduras on small-scale irrigation systems in the mountainous region near Choluteca, where aquaculture is also a component.



Dr. Yoo says that technically, it is possible to collect all the effective rainfall using structural control. Indirect rainfall, such as overland and subsurface runoff, temporary and permanent streams, springs and wells also offer opportunities for harvesting.

The major considerations in developing water harvesting systems include the quantity of water needed and available for harvest, topography, land use, and soil types present at the catchment area. A minimum annual rainfall of 50-80mm is deemed suitable for water harvesting projects; however, a minimum of several hundred mm is preferred.

PVO staff can make preliminary assessments of water harvesting potential with a minimum of training. There should be three stages in the implementation of a water harvesting project. The first is site assessment during which the objective is defined and the most likely alternative system is suggested for achieving the objective. The second stage involves a detailed engineering survey of the site for system implementation. Lastly, the system is put into place. After having assisted several member PVOs with the first stage, WHAP personnel believe that the second stage will require assistance as well. Means for doing this are being considered. In most cases the third stage will probably be implemented by local contractors or technicians under PVO staff supervision.

WHAP can prepare advanced materials to train qualified PVO staff with an agriculture background to make necessary assessments of water harvesting potential. Questions on this topic should be directed to Dr. Bryan Duncan, Technical Assistance Coordinator for the Water Harvesting/Aquaculture Project for the International Center for Aquaculture, Auburn University, Alabama, USA 36849. Dr. Duncan also has video tapes available for loan to interested PVOs which describe water harvesting/ aquaculture technology and its applications. For related reference materials, see *Technical Notes* in PONDERINGS, Spring 1986.

Related questions concerning other aspects of multi-purpose water development including soil conservation, forestry, small enterprise projects, arid and semi-arid lands, and plants and land usage may be directed to the Joint Center.

In the collaborative spirit of the Joint Center, this article is the result of a group effort involving Dr. Bryan Duncan, Alex Bocek, Dr. K. H. Yoo, Joyce Moore, and Phyllis Stiles.

WHAP Update June 1987

Total Number of Countries Served:
39 (21 in Africa, 1 in Middle East, 7 in Asia Pacific, 10 in Latin America)

Field Projects Underway:
17 projects in 13 countries in 150 communities implemented by 6 PVOs

Total Technical Training and Program Assistance:
37.9 person months

Additional Field Projects Being Developed:
9 projects in 6 countries

Note: These totals reflect the project to date.

Technical Notes

by Dr. Bryan Duncan and Alex Bocek, Auburn University

The Food and Agriculture Organization of the United Nations has published two illustrated training booklets on the common carp. These are:

1. *Common Carp 1*
   Mass Production of Eggs and Early Fry
2. *Common Carp 2*
   Mass Production of Advanced Fry and Fingerlings in Ponds

These step-by-step manuals have good drawings and information for anyone interested in the subject areas. Previous experience with fish will be necessary to apply the techniques described.

For information on obtaining copies, write to:

Director, Publications Division
Food and Agriculture Organization of the United Nations
Via della Terme di Caracalla, 00100 Rome, Italy

The Asian Institute of Technology has published the following:

AIT Research Report No. 184, "Pilot Small-Scale Crop/Livestock/Fish Integrated Farm"

AIT Research Report No. 198, "Buffalo/Fish and Duck/Fish Integrated Systems for Small-Scale Farmers at the Family Level"

Both have good information on the stated topics relevant to areas in Southeast Asia. Each contains production and economic costs and returns for the various systems tried with explanations for some of the results obtained. Photos and figures are included.

For information on obtaining copies, write to:

Environmental Sanitation Information Center
Agricultural and Food Engineering Division
Asian Institute of Technology
P.O. Box 2754, Bangkok 10501
Thailand

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CAMEROON TRAINING

The fourth regional WHAP training, hosted by Save the Children - Cameroon and the Government of Cameroon, took place March 10-14, 1986. The training, designed to provide PVO staff with an introduction to water harvesting, aquaculture and integrated agricultural activities, was held near Bamenda, a town in northwest Cameroon. Thirteen PVO staff members from eight countries and five staff members of the Mbengi-Momo Fisheries Station, where many of the field activities took place, attended the training.

Participants in the training held in Cameroon

Training participants sponsored by Catholic Relief Services were Vewonyi K. Adjavon - Togo, Frederick Amang - Ghana, Allie Forna - Sierra Leone, Magued Helmey - Egypt, and Jonas Mva Mva - Cameroon. CARE sponsored Jean-Bernard Lindor from Cameroon and Leo MacGillivray from the Congo. Heifer Project International sponsored Frederick Johnnie and Frank Anthony from Sierra Leone, Lutheran World Relief sponsored Thomas Berkas and Ratolganahary Joseph from Madagascar, and Church World Service sponsored Abdou Rahman Sarr from Senegal. Mulah John Tayim, John Barah and three other staff members of the Mbengwi-Momo Fisheries Station also attended many of the classes. Barah, Director of the station, is an alumnus of ICA at Auburn University. Wilfred Banmbuh, Cameroon Country Director for SCF, deserves a special thanks for arranging and hosting this very successful training.

For many of the trainees, it was a unique opportunity to meet other development workers with similar interests and share their knowledge and experiences with each other. This informal exchange, coupled with structured classes and individual meetings with the trainers, provided the trainees with a variety of insights into water harvesting/aquaculture technology.

Technical trainers Dr. Bryan Duncan from Auburn University and Dr. Frank Merriwether from the University of Arkansas at Pine Bluff and Nancy Blanks, Project Director for WHAP, labeled the training as "one of the best."

Technical Notes

by Dr. Bryan Duncan, Auburn University

There is often a need for harvesting (collecting and storing) surface water for its many uses, whether a region is arid, semiarid or tropical with substantial rainfall. Structure designs will vary depending upon rainfall patterns--for example, to protect against heavy flows or reduce evaporation and seepage--but basic principles are the same. It must also be kept in mind that the cost and sophistication of water harvesting structures varies considerably, and in each case the least-cost alternatives should be sought. Listed below are useful references.

1. More Water for Aquaculture: Promising Technologies and Research Opportunities. National Academy of Sciences, Washington, D.C., 1974.

This publication is free to requests made on organizational letterhead. It is a general introduction to the topic and not a technical manual, however, the bibliography has many citations of technical works. A French-language version is available. It may be obtained from: Office of Science and Technology, Development Support Bureau, Agency for International Development, Washington, D.C.

2. Handbook of Water Harvesting. U.S. Dept. of Agriculture, Agricultural Research Service, Agriculture Handbook Number 600.

This handbook describes some of the methods and materials being used to collect and store precipitation runoff to provide drinking water and presents a step-by-step guide to the design, selection of materials, installation, and maintenance of water harvesting systems. Copies of this publication may be purchased from the U.S. Government Printing Office, Washington, D.C. 20402. When ordering by mail, ask for the publication by title and series. For faster service, call the GPO order desk at (202) 783-3238 and charge the publication to your credit card.

3. Ponds - Planning, Design, Construction. U.S. Dept. of Agriculture, Soil Conservation Service, Agriculture Handbook Number 590.

This manual deals with most of the important aspects of site selection, design and construction of earthen ponds for capture and storage of surface runoff water. It is a very useful book, though estimation of runoff depends upon rainfall data that may not always be available in developing countries, in which case experience will be required to make estimations. This publication is available from the U.S. Government Printing Office at the address given above. A limited number of copies are available from Bryan Duncan at ICA.

4. Field Engineering: An Introduction to Development Work and Construction in Rural Areas. Compiled and edited by Peter Stern and others from an original work by F. Longland, Intermediate Technology Publications, 1983.

In addition to water development, this very handy manual deals with a variety of basic engineering methods applicable to rural development in developing countries. It should be on the shelf (or in the suitcase) of every development worker dealing with technical subjects related to engineering.

PROJECT SUPPORT FUNDS AWARDED

One of the unique features of the Water Harvesting/Aquaculture Project is the provision of Project Support Funds. A sum of fifty thousand dollars is allotted annually to assure that funding crises will not endanger approved field projects.

The six PVO members of WHAP submitted 17 worthwhile project proposals with budgets totaling $149,354. Since only $50,000 was available, some difficult decisions had to be made. The Advisory Council, which is made up of representatives of all the members of the Water Harvesting Project, decided to evaluate the proposals using the following questions as guidelines:

1. Was the proposal submitted by someone who had attended one of the regional trainings?
2. Had the project received technical assistance from WHAP?
3. Were water harvesting and integrated activities central to the project?
4. Was the project community-based and directed toward low-income families?
5. Was the project likely to promote further development activities?

Using these criteria, the Project Support Funds were distributed among the following six projects:

- CARE - Support for Phase I of a Community-Based Technical Assistance Pilot Project in Renewable Resource Management, Bolivia - $15,000.

- Catholic Relief Services - Aquaculture Project, Community of Muyen, Honduras - $5,341.

- Catholic Relief Services - Community Aquaculture/Tole, Panama - $7,100.

- Catholic Relief Services - Community Aquaculture/Canazas, Panama - $7,042.

- Save the Children - Water Harvesting/ Aquaculture Project, Nepal - $14,000.

- Save the Children - Aquaculture Project, Munsha Impact Area, Zimbabwe - $5,285.

The Advisory Council was able to recommend projects whose budgets totaled slightly more than $50,000 because some of the budget items were identified as training and technical assistance costs and could be provided out of other project funds.

It was very difficult to eliminate projects because all of the proposals submitted represented a well-defined need. However, since Project Support Funds will also be available for the next fiscal year, projects which are not able to find other funding should resubmit proposals for consideration in the next funding cycle.

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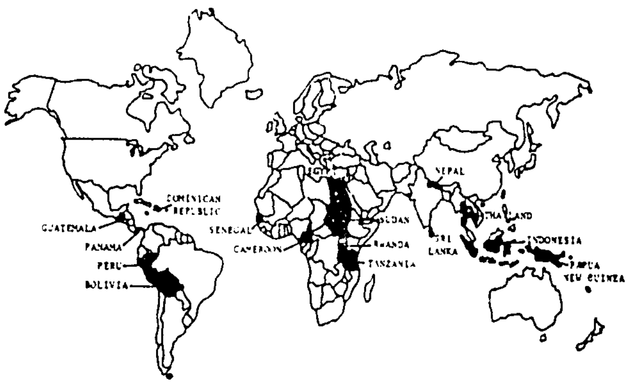
HOW TO REQUEST TECHNICAL ASSISTANCE

Since the beginning of the Water Harvesting/Aquaculture Project in 1984, Dr. Bryan Duncan and other technical experts from Auburn University have visited PVO field projects in Bolivia, Egypt, Nepal and Sudan as well as in 12 other countries across the world. During these visits they have provided a wide variety of technical assistance ranging from feasibility studies at undeveloped sites to consultations at established sites where water harvesting is integrated with a wide range of aquacultural and agricultural activities.



WHAP field projects are located in 16 countries across the world.

Because of the wide variety of technical assistance needs, it is important for WHAP's technical experts to have some basic background information on each field project in order to be prepared to provide the most appropriate advice. Dr. Duncan has suggested that a request for technical assistance be accompanied by a one-page summary that includes the following information:

1. Project Description. This should describe the location, basic environmental conditions, and the current water-related activities at the site.
2. Scope of work. This should include a brief description of what is expected from the technical expert, when the assistance is needed, and the estimated time necessary to complete the task.

3. Contact person. Who is the person in charge of this project at the site?

If the field project is supported by a PVO participant in WHAP, there is no charge for the consultation or the travel to and from the site. (Member PVOs are CARE, Catholic Relief Services, Church World Service, Heifer Project International, Lutheran World Relief, and Save the Children.) However, the project should be prepared to support the technician during the time he is providing technical assistance at the field site.

An effort is made to combine technical assistance visits in order to conserve travel costs, so it is important to make TA requests with as much lead time as possible to facilitate scheduling. Requests should be sent to the home office of the supporting PVO which will forward the request to the Water Harvesting/ Aquaculture Project.

HPI OFFERS THIRD ANNUAL INSTITUTE ON LIVESTOCK IN DEVELOPMENT

The third annual Institute on Livestock in Development will be held August 3-8 at HPI's International Learning and Livestock Center in Perryville, Arkansas.

The emphasis of the Institute is on increasing all participants' skills and knowledge in the changing arena of livestock development. It is directed toward people who work in rural development with low-income families, primarily focusing on Third World countries.

Livestock development experts from HPI and Winrock International will give presentations on major issues in small-scale livestock development and lead group discussions. Field visits will be made in the Central Arkansas area to farms which are examples of innovative work in small-scale livestock production.

The cost per participant is $345, which includes all meals and lodging. For further information contact David Gill, Heifer Project International, Route 2, Perryville, AR 72126. (501) 889-5124

SMALL LIVESTOCK PRODUCTION COURSE

A workshop entitled "International Short-Course in Small Livestock Production" will be held June 2-6, 1986, at Alabama A & M University in Normal, Alabama. The tuition for the course is $20 per trainee.

The workshop is intended for trainees with a strong interest in international small animal agricultural development, with emphasis in self-sufficiency food production for the developing countries. The International Small Livestock Research Center is presently focusing on species which include rabbits, guinea pigs, chickens, ducks, guinea fowl, and coturnix quail.

For additional information about the workshop or the Research Center, contact Dr. Steven Lukefahr, Dept. of Food Science and Animal Industries, Alabama A & M University, Normal, AL 35762. (205) 859-7433

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Winter 1986

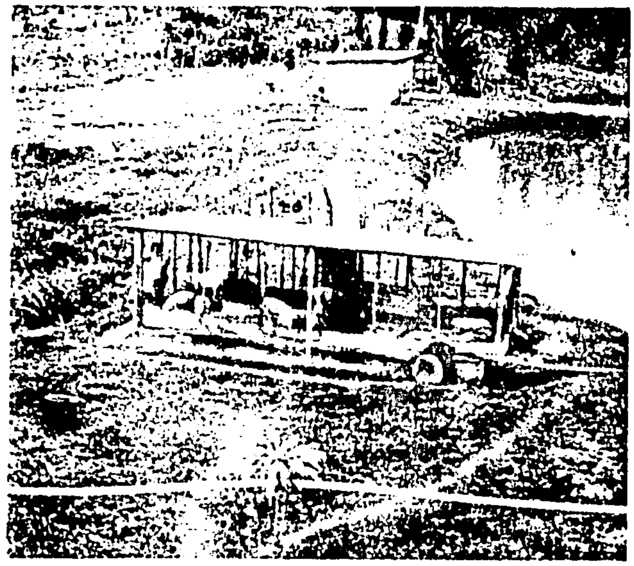
SCF, CARE WORK TOGETHER IN NEPAL

Cooperation is an important underlying theme of the Water Harvesting/Aquaculture Project. By developing a network of organizations who are interested in the same basic technology, WHAP has brought together people who have shared ideas, information and inspirations. This is a strategy that becomes increasingly important as we are faced with limited resources.

In Nepal we can see a good example of organizations cooperating to share resources. Both CARE and Save the Children Federation (SCF) have projects in an area east of the city of Pokhara in central Nepal. This region is characterized by steep hills, low mountains and narrow valleys watered by streams which are tributaries to the Marsyangdi River. Although the projects have different emphases, the two PVOs are working together as well as with the Fisheries Department of HMG-Nepal and with USAID.

J. R. Snow, a retired professor from Auburn University and the first volunteer consultant for WHAP, visited Nepal between November 19 and December 7, 1985. Professor Snow and his wife, who accompanied him to Nepal, found that their lifelong interests in hiking and camping were put to good use as they trekked to 30 existing and potential water harvesting/ aquaculture sites in the Himalayas.

Because animal manures are used for field applications, Snow feels that aquaculture at most sites would benefit from an



Aquaculture benefits from an integrated approach using pigs to fertilize ponds.

integrated approach combining rice, ducks or livestock with fish.

One innovative farmer was using a pig/fish combination that worked well for him. His two hand-dug, rectangular ponds with areas of 118m2 and 112m2 were stocked with grass carp, silver carp and common carp. The ponds were fertilized by five pigs which were raised in sties near the ponds. During the previous harvest, the ponds produced 68.4 kg or 0.297 kg/m2 of fish at a very low input cost.

There are also some larger lakes in the region. Lake Rupa Tal with an area of approximately 117 ha supports a commercial fishery during the winter months. There is both gill netting and cage culture present in the lake. The fisheries are being threatened by a high sedimentation rate, although watershed improvement measures such as reforestation are being implemented and should reduce erosion.

Peter Heffron, acting project director for CARE, and Gary Shaye, project director for SCF, feel that the next step in improving water harvesting/aquaculture potential for Nepal is further training. Planning and presenting this training is yet another opportunity to use cooperation for the benefit of all those involved.

WEST AFRICA TRAINING

The regional training for West Africa is scheduled for March 10-14 at the Aquaculture Station at Ku-Bome in the Republic of Cameroon. The training will be centered around the theme of Water Harvesting and Integrated Aquaculture/Agriculture for Village Development and will involve PVOs from countries in the region surrounding Cameroon.

Save the Children has been working with WHAP and the Ministry of Agriculture of the Republic of Cameroon to arrange facilities for the training.

The course is intended for the administrative and program staff of Catholic Relief Services, Church World Service, Lutheran World Relief, CARE, Save the Children and Heifer Project International. The approximately 20 trainees will participate in lectures, discussions and field activities.

The topics to be covered include social considerations, feasibility, aquaculture principles and practices, waterborne human diseases and economic considerations.

Bryan Duncan from Auburn University, Frank Meriwether from the University of Arkansas at Pine Bluff and Nancy Blanks from the Joint Center will be the trainers and will also be scheduling on-site technical assistance visits following the course.

A similar course held at the National University of Rwanda in July 1985 involved participants from Uganda, Zimbabwe, Zambia, Kenya, Rwanda and Burundi.

Technical Notes

by Dr. Bryan Duncan, Auburn University

The following publications are recommended as primers on water harvesting and aquaculture.

Simple Methods for Aquaculture: Water for Freshwater Fish Culture, FAO Training Series 4, UNFAO, Rome, 1981.

This well-illustrated publication presents simple methods for the collection and storage of water useful for many applications (not just aquaculture). It is available in English, French and Spanish, and may be obtained in the U.S. from UNIPUB, 1180 Avenue of the Americas, New York, NY 10036.

Fish Culture for Small-Scale Farmers, by Peter Edwards and Kamtorn Kaewpaitoon.

This useful manual deals with justifications for fish culture and all aspects of fish pond management, including integration with other animals. This well-illustrated manual is elementary in approach. It is recommended for those with little or no technical background. It is available in English or Thai from Dr. J. Valls (ENSIC), Library, Asian Institute of Technology, PO Box 2754, Bangkok 10501, Thailand.

Freshwater Fish Pond Culture and Management, by Marilyn Chakroff.

This publication is more detailed than the ones mentioned above, but is still aimed at the uninformed, interested person. It is available from VITA Publication Sales, 80 South Early St., Alexandria, VA 22304.

For information about publications dealing with more detailed aspects of water harvesting or aquaculture, contact Bryan Duncan, Swingle Hall, Auburn University, Auburn, AL 36849.

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"Technical Notes" will be a regular feature of Ponderings. If you have questions about water harvesting or aquaculture that you would like answered in future issues, send them to the Editor or to Dr. Duncan.

WHAP LINKS PUSPETA/SPRING CREEK

Dear Friends,

Some of the most interesting parts of the Water Harvesting/Aquaculture Project are the unintended results which happen along the way. While I was in Indonesia taking part in the second regional training, I became aware that PUSPETA, the cooperative which hosted the training, was not only working with farmers but was also developing programs for landless people.

PUSPETA's staff took me on a tour of two of their projects — a sewing project and a furniture project making use of the wood carving skills of the Indonesian craftsmen. A master Dutch furniture maker had designed replicas of antique furniture using local mahoghany. The carefully made furniture was impressive.

The Cooperative was working on two problems — finishing the furniture and marketing it. Before the furniture is made the wood is dried to the proper 12 percent moisture content, but due to the high humidity, final finishing cannot be done in Indonesia. PUSPETA asked me to think about solutions to these problems when I returned to the States.

Back home, the Economic Development Center at Western Carolina University's Center for Improving Mountain Living told me about Spring Creek, an isolated mountain community with high unemployment where people had formed a cooperative to develop job opportunities. Spring Creek might welcome the opportunity to develop a furniture finishing business since a number of residents had prior experience in furniture finishing.

After considerable discussion, the Spring Creek Cooperative decided that this opportunity would match their goals and they have created a foundation to develop a plant and train residents to finish the Indonesian furniture.

A group of former Peace Corps officials and volunteers is working to develop markets and capital for the project in the U.S. So, a three-way partnership is underway. It should not be long before the first load of furniture arrives here.

This has been a delightful but unexpected result of WHAP. It is an example of how we can maximize resources and support our efforts in new and different ways.

Nancy Blanks

MORE ON EVALUATION

The last issue of Ponderings described the two baseline inventories or surveys developed by Ralph Montee and Dr. Fred Bates. Several people have written asking for more information about these evaluation tools.

"The Community Inventory" which is designed to assess the overall level of development in a community and the "Household Inventory Schedule" which is used to describe the status of individual households within the community, are available upon request. Write to: Ralph Montee, Joint PVO/University Rural Development Center, Western Carolina University, Cullowhee, NC 28723.

FROM THE EDITOR

While we were working on this edition of the newsletter, Sam, head of the WCU print shop, expressed some amusement about using a picture of pigs on the front page. As I completed my best lecture on integrated agriculture/aquaculture, he said, "I understand, it's like a family fuss — one thing leads to another."

The same can be said about WHAP. Training and technical assistance lead to the development of water harvesting projects. In turn, we hope these will lead to better nutrition, higher income and eventually, to other development opportunities. As the project continues, we will be sharing more stories about "one thing leading to another."

Ponderings is issued quarterly by the Joint PVO/University Rural Development Center, Bird Building, Western Carolina University, Cullowhee, NC 28723. (704) 227-7492. Address enquires to Joyce Moore, Editor.

AUBURN SHORT COURSE

The annual short course on Water Harvesting/Aquaculture will be held at Auburn University August 25-29, 1986. The course is jointly sponsored by the International Center for Aquaculture at Auburn University and the Joint Center at Western Carolina University.

The course is structured for the administrative and program staffs of PVOs. Participants do not need a technical background to attend the course. Course objectives are:

1. to create awareness of water harvesting/aquaculture as a simple technology with potential for accelerating rural development;
2. to create awareness of opportunities for development made possible by establishing small pond water resources; and
3. to give development practitioners sufficient information to make preliminary assessment of the feasibility of water harvesting projects.

There is no cost for participants from PVOs associated with the Water Harvesting/Aquaculture Project. Others must pay a registration fee of $50. All participants must provide for his or her own transportation, meals and accommodations.

For more information contact Dr. Bryan Duncan at the International Center for Aquaculture, Auburn University, Auburn, AL 36849 (205) 826-4786; or Nancy Blanks at the Joint Center (704) 227-7492.

AQUACULTURE GOES VIDEO

Did you know that...

- in 1981-82, the amount of protein in the human diet provided by fish was only slightly less than the protein provided by beef and pork combined?
- since 1967, the price of fresh fish has increased 489 percent compared to 170 percent for eggs, 230 percent for vegetables, 248 percent for wheat and 261 percent for fruit?
- in 1984, shrimp was Equador's second most important export after oil?
- aquaculture produces 30% of the fish consumed in China and India?

This information and a lot more can be found in a new video called "Aquaculture: Its Time has Come," produced by Auburn Television for the International Center for Aquaculture at Auburn University. The 20-minute tape provides a good introduction to aquaculture and describes its central role in the concept of integrated agriculture.

Partial funding for the videotape was provided by the Agency for International Development and copies have been sent to USAID missions throughout the developing world. Copies are available from ICA at Auburn University. For more information contact Dr. E. W. Shell, Director, International Center for Aquaculture, Auburn University.

Ponderings
Joint PVO/University Rural
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PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Summer/Fall 1986

WATER - CATALYST FOR DEVELOPMENT

Water is a very important element in our lives. It's absence or presence can make a vast difference in how well we live. If water is plentiful, we take it for granted; it is only when it becomes scarce that we realize how dependent we are on it. Crops and livestock are usually the first to feel its absence. Households and communities run less smoothly when water supplies are disrupted and industries which are dependent on water have to reduce their production or shut down.

Approached from the other direction, a new or improved source of water where none had been available before provides opportunities for households and communities. Water harvested in ponds during rainy periods and saved for dryer times can be used in many ways. Food production can be increased through irrigation; reforestation can be encouraged by planting and sustaining young trees; aquaculture is possible and, combined with the production of other livestock, becomes nearly self-supporting. A reliable source of water may encourage new income-generating opportunities. As these development opportunities become available, they are expected to have a positive effect on the standard of living of a family or community.

One of the goals of the Water Harvesting/Aquaculture Project is to design an evaluation system that will determine what does happen when new or improved supplies of water in ponds become available. In order to measure this change it is necessary to find out some basic information about families and their communities so that we have a baseline to use in measuring or evaluating the impact of increasing or improving water resources.

Ralph Montee, evaluation coordinator for WHAP, is working with PVOs, the Advisory Evaluation Panel and Dr. Frederick Bates, the evaluation design consultant from the University of Georgia, to develop a framework to measure these changes. Montee, Bates and Beth Schmidt, who worked on the project first as an intern from the South-East Consortium for International Development Center for Women in Development and later as a volunteer consultant, have variously traveled to Bolivia, Nepal, Thailand and Indonesia to test the evaluation process and begin collecting information about the people and communities where water harvesting projects are being implemented.

As one PVO field staff wrote to Nancy Blanks, the Project Director, "It is no longer good enough to say let's at least do something. All too often that something is, in the long run, more destructive than useful." As a project that is based on university/PVO cooperation, WHAP is combining university and PVO resources to determine what actually happens when a development intervention is made. This knowledge can be used to improve both the Water Harvesting/Aquaculture Project and other collaborative development projects that are undertaken in the future.

Technical Notes

by Dr. Bryan Duncan, Auburn University

PUBLIC HEALTH ASPECTS OF WATER HARVESTING/AQUACULTURE PROJECTS

Wherever new or more extensive water resources are developed, public health implications are always a concern. In creating water resources to solve problems of health, nutrition and income, it is not our desire to create other problems. Harvest and storage of overland runoff, stream flow and other surface water, which is generally unprotected from environmental contamination and is accessible to insects, snails and other potential disease vectors, is of special concern to development workers. It is interesting to note, however, that, in situations where the quantity of water is critically limited, public health conditions appear more related to the quantity of water available rather than the quality of the water. While this observation is not an excuse for ignoring water quality, it does suggest that water of poor quality is better than no water. Nonetheless, water-related development projects must be committed to providing the best possible water quality.

Conditions potentially harmful to human health, where a pond water source is concerned, may result from:

1) Substances entering the pond with the water. For example, pesticides drained from adjacent fields or other upstream areas or carried on the wind in the case of aerial spraying. Such harmful substances are often more dangerous for fish than for human users.

2) Infectious diseases introduced into the pond via human and animal manures used as fertilizers. Ponds are effective as sewage treatment units, and the pond environment is unsuitable for the survival of pathogenic bacteria. There is potential, however, in some cases where human feces are used, for the transmission of polio, cholera, typhoid, hepatitis, dysentery (bacterial, viral and protozoal), schistosomiasis, dracunculosis, among others.

3) Proliferation of disease vectors that require an aquatic environment for all or part of their life cycles, the most important of which are mosquitoes and snails. Some diseases transmitted by these vectors are malaria, yellow fever, dengue fever, encephalitis, filariasis, clonorchiasis, paragonimiasis and schistosomiasis.

The good news is that a pond properly maintained for the most efficient capture and storage of water and cultivation of fish is an unfavorable environment for the survival and proliferation of aquatic-borne disease agents and their vectors. Maintaining ponds free of aquatic vegetation and debris reduces vector habitats. Tilapia, the most commonly utilized fish in warm climates, will eat mosquito larvae. There are fish that will feed on snails. The "sewage treatment" capabilities of a pond help to control disease transmission. Placing feces in a pond denies access to flies, common vectors of infectious disease. Fish and other food products coming into contact with contaminated pond water rarely are a source of disease if cleaned and/or cooked.

It is important in the planning stages of water harvesting/aquaculture projects to thoroughly understand the public health implications in the targeted geographical area, so that they may be considered in the project design.

These are a few general considerations. The author will gladly provide more detailed information for interested persons.

WHAP PROJECT OVERVIEW

The Water Harvesting/Aquaculture Project (WHAP) is not just one project but is a collection of many projects, each sponsored by one of six private voluntary organizations (PVOs). These PVOs are: CARE, Catholic Relief Services (CRS), Church World Service (CWS), Heifer Project International (HPI), Lutheran World Relief (LWR), and Save the Children Federation (SCF).

WHAP exists to provide training and technical assistance to these PVOs so that they can initiate or improve their activities in the area of water harvesting, aquaculture and integrated agriculture. Auburn University provides the TA and training expertise and the Joint PVO/University Rural Development Center coordinates WHAP and encourages collaboration among all the participating agencies.

Since the beginning of WHAP in 1984, projects in 18 countries across the world have received technical assistance from Auburn University's International Center for Aquaculture (ICA). Some of these projects were already underway and some new projects are being developed with assistance from WHAP. The following brief descriptions provide an idea of the diversity of projects that are being developed.

Bolivia - CARE

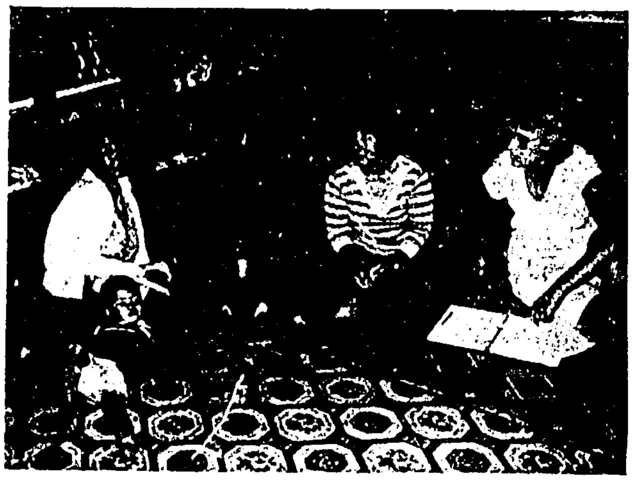
In Bolivia CARE is developing a model for community-based natural resource management using water as a focal point. The project area in southern Bolivia is in a semiarid mountain valley. Rainfall is seasonal and erosion is a severe problem. CARE is working with communities to assess their local natural resources, develop a plan based on this assessment and implement the plan. Watershed management, including water harvesting, aquaculture and integrated agriculture, is a concept that has been incorporated in the community planning process.

Art Flanagan, who was assistant country director of CARE/Bolivia at the time, attended the 1984 training at Auburn, and Ron Phelps from ICA has made several TA visits to Bolivia. In June 1986, CARE received $15,000 of project support funds from WHAP to assist the community-based design feature of the project. Ralph Montee has visited Bolivia to begin the evaluation component of the project.

The community of San Mateo provides a good example of water harvesting as a catalyst for development. A large pond is being dug to provide water for smaller ponds where fish and ducks will be raised. The runoff water from the fish ponds will be used to irrigate fruit trees. A small brick-making industry is being developed near the large pond. The 11 families in the community have organized into a cooperative to manage the pond and the use of the pond water.

Thailand - HPI

The Center for the Uplift of the Hill Tribes (CUHT) is a training center for the Karen people, a tribal minority living in northern and western Thailand. The Karen people are primarily subsistence farmers and, although some have irrigated paddy rice fields in their narrow valleys and terraced hills, most families must also depend on slash/burn cultivation. Many have diets that are protein deficient.



Beth Schmidt (r) interviews Thai family.

CUHT is sponsored by the Karen Baptist Convention and receives support from HPI. The Center has about six acres of land which supports gardens, orchards, fish ponds, pigs and ducks. In addition to being a training center for approximately 50 students each year, CUHT is also an agricultural experiment and demonstration center for an extensive village extension program.

Sunny Danpongee, CUHT project manager, attended the training held in Indonesia and Bryan Duncan has made three technical assistance visits to the center. Beth Schmidt and Fred Bates have visited the area to begin the evaluation process.

HPI has recently funded a full-time aquaculture technician, Russell Gaulin, who will design trials, demonstrations and training for aquacultural/agricultural extensionists and help the extension specialists design outreach programs for the Karen villagers.

Senegal - CWS

In Senegal, Church World Service is developing an aquaculture project in Keur Momar Sarr at the southern tip of Lac de Guier. This is an area where CWS conducted an emergency food program for formerly nomadic people who had been dislocated by the extreme drought of 1983.

Trainees inspect cage culture.

CWS hopes to introduce and develop fish farming techniques in an area where the fish supply in natural waters is declining so that people can increase both their income and their protein intake.

There are several factors that indicate that an aquaculture project could be successful: abundant water, clayey soils suitable for constructing ponds, adequate nutrients for fish food, a demand for fish and a positive attitude toward aquaculture. In addition, the CWS technician, Abdou Sarr, has completed a four-month aquaculture course at ICA and also attended the training held in Cameroon. He has initiated a cage culture project and will be working with support from Bryan Duncan who visited Senegal to further monitor the conditions of the area and develop a plan for a more extensive aquaculture project.

Somalia - SCF

In Quoriyoley, about 150 km north of Mogadishu along the Shebbellee River, Save the Children is working with refugees from Ethiopia to implement an irrigation project and to plan a dryland farming project.

Kyung H. Yoo, a consultant from Auburn, visited the area to help assess the irrigation project and make suggestions for the design of water harvesting systems to support dryland farming. The flat terrain and thick vegetation will make large ponds difficult to fill but due to the high clay content of the soil, smaller, more numerous ponds should be practical. Having available water will allow farmers to live in the area they farm, rather than traveling 5-10 km between home and fields as they do now.

SCF is planning to assemble a design team to further study the area and develop more detailed plans for the project.

Egypt - CRS

Catholic Relief Services has an extensive aquaculture project in Egypt. The el Nozah aquaculture station is located near Alexandria at the head of a 3,000 m x 80 m drainage canal. It is currently functioning as a small adaptive research station, a training center and a fingerling production facility in conjunction with Governate of Alexandria and World Bank aquaculture development projects.

CRS is also developing plans for a commercial fish farm at Lake Mariyut, Alexandria, where duck production is combined with fish production. In order to provide extension training to small producers, CRS is developing "packages" with information on fish production, fish/duck production and fish/rice production.

Ducks complement fish production.

Maqued Helmey, CRS project officer, attended the Cameroon training and technicians from ICA have made two trips to Egypt to consult with people there on their programs.

Tanzania - LWR

Dennis and Meredith Murnyak, agricultural missionaries for the Lutheran Church of America, are developing an integrated fish farming project in a rural area near Arusha in northern Tanzania. They began the project in 1984 and for the first 18 months concentrated primarily on fish farming. Since then they have expanded the project to include rabbits, ducks and vegetable gardening.

The Murnyaks have expanded the project primarily through extension activities and presently 130 ponds with an average size of 175 m^2 have been constructed in 20 villages. One of the important factors in the expansion of their project has been the success of farmers who first build ponds. "If they succeed, others follow. If not, there is little interest," according to the missionaries.

The Murnyaks received an orientation at Auburn and Bryan Duncan visited them in Tanzania to provide help with pond construction techniques. Currently the Murnyaks are training farmers to act as trainers to spread the idea of integrated fish farming in their own and neighboring villages.

These six projects are representative of the technical assistance that has been provided to PVOs in 18 different countries. Similar descriptions could be made of activities in Guatemala, Indonesia, Nepal, Bangladesh, Kenya, Congo, Dominican Republic, Papua New Guinea, Peru, Sudan, Sri Lanka and Uganda. In addition, trainees from 13 other countries are beginning to develop projects using knowledge they gained through WHAP.

The Water Harvesting/Aquaculture Project is a unique development intervention. Its strength is that it is built on communication, collaboration and long-term support and accountability.

Fish provide quality protein diets.

FROM THE EDITOR

There was an error in the Technical Notes in the Spring 1986 issue of Ponderings. The first publication listed should have read More Water for Arid Lands: Promising Technologies and Research Opportunities. National Academy of Sciences, Washington, DC, 1974. If the request is made on organizational letterhead, this publication is free from the Office of Science and Technology, Development Support Bureau, Agency for International Development, Washington, DC 20523.

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AUBURN TRAINING

During August, WHAP sponsored the third US training for PVO program and field staff at Auburn University. The Auburn training, which is similar to that presented to PVO field staff in Panama, Indonesia, Rwanda and Cameroon, has been an important event in the history of WHAP.

The first training held at Auburn in 1983 set the stage for the Water Harvesting/ Aquaculture Project. Participants in the training went back to their home agencies with enthusiasm for the concept of water harvesting and aquaculture and the development opportunities provided by new sources of water. That training has had far-reaching effects because of some of the people who attended it. For example, Peter Heffron, who is currently with CARE/ Nepal, was with CARE in the Dominican Republic when he attended the training in 1983. WHAP has provided TA for CARE in the Dominican Republic and CARE is currently developing a field project in Nepal where they often share TA visits with a Save the Children field project in a neighboring panchayat.

Attending the most recent training at Auburn were: Dr. Gandhi Selvanathan, OIC International; K. Krishnan,CARE/ Ethiopia; Rev. J.A. Gaines, Helping Hand Rescue Mission; Margie Peronto and Mickey Levitan, Save the Children; I.F. Harder, Harder, Heifer Project International; Dr. Ziad Ali and Norman Al Shishani, Near East Foundation; and John Morrison, University of Arkansas at Pine Bluff. Dr. Bryan Duncan conducted the training with assistance from Dr. Ron Phelps, Frank Meriwether, Dr. Steve Lukefahr and Dr. Upton Hatch. Nancy Blanks and Mary Kay Cooley from the WHAP Project Office also attended part of the training.

TILAPIA GUIDELINES AVAILABLE

A new publication, "<u>Tilapia Nilotica</u>, Fry and Fingerling Production Guidelines for Community Development," is available from Auburn University's International Center for Aquaculture.

The guide, written by J.A. Hargreaves, L.L. Lovshin and B.L. Duncan, covers: the reproductive biology of <u>Tilapia nilotica</u>; facility requirements; fry and fingerling production techniques for single ponds, multiple ponds, net enclosures and concrete tanks; fertilization; and feeding. It also includes a sample management program. A companion publication dealing with post-fingerling production is also in process.

For copies of the publications contact Bryan Duncan, Department of Fisheries and Allied Aquacultures, 203 Swingle Hall, Auburn University, Auburn, AL 36849.

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PONDERINGS

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Fall 1985

INDONESIA PROJECT UNDERWAY

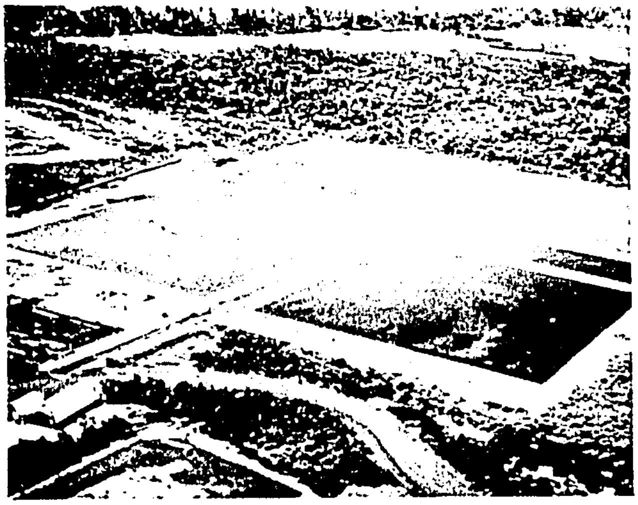
The first full-scale field project to get underway in the Water Harvesting/Aquaculture Project is in Indonesia. The Cooperative League of the USA (CLUSA) and Heifer Project International (HPI) are working together at two sites—one is a fish production/demonstration facility for PUSPETA, the Farmer Service Center in Klaten, and the other is a tambak development project for the Farmers Cooperative Center in Kabupaten, Luwu.

Dr. Bryan Duncan and Dr. Tom Popma from Auburn University's International Center for Aquaculture made their first technical assistance visit to Indonesia in April, 1985, and Dr. Duncan will return for a three-week visit in January, 1986.

PUSPETA

The people at PUSPETA approach small scale farmer development in two ways, by helping the farmer obtain more disposable income, and by helping the farmer generate more food for family consumption. Rice has traditionally been the primary source for both income and food, but with the increase in production, prices have stabilized and farmers are looking for new ways to supplement their needs. Several approaches to Integrated Farming Systems, including water harvesting and aquaculture, are being explored at PUSPETA.

In the planning stage is a seven-pond system that will include three production ponds for final growth of male tilapia to market size, a nursery pond where tilapia fry are grown to approximately 30g, a fry production pond for spawning, a holding pond for temporary holding of marketable fish and a combination rice/fish production plot.

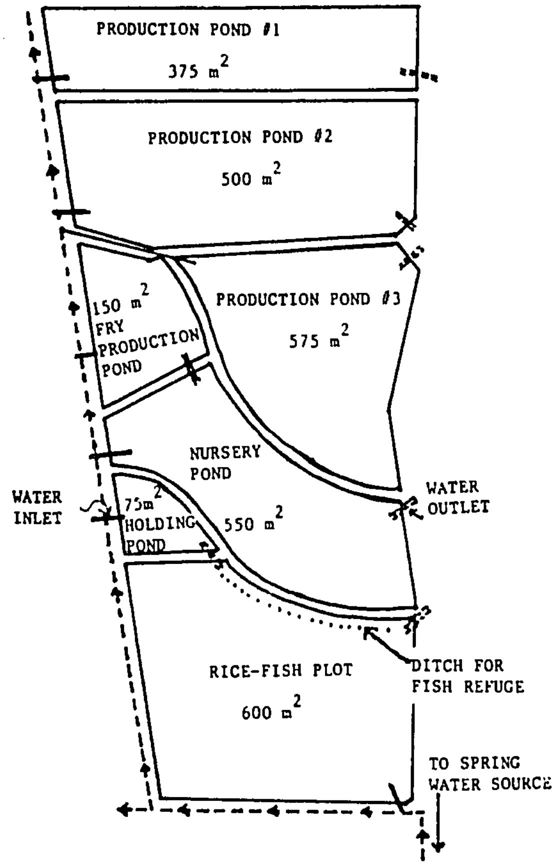


Tambaks are brackish water ponds where shrimp and milkfish are grown in the coastal zones of Indonesia.

The three production ponds will be managed for the production and rearing of hand-selected Tilapia nilotica at a density of approximately one per square meter. Three contrasting feeding systems will be used: production pond #1 will receive no supplemental feeding; pond #2 will receive manufactured feed only, and pond #3 will receive half as much manufactured feed as pond #2 plus manure from 15-20 laying chickens and 35-40 ducks.

The rice/fish plot will be used to demonstrate the production of fish in the same field where rice is grown.

PROPOSED POND MODIFICATIONS FOR PUSPETA



After these three production methods have been tested and evaluated, PUSPETA will use the ponds as a training site where farmers can learn pond construction and management skills and marketing techniques. After training, the farmers will continue to receive support from PUSPETA.

Kabupaten, Luwu-Tambak Development

Kabupaten, Luwu is a large district of the province of Sulawesi Selaltan. This lightly populated and poorly developed district was designated by the Government of Indonesia as a resettlement area for transmigrants from densely populated regions of the country.

One of several development initiatives intended to improve agricultural productivity for the area is the Farmer's Cooperative Center (FCC). The FCC, which receives support and assistance from CLUSA and HPI, is working to extend services to tambak farmers.

Tambaks are fish ponds, often 1-2 hectares in size, that are constructed in the mangrove swamps of the coastal zone and fringing tidal rivers. Water enters these ponds during high tide where it is trapped by sluice gates to provide an environment favorable for growing brackish water species such as shrimp and milkfish.

The FCC hopes to help farmers improve their dike construction techniques and their sluice gate design as well as their management practices in order to increase shrimp and milkfish production.

Another problem to be addressed is helping tambak farmers find or create reliable sources of milkfish fry and shrimp post-larvae. Farmers who participate in the project are expected to share their knowledge with their neighbors.

AN INVITATION

Dear Friends,

The Water Harvesting/Aquaculture Project (WHAP) has been operational for a year and much progress has been made to acquaint the staff of private voluntary organizations (PVOs) to the development possibilities of this technology. Training held in Central America, Asia and Africa has touched many PVO staffers. Additionally, technical consultations have been carried out by the staff of Auburn University for PVOs in 12 countries.

From the letters I have received since then, it is apparent that these same staffers are interested in how they can move on from these preliminary steps to the actual integration of water harvesting into field projects which will receive ongoing technical support from WHAP.

Let me outline the factors necessary for field project status with WHAP.

■ The purpose of the Water Harvesting/Aquaculture Project (WHAP) is to provide long-term technical assistance and training to PVO field projects which include water harvesting and aquaculture.

■ Certain criteria should be considered in developing a proposal:

A. Field projects will have as a central theme the improvement of the quality of life of rural participants.

B. Environmental criteria to consider are:

1) Adequate land must be available.
2) Topography must be suitable for construction of contour ponds.
3) Soil must have adequate water retention qualities.
4) The water source must be adequate to fill the pond.

C. Elements other than pond construction (such as aquaculture, irrigation and animal husbandry) are being planned to make maximum use of the water to stimulate other development activities.

D. There should be a village or regional focus and there should be evidence that there is either some local organizations in existence or a potential for forming such an organization which will provide local participation and control.

■ Short-term or one-time-only technical assistance can be requested by any affiliated PVO and will be handled as soon as possible. Technical experts will be sent to sites to carry out the TA. Requests should be made to PVO headquarters.

■ For long-term technical support and training a Field Project proposal should be developed and submitted to the PVO headquarters office. Present PVO participants are CARE, Catholic Relief Services, Church World Service, HPI, Lutheran World Relief and Save the Children Federation.

■ If feasibility studies are needed prior to making a decision about developing a Field Project proposal, requests for this should come through headquarters also.

I hope this clarifies Field Project Development. If you have any questions, please do not hesitate to write.

Nancy Blanks

Ducklings and fingerlings (in plastic bags) will soon be adding nutrients to ponds...

where the water can be used for crop irrigation.

FROM THE EDITOR

A "thank you" goes to those of you who have used information from the newsletter and trainings to pass on to others and have written to let us know about it. That includes Mr. Edgar Fuentes from HPI in Guatemala and Mr. A. John Knight in Madras, India. We hope that this sharing of information will increase in the future.

Beginning with the Winter issue of Ponderings, Auburn University's Dr. Bryan Duncan will be contributing a regular column on resources and technologies useful to people working in the field of water harvesting and aquaculture.

It is good to hear from you so please continue to send ideas, information, news or photos for future issues.

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EVALUATION - A USEFUL TOOL

Evaluation plays an important role in the Water Harvesting/Aquaculture Project. Ralph Montee, evaluation coordinator, feels that the evaluation design he and Dr. Fred Bates, consultant for the project from the University of Georgia, have developed with the assistance of the Volunteer Advisory Evaluation Panel and members of the WHAP Advisory Council, can also be adapted for use in other development situations.

They have designed two baseline inventories or surveys—one to assess the overall level of development in a community and the other to describe the status of individual households within the community. The baseline data gathered through these surveys will be used as a yardstick to measure development in a community where water harvesting/aquaculture has been introduced or expanded.

The baseline data will also provide a means of assessing whether or not the kinds of multipurpose development expected from water harvesting/acquaculture as a core intervention in rural development has taken place or not.

The surveys are designed for flexibility. There are three classes of questions—essential, recommended and optional, so the degree of detail can be modified according to the field situation.

Not all of the field projects receiving TA from WHAP will participate in gathering baseline data. Only those which indicate an interest in the full range of TA available through the Project and also have the potential for broader multipurpose development will be considered. That may involve only three of four field projects with appropriate locations. However, we hope to receive monitoring reports from all PVO field projects that have received TA through the Water Harvesting/Aquaculture Project.

Gathering baseline data is an added responsibility that many field projects may not have the time or personnel resources to undertake. In such cases WHAP is working with the South-East Consortium for International Development-Center for Women in Development (SECID-CWID) to provide trained technical assistants to help conduct the inventories. SECID-CWID provides travel and subsistence for these women so that field projects have little added expense. In some situations the PVO may wish to provide an individual to gather the data or a counterpart to work with the technical assistant to gain experience in evaluation techniques.

The inventories are designed to be repeated after a period of three to five years to measure the changes that have occurred during that time and to determine what part of the changes may be attributed to the introduction or improvement of water harvesting and aquaculture practices.

Evaluation of field projects often varies from agency to agency. Montee and Bates feel these evaluation tools are big steps toward standardizing baseline data collection so that the information will be more useful for both PVOs and the Joint Center.

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PONDERINGS

A Quarterly Newsletter of the Water Harvesting/Aquaculture Project

Summer 1985

A LETTER FROM THE PROJECT DIRECTOR

Bryan Duncan and the other folks from Auburn call it "the vision." The formal name is Training in Water Harvesting/ Aquaculture and Integrated Agriculture. For the grassroots people across the developing world it is food, water, and survival. By whatever name, it is apparent that the training is making an impact.

The overseas training of PVO staff in Central America and South Asia has been profitable not only from the standpoint of providing basic knowledge as to the applicability of water harvesting as a core intervention in rural development but also as a means for the project staff to better understand the varieties of works being carried out by PVOs and the great challenges faced in those development efforts.

There are some statements from training participants that I remember very clearly. From a staffer from a country in Central America: "We must promote self-sufficiency. The infrastructure of our country—roads, markets, supplies—is in such disarray that the campesinos must be assisted in acquiring complete self-sufficiency."

From a participant from a Pacific Island country: "We have no topsoil. Our only economy is based on tourism. My people are at the mercy of this industry. Almost all of our food is imported. For village people it is too expensive. We have much malnutrition. This project can help us."

During the training, knowledge was not just given: it was shared. An Indian trainee with vast agricultural training was particularly helpful and giving at the training site in Yogyakarta, Indonesia.

During a visit to Nepal, Project Director Nancy Blanks visited Lake Rupa Tal where CARE has a fisheries project.

Perhaps my greatest impression was and will remain that we are all on the same team, working in different ways and places but with the same goal, to sustain and improve the quality of life for all people. There were no barriers between PVOs, universities, or project staff.

So far we have trained 35 PVO overseas staff members. The next training will be in East Africa. I can't wait to meet the participants and begin again to share and to learn.

The next step, implementation of field projects, lies ahead of us. We have several viable proposals already submitted from across the world. So we move forward from a very solid base. I personally thank all of the folks who have worked so hard to make this project real. I also want to thank the PVO staffers who have taken the time to write their thoughts, ideas, and hopes to me. More next time,

Nancy Blanks

TECHNICAL ASSISTANCE MUSHROOMS

Since the beginning of the project, Dr. Bryan Duncan and his associates at ICAA have provided technical assistance in six countries and the list of projects waiting for visits is growing. The following is a summary of ICAA's technical assistance itinerary through May:

Feb. 15-22. Dr. Ron Phelps travelled to Peru at CARE's request to assess the potential for agro-aquaculture activities along the coastal region and also in the highlands near Huaraz.

Feb. 23-Mar. 1. Dr. Phelps then went to Tarija in southern Bolivia to review the water-related activities of CARE's renewable resources management program there.

Mar. 2-10. After the Panama training Dr. Duncan and Dr. R.O. Smitherman travelled to Guatemala where they reviewed CARE's Family Fish Pond Project and offered suggestions relative to project performance. Dr. Duncan also visited sites near Solola at the request of CRS where there is excess water that might be used for agro-aquaculture.

April 11-23. Before the Indonesia training, Dr. Duncan was asked to review a tambak development project proposed jointly by HPI and CLUSA in Luwu, Sulawesi.

May 4-8. After the Indonesia training, Dr. Duncan travelled to Chang Mai, Thailand, where he looked at the possibilities of improving the water harvesting/aquaculture components at a training project run by the Karen Baptist Convention and sponsored by HPI.

May 4-14. Dr. Tom Popma, at the request of HPI, returned home from the Indonesia training via Papua New Guinea where he assessed the possibilities of water harvesting and aquaculture within the framework of Lutheran Economic Services' food production effort.

Dr. Phelps is scheduled to visit the Dominican Republic in June and will be returning to Bolivia with Mert Cregger in July. We currently have requests to visit projects in Ghana, Togo, Egypt, Tanzania, Zambia, Congo, Jordan, Senegal, Nepal, and the Philippines. Dr. Duncan and others from ICAA will be responding to several of these requests in conjunction with the training in Rwanda, and the others will be scheduled as soon as possible.

ELEPHANT EXPERTISE?

Do you need help with your draft elephant? If you do, we may not be able to help because that's one area where Heifer Project International has no professed expertise. However, there are other areas where HPI has skills that other PVOs may find useful. Dr. Alden Hickman, HPI's director, has offered to provide assistance to other PVOs in the Water Harvesting/Aquaculture Project in two main areas:

1) evaluating proposals that involve the introduction or use of poultry and livestock and
2) aiding in locating competent resource people such as veterinarians, extension personnel, or farmers who would act as consultants.

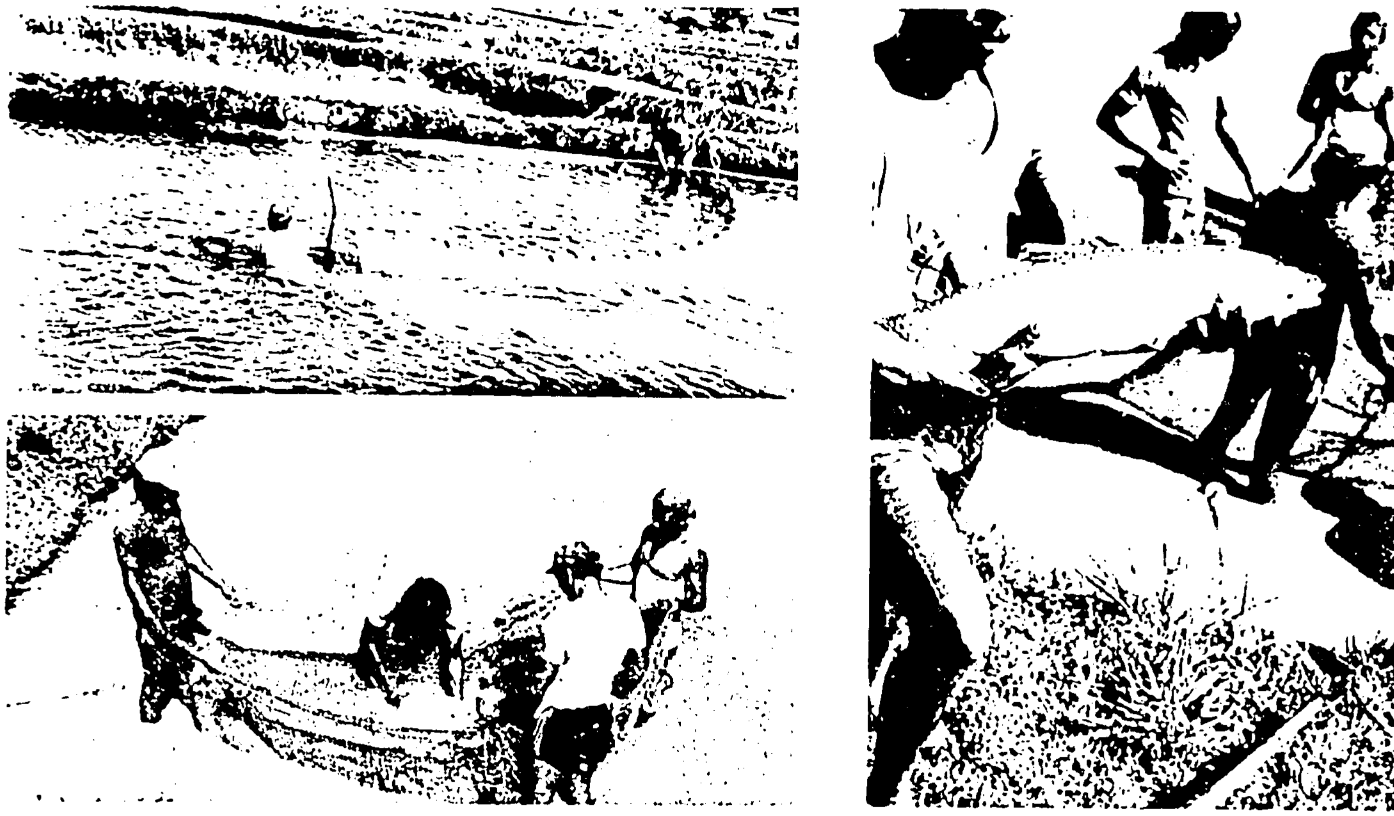
If these resources are to be used in WHAP-associated projects, the Project Support Fund is a possible avenue for reimbursing HPI. If there is no connection with WHAP, then the PVO requesting assistance would need to negotiate with HPI for reimbursement. And if there is sufficient demand, HPI can probably come up with an expert on elephants.

EVALUATION PANEL MEETS

One of the unique aspects of the Water Harvesting/Aquaculture Project is its evaluation component. Although the evaluation process has raised questions that sometimes seem difficult to answer, it also presents a rare opportunity to answer some difficult questions.

The evaluation design encompasses two levels and three main areas of evaluation activity. The first level is that of monitoring individual field projects. The second level, summative evaluation, is broken into two areas:

- the assessment of water harvesting/aquaculture as a core intervention and accelerator of rural development and
- testing the effectiveness of the collaborative management methodology involving PVOs and universities in the development of new rural development strategies and techniques for delivering technical, organizational, and material resources for development.



At the Panama training, held in Santiago in conjunction with Nacional de Acuicultura, workers examine the contents of an experimental pond at the Divisa Station.

Ralph Montee, the evaluation coordinator for the project, has brought together a group of people who have broad experience in the field of evaluation to form a volunteer advisory panel for the evaluation process. These include:

-Dr. Frederick Bates, the evaluation design consultant from the University of Georgia,
-Dr. Eloise Murray from Pennsylvania State University,
-Dr. Mary Rojas from Virginia Polytechnic Institute and State University,
-Armin Schmidt from Heifer Project International,
-Edgar Stoesz from Mennonite Central Committee,
-Dr. Judith Tendler from Massachusetts Institute of Technology,
-Dr. John Thomas from Harvard Institute for International Development, and
-Dr. Simon Williams from the Center for Rural Development.

On May 4 and 5, four of the panelists met in Cullowhee to work with Ralph in developing materials and guidelines for the evaluation process. Dr. Bates and Dr. Williams also attended the WIAP Advisory Council meeting at Auburn later in May to meet the project participants. The panel is enthusiastic about being involved in such an innovative project.

FROM THE EDITOR

Welcome to the first edition of Ponderings. (The name grew out of a group discussion, so there is still some question of just which person gets the dubious honor of receiving the stuffed tilapia.) I hope you will find the newsletter both interesting and useful. But both of these chracteristics will depend a great deal on you. If you have ideas, articles, information, photos, or news of upcoming events, please pass them on to me.

Our publishing schedule will be June, September, December, and March and it will be helpful to have materials for each newsletter by the 1st of each of those months. Let me hear from you soon.

Ponderings is issued by the Joint PVO/University Rural Development Center, Bird Building, Western Carolina University, Cullowhee, NC 28723, (704) 227-7492.

Joyce Moore

ATTACHMENT C. "Water Harvesting and Aquaculture for Rural Development" Series

WATER HARVESTING AND AQUACULTURE FOR RURAL DEVELOPMENT

AN INTRODUCTION TO WATER HARVESTING

WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Throughout history man has been dependent on an adequate water supply for his food, security and well being. Water is a universal felt need and is considered the principal limiting factor for human life. Destruction of natural watersheds has caused critical water shortages affecting vast areas and populations. Ways to help insure adequate water supplies for household, agricultural and other uses are available to farms and communities. The technology is called water harvesting.

Water harvesting is the practice of collecting and storing water from various sources for beneficial use. Water harvested from a watershed and conducted to ponds for storage can substantially increase available water for garden irrigation, livestock watering, aquaculture and other domestic needs.

THE HYDROLOGIC CYCLE

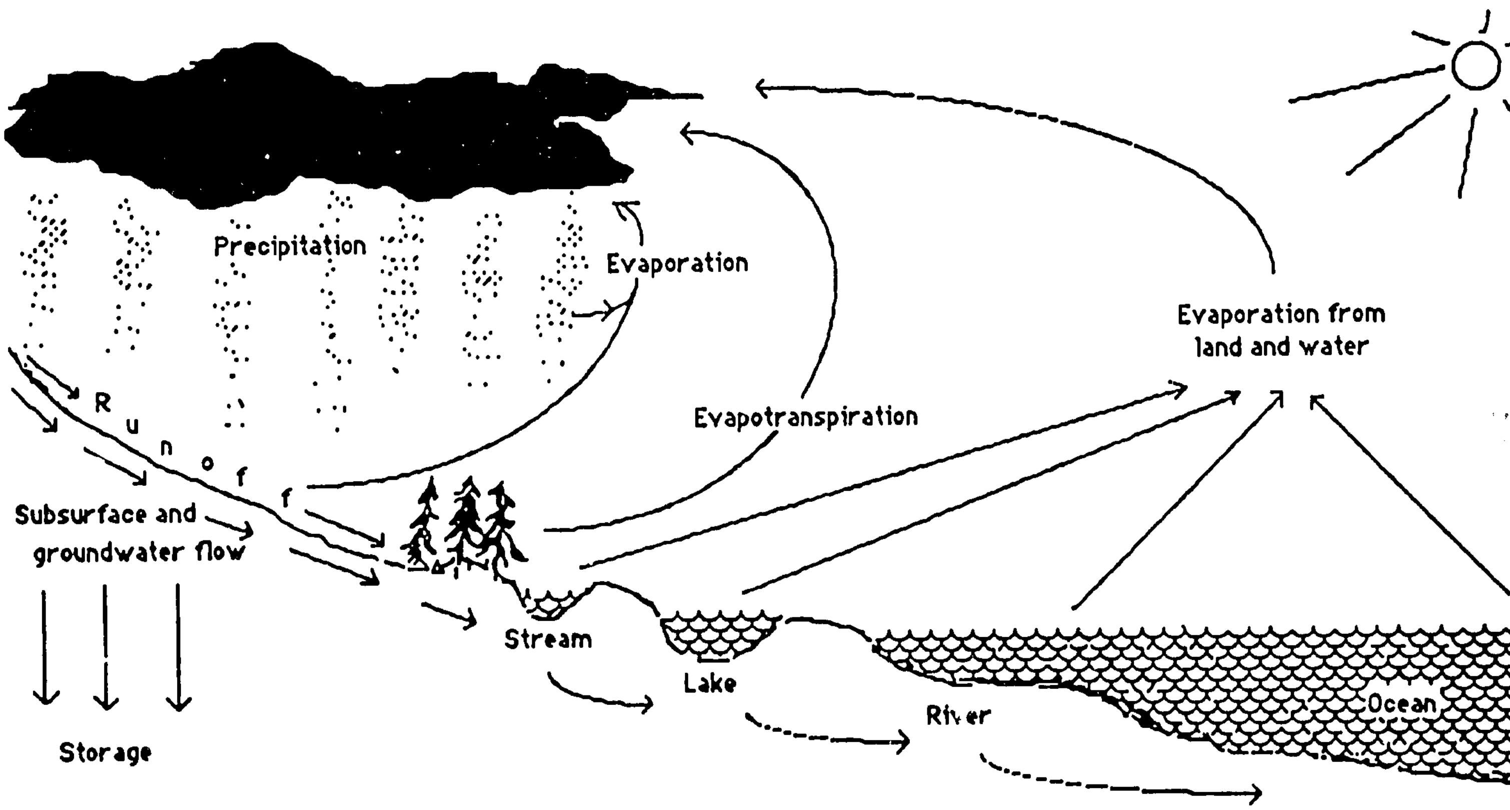


Figure 1: The hydrologic cycle.

The circulation of water in its various forms around the earth is called the hydrologic cycle. Water may be harvested effectively by man at certain points in the hydrologic cycle. An understanding of how water circulates around the earth will assist in the selection of an appropriate technology for harvesting it.

The sun heats water causing it to evaporate from the earth's surface. Water returns to the earth in the form of rainfall, snowfall, sleet, dew and hail. The higher the temperature of an air mass, the more water vapor it can carry. As air masses cool, water vapor changes to liquid forming droplets that fall of their own weight. Air cools due to expansion as it is lifted over mountains by collision with warm air masses and the heating of moisture-laden air close to the earth's surface (convection cooling).

The most important source of air moisture is water which evaporates from the oceans, but water may also evaporate from other open bodies of water and from the ground. Transpiration from plants (evapotranspiration) is another source of atmospheric moisture as water moves through plant roots, up the stem, through the leaves and to the atmosphere. For example, a corn field may transpire up to 7,000 to 10,000 gallons of water per hectare per day into the atmosphere.

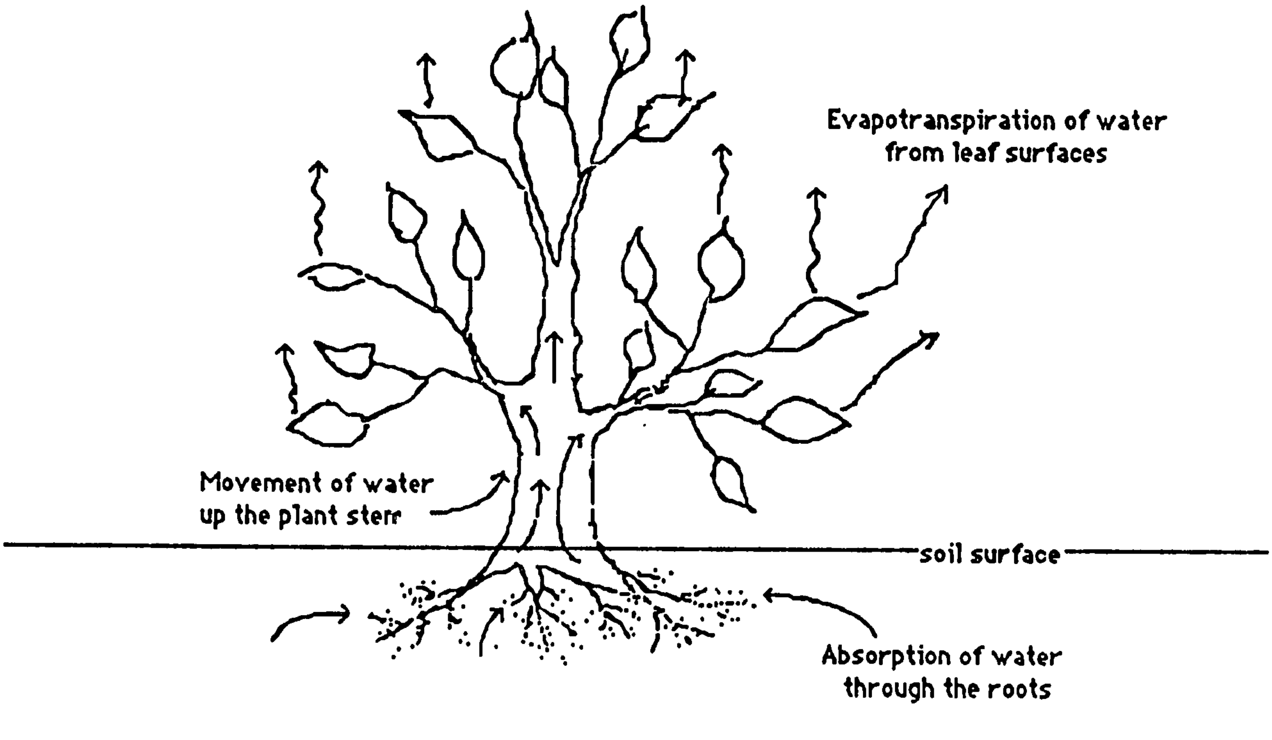


Figure 2: Transpiration of water by a green plant.

SURFACE WATER

Some precipitation runs overland by natural drainage channels where it eventually enters rivers, lakes and oceans. Most precipitation infiltrates the soil and becomes "ground water". Harvesting water on the earth's surface may be done only before it evaporates. Surface runoff, for example, can be intercepted and stored in impoundments for later use.

Water shortages in many areas of the world can be alleviated by harvesting surface runoff water. Criteria used to determine an appropriate harvesting method for a given location include: 1) the purpose for which the water will be harvested; 2) land slope; 3) soil properties; 4) construction costs; 5) amount, intensity and seasonal distribution of rainfall; 6) social factors such as land tenure and traditional water use practices. The following figures illustrate practical devices and systems used to harvest water.

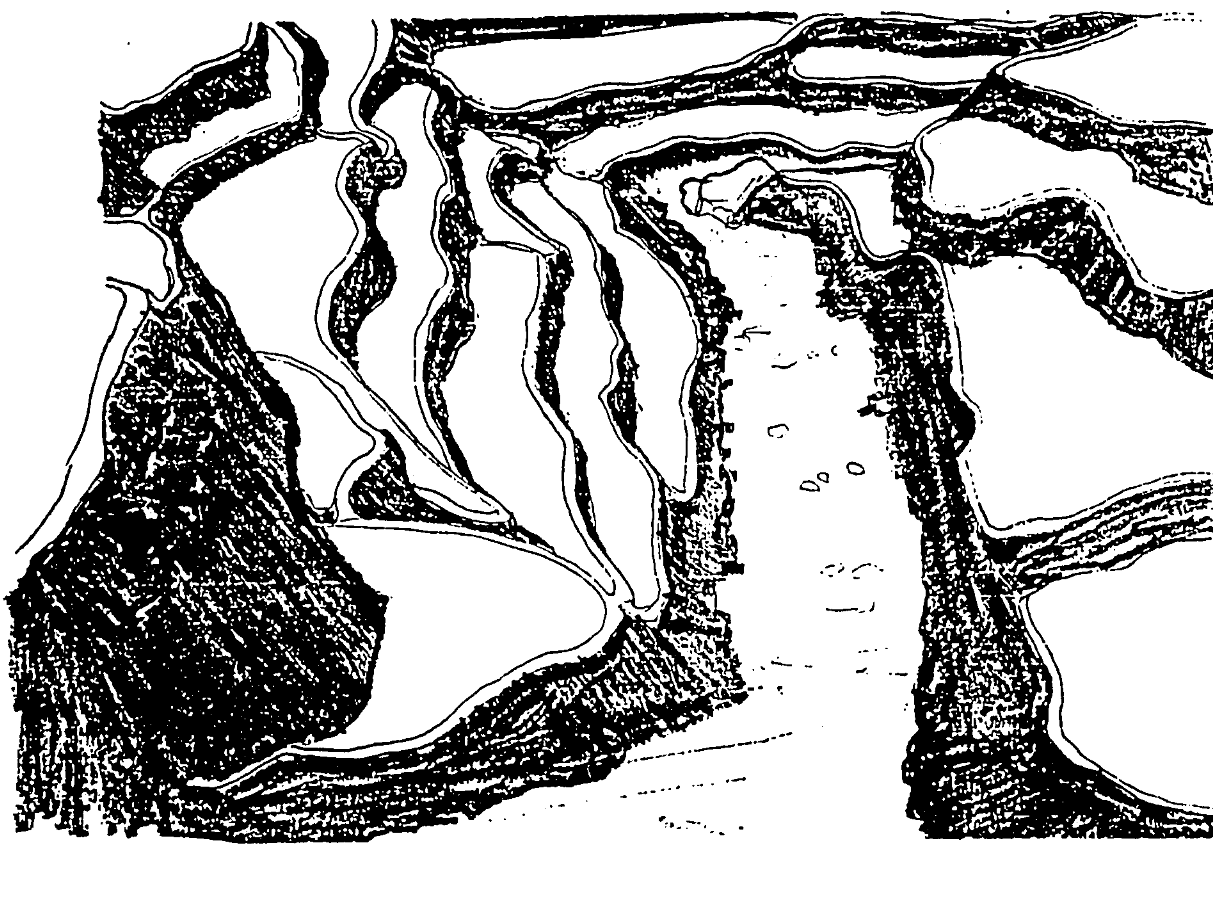


Figure 3: Terraces are effective in harvesting surface runoff for cultivating rice and other crops.

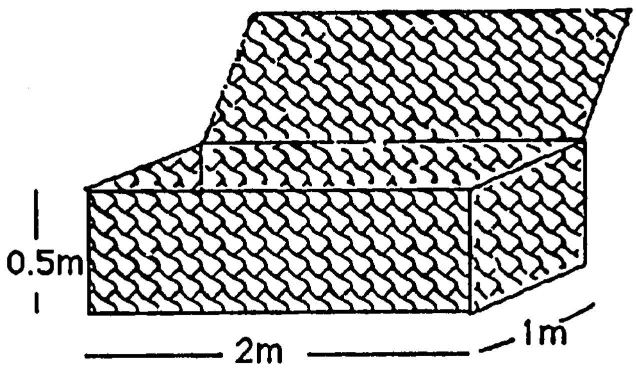


Figure 4: Gabions constructed of wire mesh and fashioned like a cage are gaining wide use in Africa.

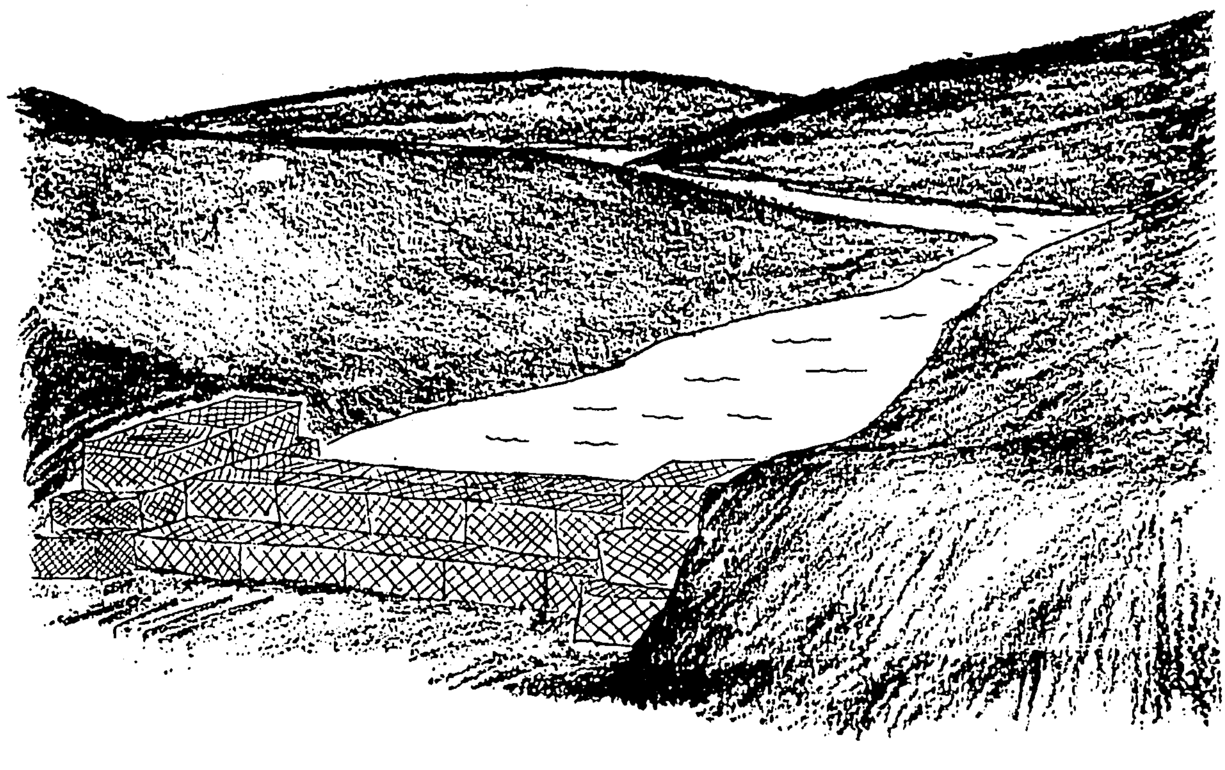


Figure 5: Gabions are filled with rock and placed across small valleys to act as a barrage to retard runoff. Runoff water collected behind the barrage seeps into the ground. Resulting high soil moisture allows farmers to plant crops behind the barrage after rainy season.

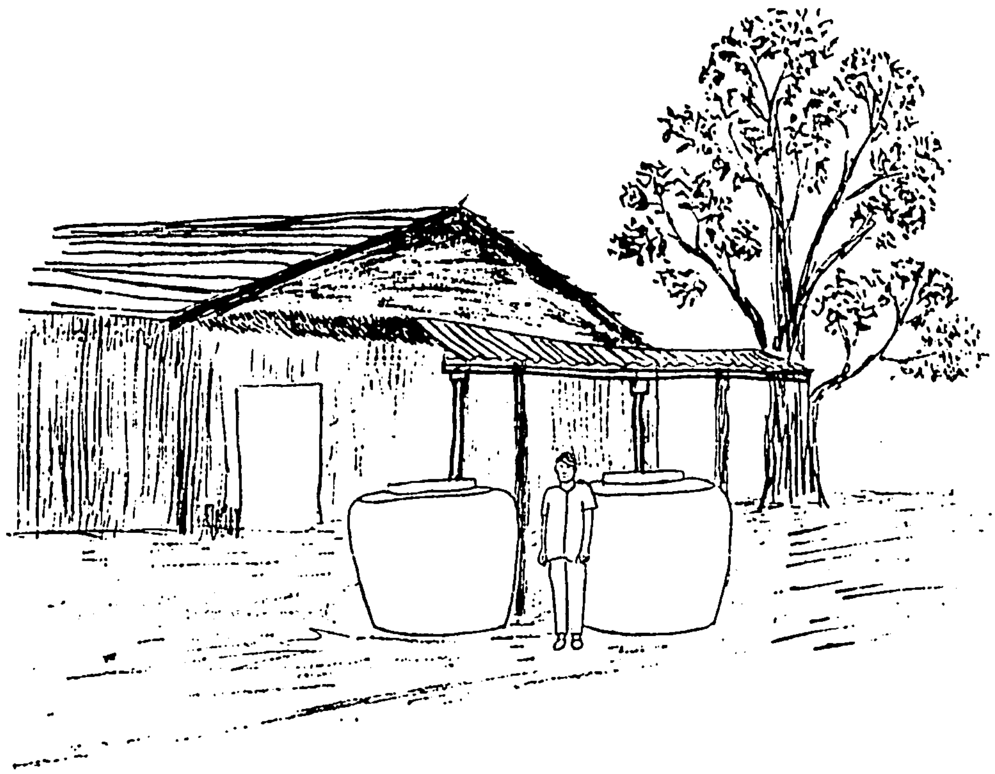


Figure 6: Large jars made of ferrocement are used in Thailand to harvest rainwater from roofs. These roof catchment devices may provide a family with enough drinking water to last through the dry season.

Figure 7: Small ponds provide opportunities for agricultural diversification. They are suitable for harvesting runoff water in rural areas, thus storing it for many purposes which include small scale irrigation, household uses, livestock watering and aquaculture. Ponds properly built and maintained have an indefinite life.

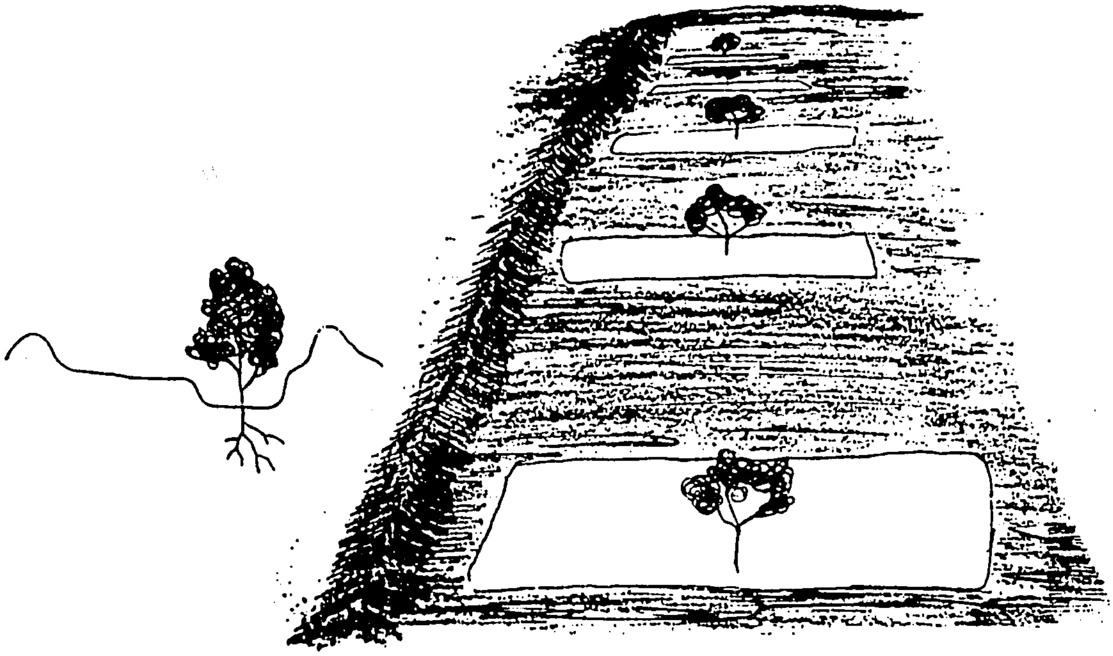


Figure 8: Micro-catchment farming concentrates runoff water from a large area into a small basin. Fruit trees or other crops are planted in the basins.

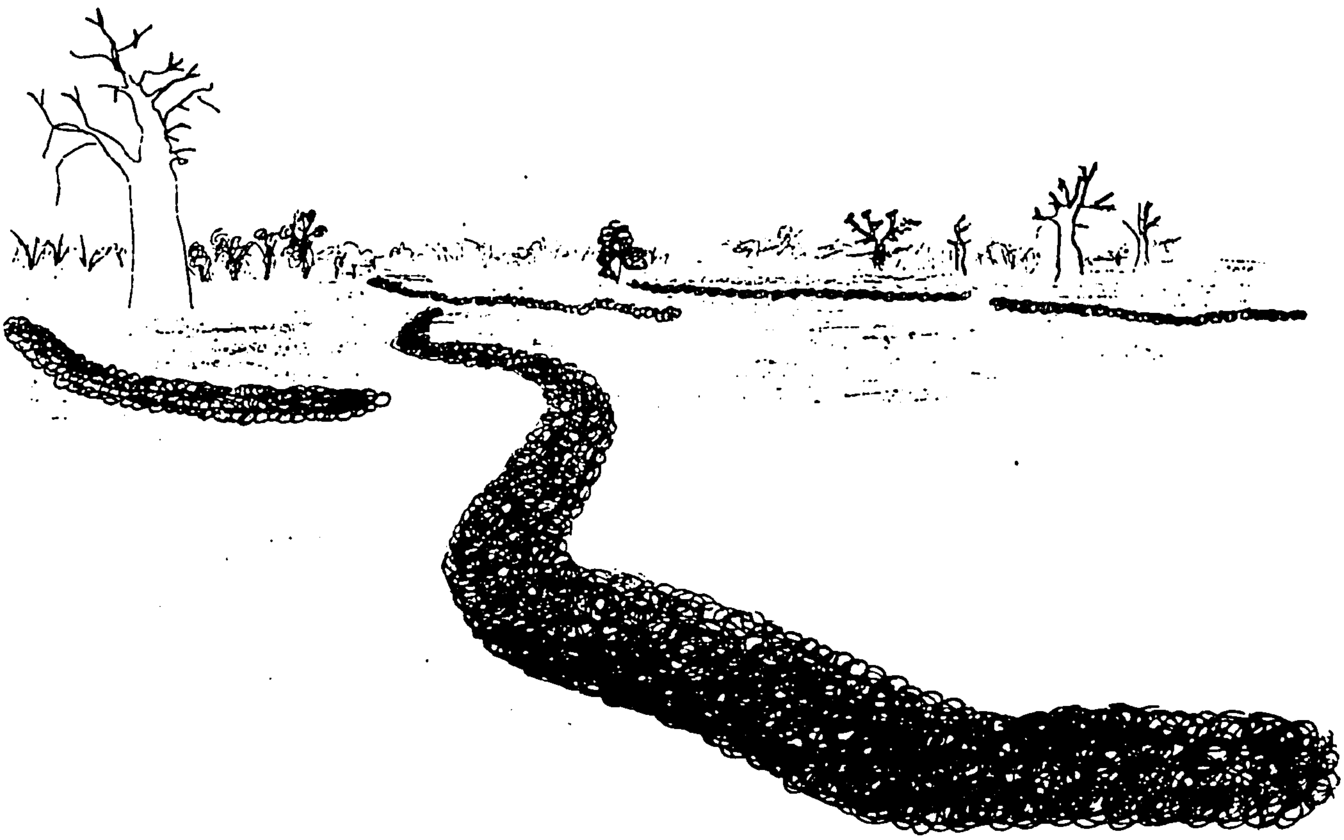


Figure 9: A modification of microcatchment farming involves watershed modification to direct and concentrate runoff water into a designated area. Collecting ditches or low stone walls built on land contours can channel water to the point of use.

SUBSURFACE OR GROUND-WATER

Some rainwater infiltrates into the soil where living plants can take it up through their roots. Structures such as gabions and ponds, which harvest rainfall runoff, increase the amount of subsurface water available to plants. Water infiltrating into deeper soil layers beyond the reach of plant roots is called ground-water. Ground-water may be widely dispersed among particles of soil, sand, gravel or rock and be unharvestable. Soil type and moisture content determine the rate and amount of soil infiltration, which may vary from a fraction of a centimeter to several centimeters per hour. Eventually, water may reach a porous soil layer saturated with water. These porous soil layers are called aquifers. Water is typically harvested from aquifers by pumping or lifting from wells. The top layer of saturation is called the water table. Wells must be dug or bored down into this zone before water can be withdrawn from the aquifer.

An artesian aquifer is under natural pressure due to confinement between upper and lower impervious soil layers. (See Figure 10). At the lower elevation, pressure will push water upward if a well shaft penetrates the upper confining layer. Water in the shaft may rise considerably above the normal water table and even flow freely from the well due to pressure from the confining beds below. Figures 10 and 11 illustrate how water tables and aquifers are positioned relative to various soil layers.

Aquifers can become depleted by withdrawing water faster than the rate of recharge. When this happens, wells go dry and are often dug deeper as a temporary remedy. If a depleted aquifer is not recharged with new water, deepening wells only makes the problem worse. Aquifers are recharged as rain water infiltrates to the water table. Slow runoff rates enhance infiltration. High runoff rates and low infiltration typically occur in deforested areas. Many water harvesting practices retard runoff and encourage water to infiltrate deeply into the soil, thus aiding aquifer recharge. For example, a well dug downslope from a pond will be charged by seepage through the pond bottom and may never go dry.

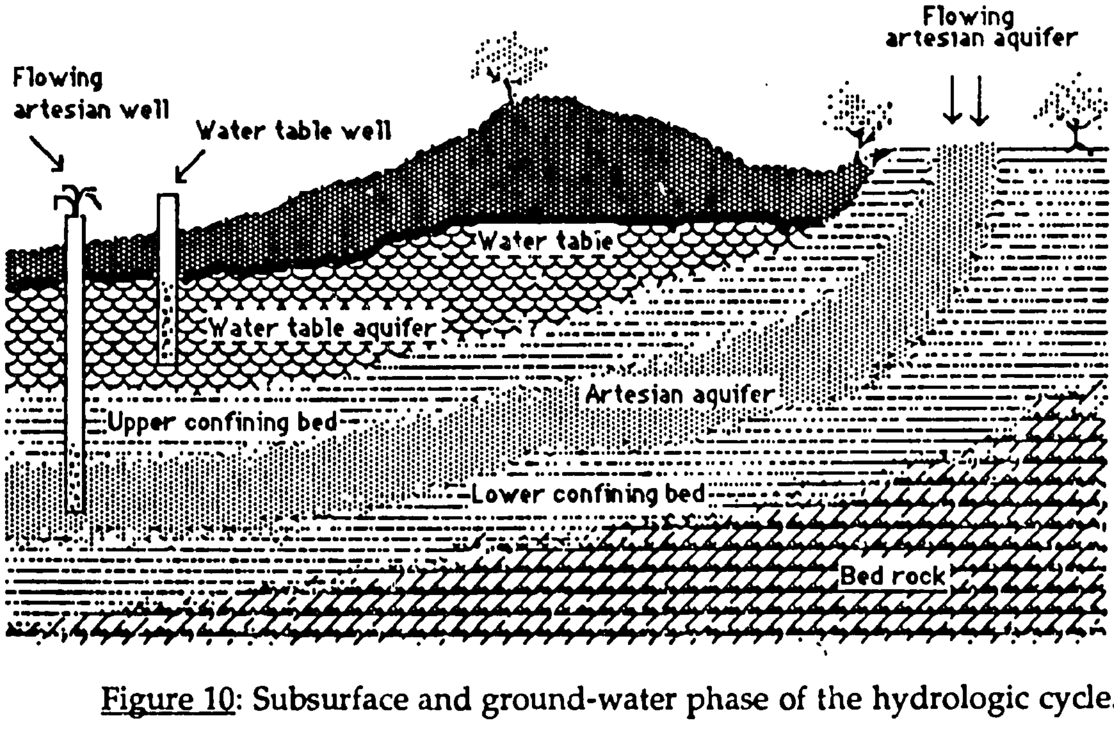


Figure 10: Subsurface and ground-water phase of the hydrologic cycle.

Water seeping from springs may be harvested, and can be a source of good quality drinking water. Springs are often found in areas where a rock or clay layer surfaces on a hillside, as shown in Figure 11. Water that is perched above this impervious layer may flow from the hillside as a spring.

Springs may dry up when the watershed or recharge area is cleared of vegetation. Springs can be prevented from drying up by building water harvesting structures on the watershed to collect rainfall runoff and increase infiltration rates. Such water conservation measures help maintain an adequate water supply to rural families and villages.

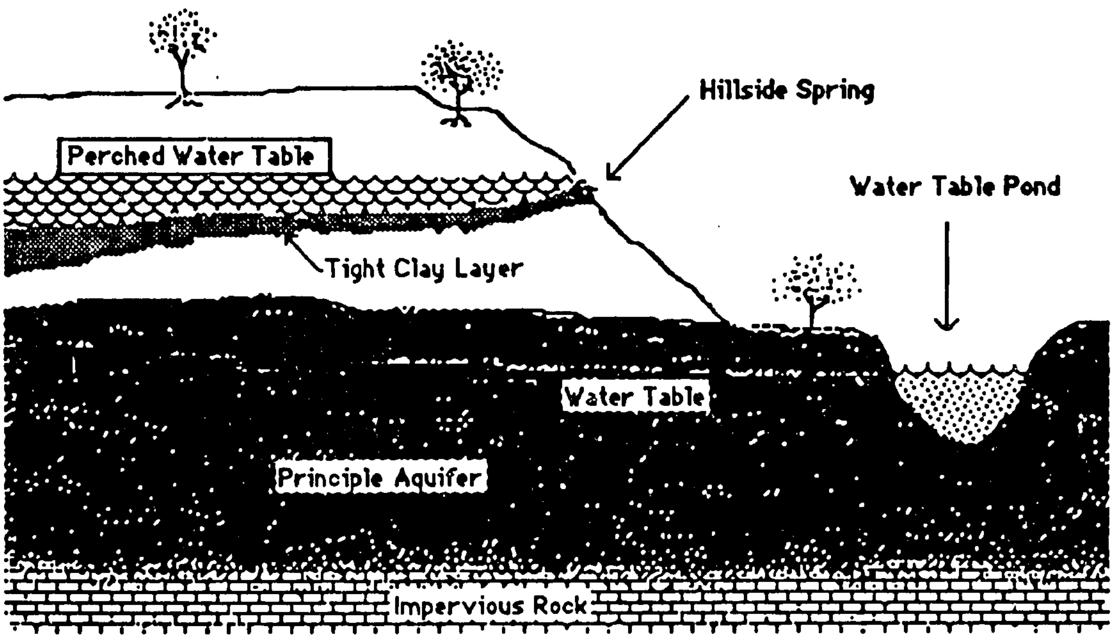


Figure 11: Perched water tables occur above impervious strata and above the main water table.

GLOSSARY OF TERMS

aquifer - a soil layer saturated with water.

artesian aquifer - an aquifer under pressure due to confinement between upper and lower impervious strata.

evaporation - the process by which water is changed from a liquid to a gas or vapor.

evapotranspiration - the passage of water through a plant from the roots, through the vascular system and to the atmosphere.

gabion - a wire cage that is filled with rock and earth and used to construct barrages for temporarily impounding water or preventing soil erosion.

ground water - water that has infiltrated soil beyond the root zone of plants.

hydrologic cycle - the natural sequence through which water cycles from the atmosphere to the earth and back to the atmosphere.

infiltration - seepage of water downward into the soil.

perched water table - a water table lying above a layer of impervious soil or rock which surfaces on a hillside as a spring.

permeability - the property of soil or rock which allows the passage of water through it.

roof catchment device - a device, such as a cement tank or cistern, that collects rain water falling from the roof of a building.

root zone - the depth to which the roots of plants penetrate the soil.

runoff - water that flows over the ground surface after a rain.

spring - a water source which flows up freely from the ground.

surface water - water, such as runoff, that stays on the ground surface and can be collected in ponds or other impounding structures.

subsurface water - water that has infiltrated soil to the root zone.

water harvesting - the practice of collecting and storing water from a variety of sources for beneficial use.

watershed - a region or area from which water flows to a single point.

water table - the top zone of water saturation in the ground.

zone of saturation - the layer or depth of soil which has become saturated with water that has infiltrated down through surface soil layers.

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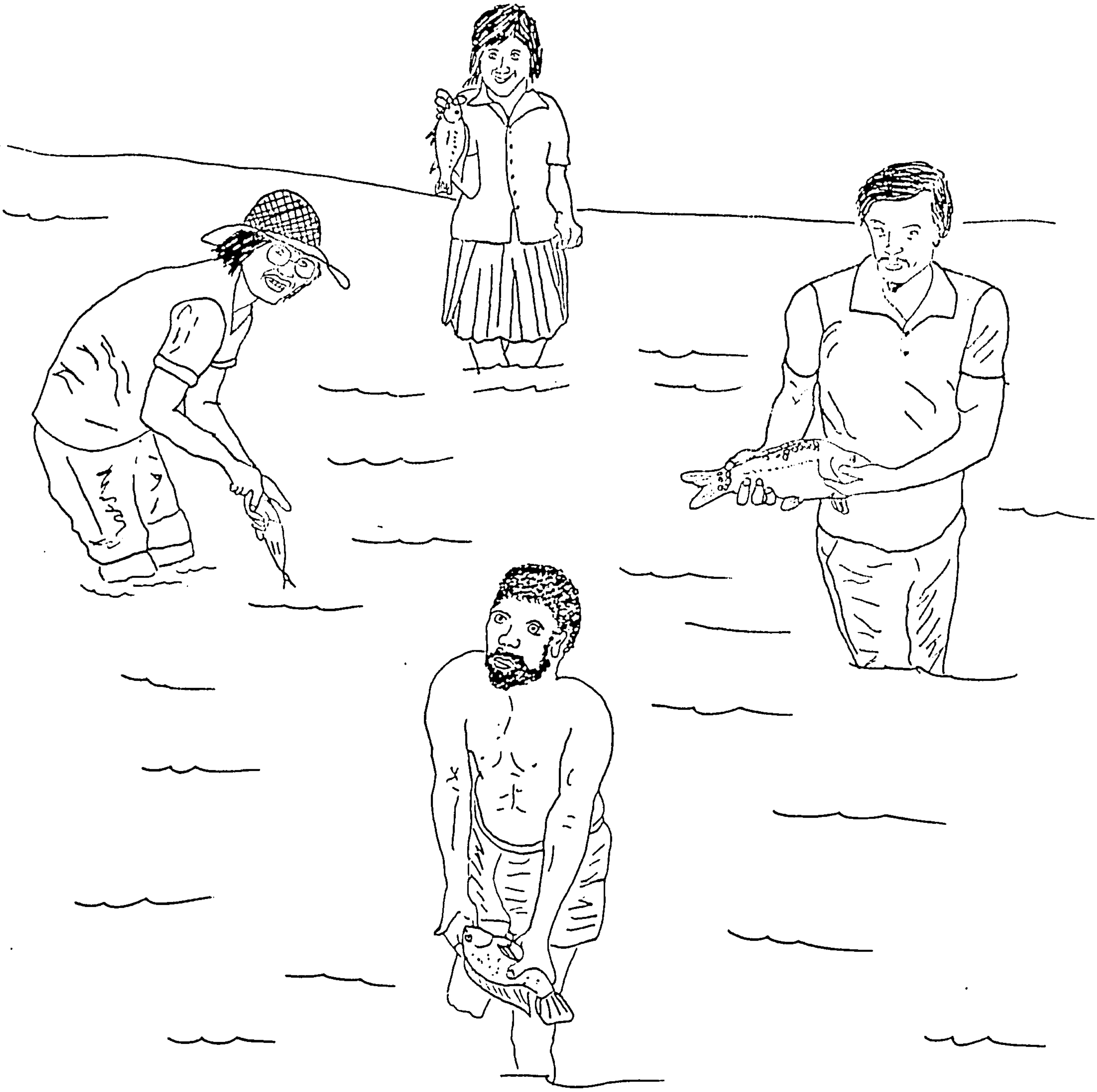
Water Harvesting/Aquaculture Project
Swingle Hall
Auburn University, Alabama 36849 USA

WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

AN INTRODUCTION TO AQUACULTURE



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

More than one-fourth of all animal protein consumed by man is aquatic in origin. Regional differences range from Asia where more than one-fourth of dietary animal protein is fish to North and South America where less than 10% of animal protein consumed by man is from aquatic sources.

Aquaculture has been been practiced in many Asian countries for centuries, but is a new form of agriculture in many African and Latin American countries. It is defined as the cultivation of animals and plants in aquatic environments. Aquaculturists manipulate certain components of the environment to achieve greater control over production of aquatic organisms than is normally possible in nature.

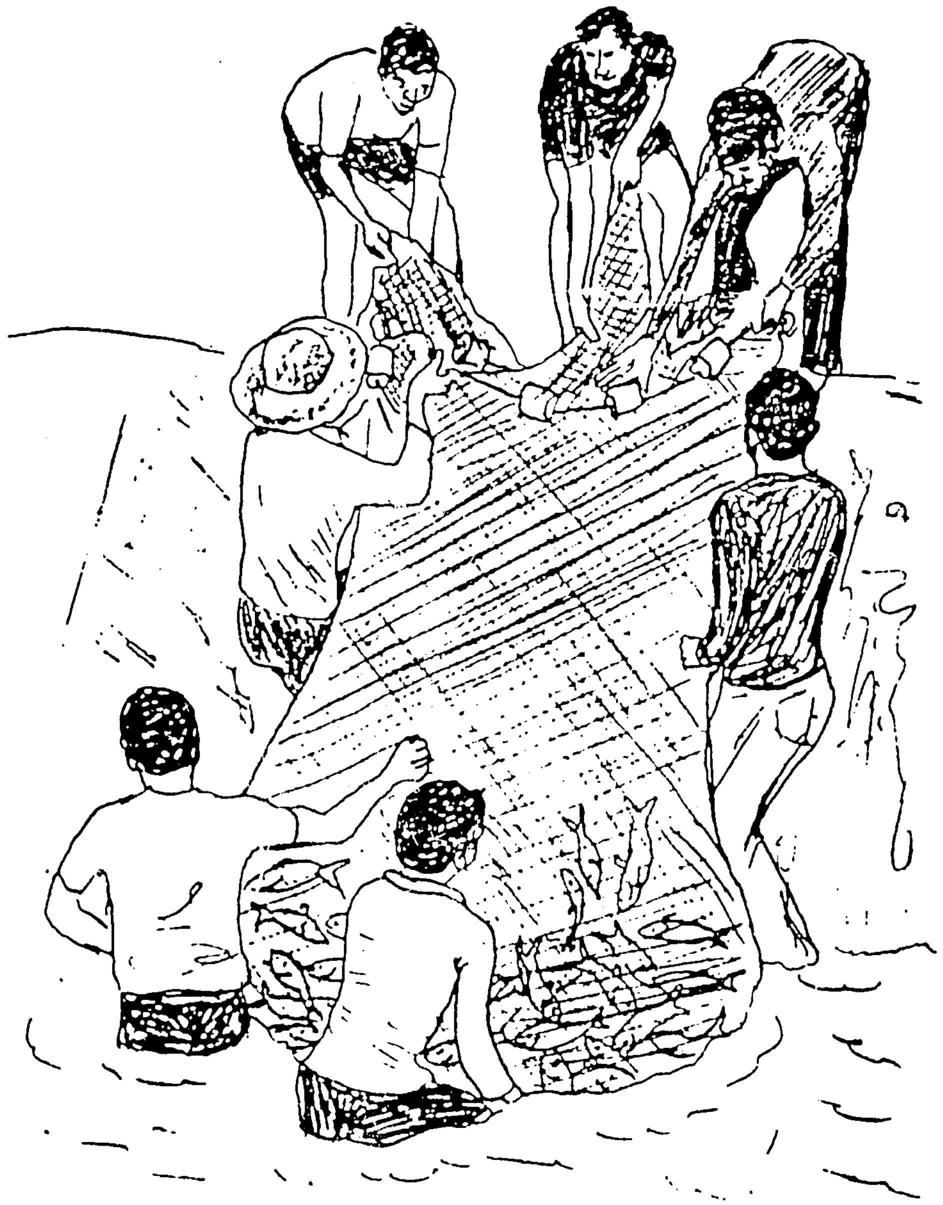


Figure 1: Increased production of aquatic animals and plants is achieved through aquaculture.

BENEFITS OF AQUACULTURE

1) Productive use of poor agricultural lands

Ponds built on the best agricultural land have the highest natural productivity. High production from aquaculture is also possible in ponds built on land which is unsuitable for other forms of agriculture. Hilly land which is difficult to farm or is easily eroded can be utilized for fish ponds. Swampy areas or soils with high salt or heavy clay content can also be utilized for aquaculture.

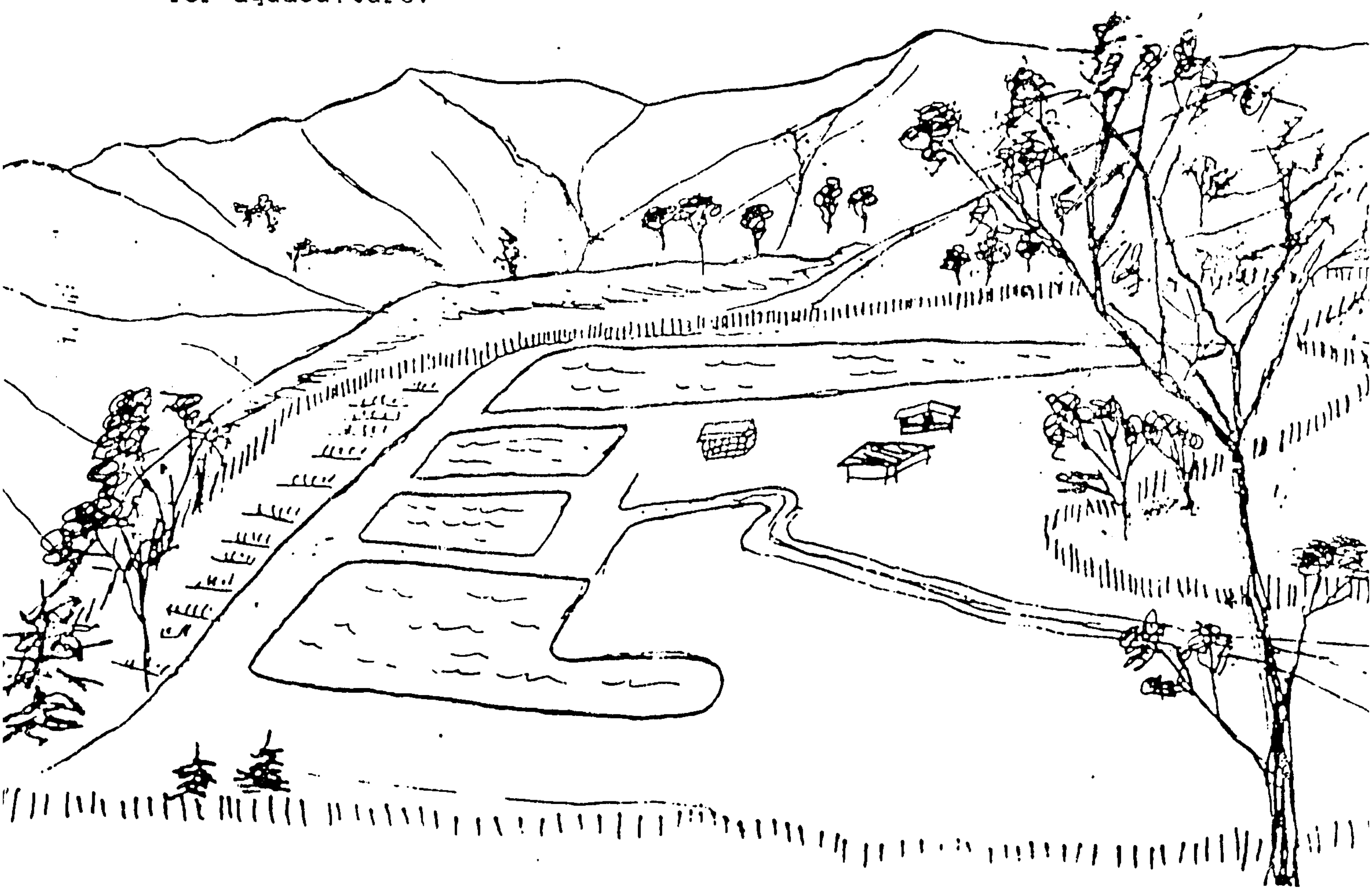


Figure 2: Small valleys often have excellent potential for pond construction.

2) Natural resource conservation

Aquaculture and water harvesting can contribute substantially to the conservation of natural resources, especially water and soil. In many developing countries, surface water is often allowed to drain away instead of being harvested and stored for beneficial use. The requirement by aquaculture for abundant water provides justification and opportunity to build ponds for harvesting and storing water. This also makes water available for supplemental irrigation, stock watering and domestic needs.

Ponds can reduce the dangers of downstream flooding by holding water high in watersheds and checking the erosional force of sudden runoff. Ponds maintain soil moisture in their vicinity and thus support vegetation and wildlife. Ponds on unimproved and unprotected watersheds trap topsoil which may be recovered and redistributed to gardens and fields. Water and soil conservation problems are often greatest in hilly areas where poorer people live. Topography in these areas lends itself to the development of watershed ponds.

3) High economic value of Aquacultural products

Aquaculture may produce a cash crop in a subsistence level economy. Farmers frequently receive higher net returns for fish relative to other traditional crops. Even small ponds can contribute substantially to farm income or reduce family spending as fish are sold, bartered or eaten.

Production costs for fish, poultry, beef and pork have been compared in numerous studies. Initial construction costs for fish farming are high, but once ponds are built fish are usually the most profitable to produce. Approximately 2,500kg of fish per year is produced in a 1 hectare pond by applying low-cost fertilizers such as plant cuttings and animal manures. Production from grazing cattle on the same land area is seldom more than half of that amount. The use of waste materials from integrated livestock and crop enterprises may also reduce input costs while raising fish production.

Fish convert food into flesh efficiently. Food protein is converted to muscle protein with about the same efficiency as chickens or swine, but they need much less starch for energy. Fish are essentially weightless in water, and thus expend little energy for locomotion or to maintain a normal upright position. They are "cold blooded" animals and do not expend energy to maintain a relatively high body temperature as do poultry, swine and cattle. Thus, the amount of food energy required to produce a kilogram of fish is much less than the amount required to produce an equal weight of terrestrial livestock.

4) High nutritional value of Aquacultural products

Fish is a high quality protein source that ranks about equal to chicken and is superior, in many respects, to red meets. The edible fraction of fish is similar to that of other animals (49 - 52% of the whole animal), but fish flesh contains higher quality and more digestible protein than red meats. Evidence that fish diets reduce cholesterol levels in the blood is increasing. Dressed fish contains about one-third less fat than red meats. Fat in fish flesh is also more unsaturated than that in red meats.

Table 1: Nutritional value of dressed fish flesh compared with other food animals.

Source of Flesh	Lean Muscle %	Edible Fat, %	Food Energy, Calories per 100 g of Edible Tisue
Channel catfish	81	5	112
Beef	51	34	323
Pork	37	42	402
Chicken	65	3	84

6) Integrated aquaculture is a highly sustainable form of agriculture

Aquaculture is sustainable because it makes use of locally available resources. Integration of aquaculture with other forms of agriculture diversifies farm productivity. This, in turn, provides opportunities for intensified production with more efficient allocation of land, water, labor, equipment and other limited capital than enterprises which are independently operated.

Stored pond water may serve as a catalyst for rural development because a variety of different activities may be simultaneously undertaken. Fish culture integrated with garden irrigation, livestock watering, and various domestic uses are all possible.

Culturing several different fish species with complimentary feeding habits together in the same pond (polyculture) is more complicated, but utilizes more of the available natural food organisms. Higher yields are thus obtainable with polyculture than is possible by culturing a single fish species. Polyculture also permits several different species that may command different market prices to be grown. A range of consumer tastes and demands may thus be served from one pond.

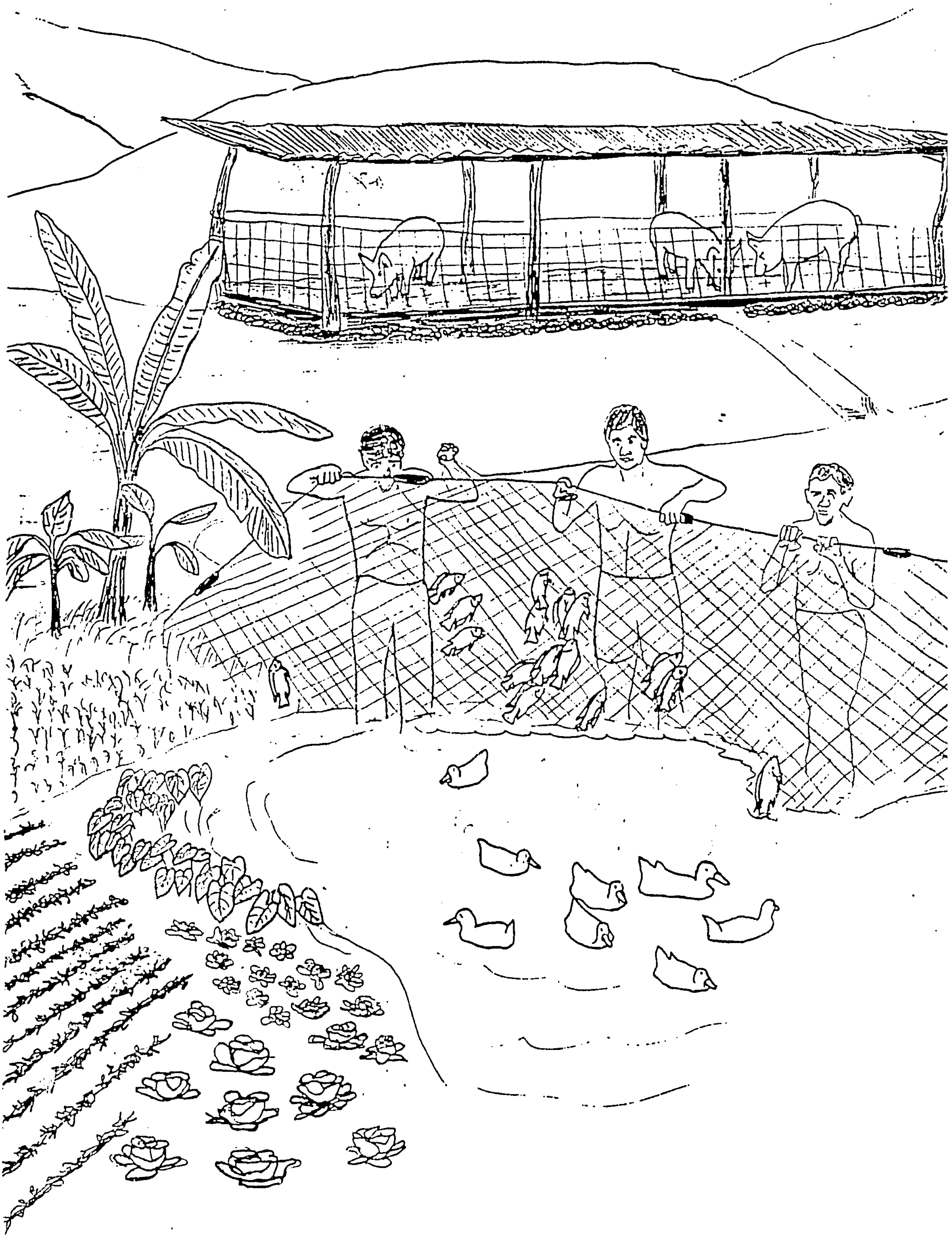


Figure 4: Aquaculture can be integrated with the production of livestock, fruits, vegetables and other water uses.

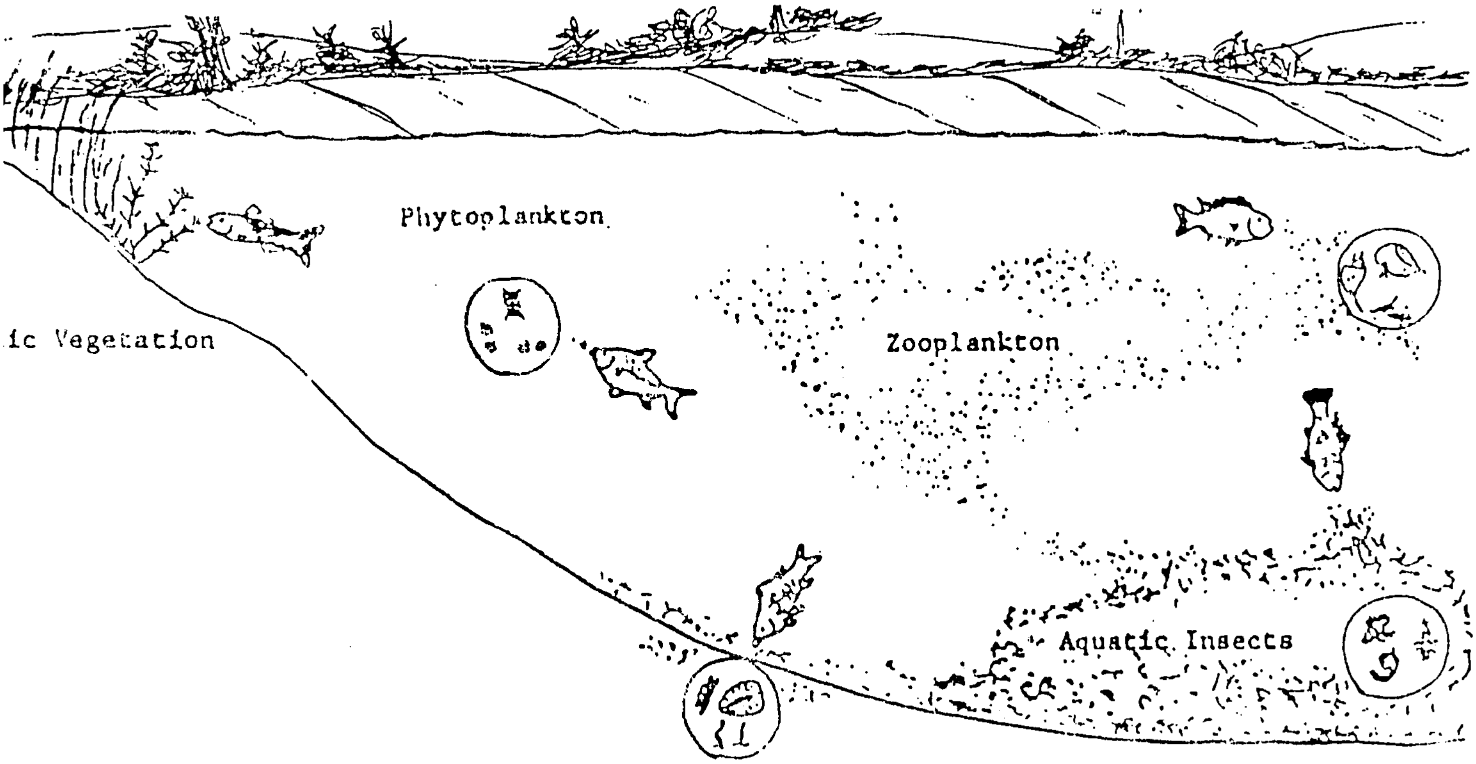


Figure 3: Polyculture utilizes more of the available food and produces a variety of fish for market.

6) Self-sufficiency for subsistence farmers

Aquaculture makes fresh fish available in rural areas. There are few regions in the developing world where fish are not an acceptable protein source. However, fish captured off the coasts of these countries are often exported and are too costly for the poor. Large populations of rural poor may live in isolated areas where transportation and market facilities are inadequate to provide them with sufficient fish.

Inland ponds allow subsistence farmers to raise fish for their families. Aquaculture helps them to diversify food production and promotes self-sufficiency by spreading the risk of crop failure. Fish are also small packages of protein which can be individually harvested and consumed as needed, without requiring refrigeration to keep large quantities from spoiling. This is an added benefit in areas without electricity or ice.

THE FEASIBILITY OF AQUACULTURE

Aquacultural production technologies are determined by the interaction of five factors which may be manipulated to some extent. These are the physical environment, culture facilities, available nutrient inputs, species cultured and the ability of producers to balance all the factors in a profitable package.

The natural environment is essentially fixed, though subject to minor modifications. It includes such climatic conditions as temperature, rainfall and storm patterns, land elevation and topography, soil characteristics (particularly water holding capacity and acidity), water availability and geographical barriers to supplies and/or markets. If these conditions are not suitable to aquacultural development, little can be done to change them.

The role of aquaculture in increasing protein consumption in the world depends on demand. This demand is determined by consumer income, the cost of alternate foods and a combination of taste preferences and dietary habits. The ability to make aquaculture profitable is also affected by traditions regarding land use, time management and allocation of other resources. Seasonal changes in demand and supply, as well as social and political factors also affect the feasibility of aquaculture.

LEVELS OF AQUACULTURAL TECHNOLOGY

A high degree of technological flexibility makes aquaculture feasible under a variety of conditions and objectives. Aquaculture may be practiced at different intensity levels. Simple systems requiring low levels of technological management and resources, and only slight modifications of the environment are termed "extensive". Aquaculture becomes increasingly "intensive" as more control of the environment and sophistication in management are used. An important aspect of aquacultural technology is the use of nutrient inputs in the form of fertilizers, foods or both. Extensive aquaculture uses low quality foods and fertilizers in small amounts. Higher quality inputs in large amounts are required for intensive aquaculture.

Small-scale aquaculture for the promotion of socio-economic development fulfills the objectives of food production, income generation and provision of local employment for small farmers. Extensive technology and associated low operating costs with higher labor requirements are often mandated by the reduced availability of investment and operating capital for small-scale farmers. Large-scale or "industrial" aquaculture is more concerned with maximizing profit through sales and relies on more intensive technology. Larger capital outlay and more advanced management skills are required.

GLOSSARY OF TERMS

aquaculture - raising of animals or plants in aquatic environments under controlled conditions.

erosion - the washing away of soil by rainfall and water as it runs over land.

extensive aquaculture - raising aquatic animals or plants under conditons of little or incomplete control over such factors as water flow, number and weight of species raised, and low quality and quantity of nutrient inputs.

food conversion efficiency or ratio - a measure of the amount of dry food required to produce an equal wet weight of aquatic animal flesh.

independent variable - a condition subject to only minor modifications, which affects feasibility for aquaculture.

integrated aquaculture - aquacultural systems integrated with livestock and/or crop production. For example, using animal manures to fertilize a pond to enhance fish production and water from the pond to irrigate a garden.

intensive aquaculture - aquaculture practiced under a high degree of environmental modification and control in which the principle nutrient source is high quality feed.

microscopic - invisible to the eye without the aid of a microscope or magnifying glass.

phytoplankton - the plant component of plankton.

plankton - the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

poikilothermic - "cold-blooded"; having a body temperature that varies with ambient air or water temperature.

polyculture - simultaneous culture of two or more aquatic species with different food habits.

watershed - an area from which water drains to a single point.

zooplankton - the animal component of plankton.

Communications and editorial comments regarding this technical series should be addressed to:
Water Harvesting/Aquaculture Project
Swingle Hall
Auburn University, Alabama USA 36849

WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

FERTILIZING YOUR FISH POND: AN INTRODUCTION

WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

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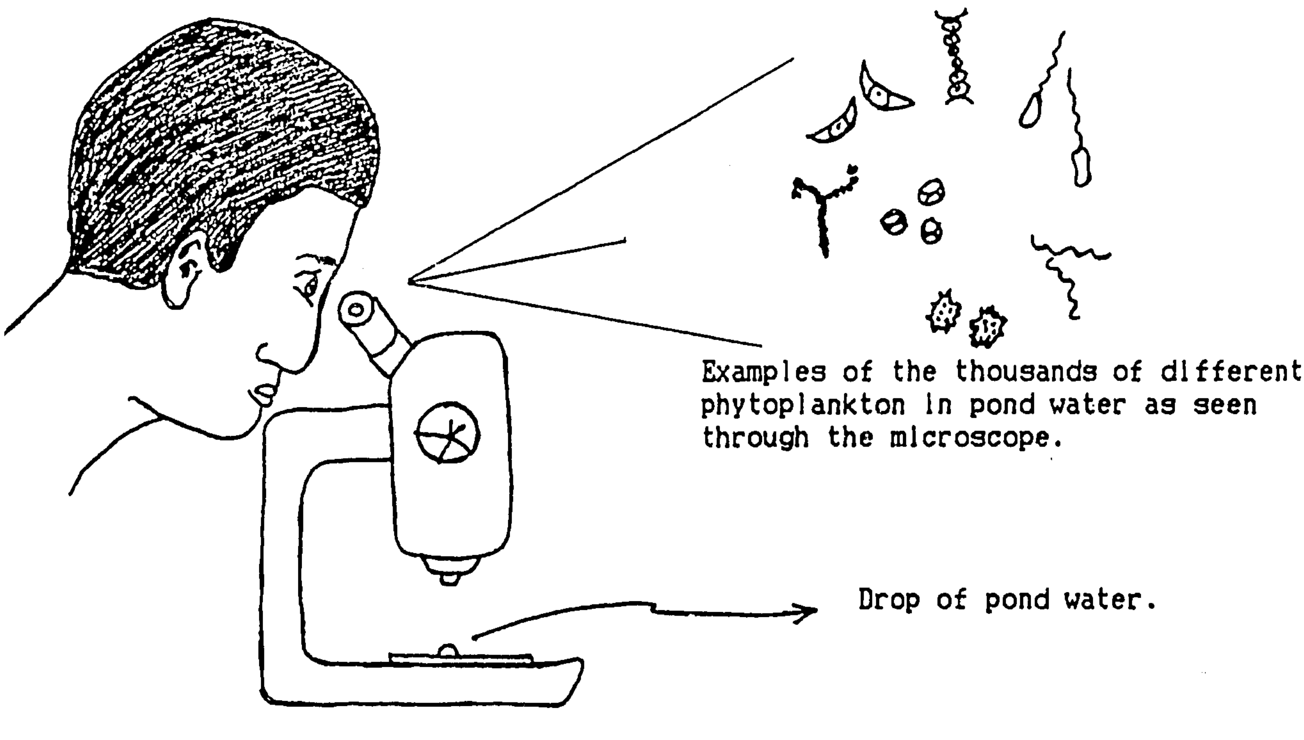
INTRODUCTION

A fish pond is a unique environment created by man. It must be managed properly to achieve good fish production. For centuries fish farmers have increased fish yields in ponds by using inorganic or chemical fertilizers and organic fertilizers or "manures".

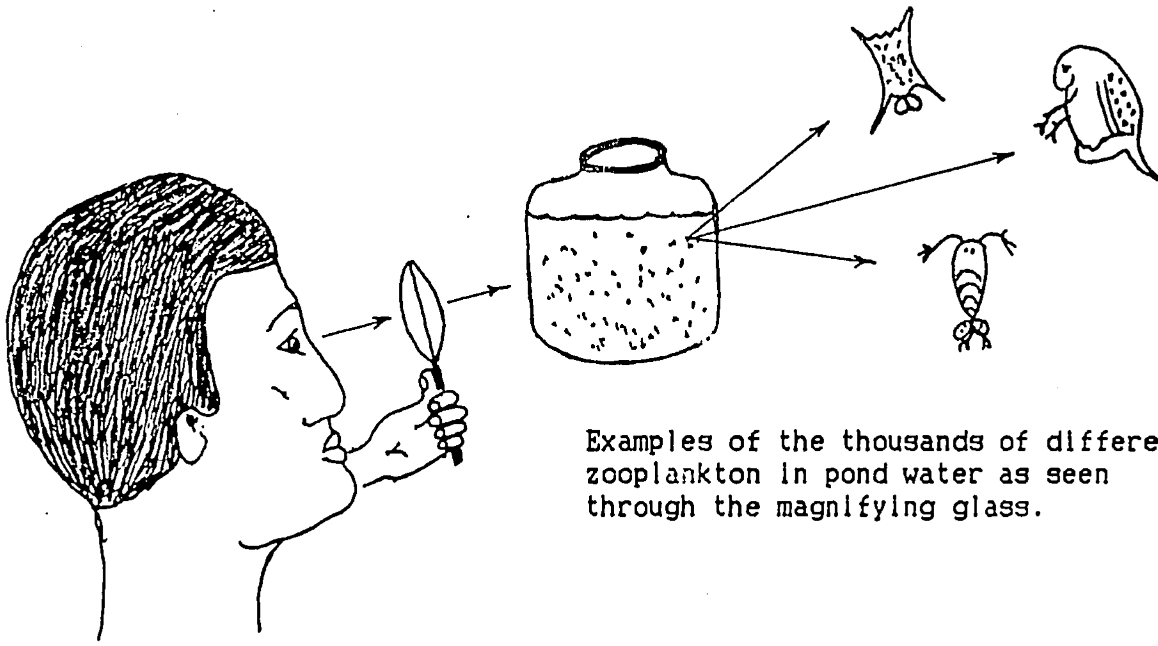
WHY FERTILIZE PONDS?

Microscopic green plants called algae or "phytoplankton" form the base of the food chain for fish. All green plants need light, proper temperature and nutrients for growth. If sufficient light and proper temperature are present, the nutrients in chemical fertilizers (nitrogen, phosphorous and potassium) are readily assimilated by phytoplankton and their abundance increases. Manure contains the same nutrients. They are released and become available to phytoplankton during and after decomposition. As phytoplankton assimilate fertilizer nutrients and reproduce to form dense communities pond water turns a greenish or brownish color. This is called a phytoplankton bloom.



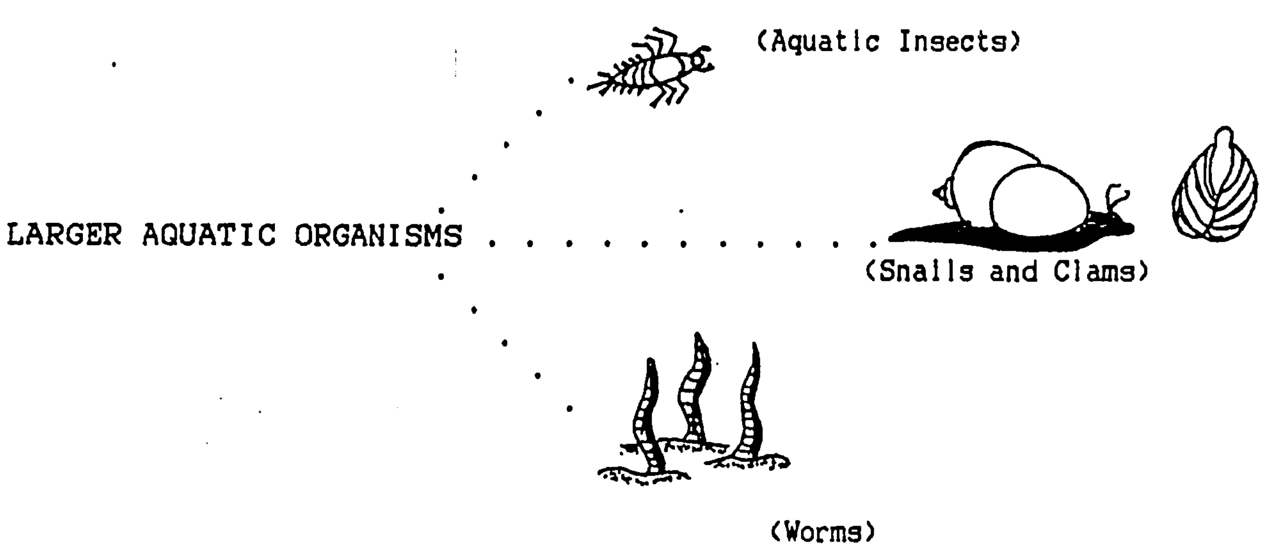
Viewing phytoplankton in a drop of pond water under a microscope.

As phytoplankton multiply they are eaten directly by some fish or by other mostly microscopic aquatic animals called "zooplankton".

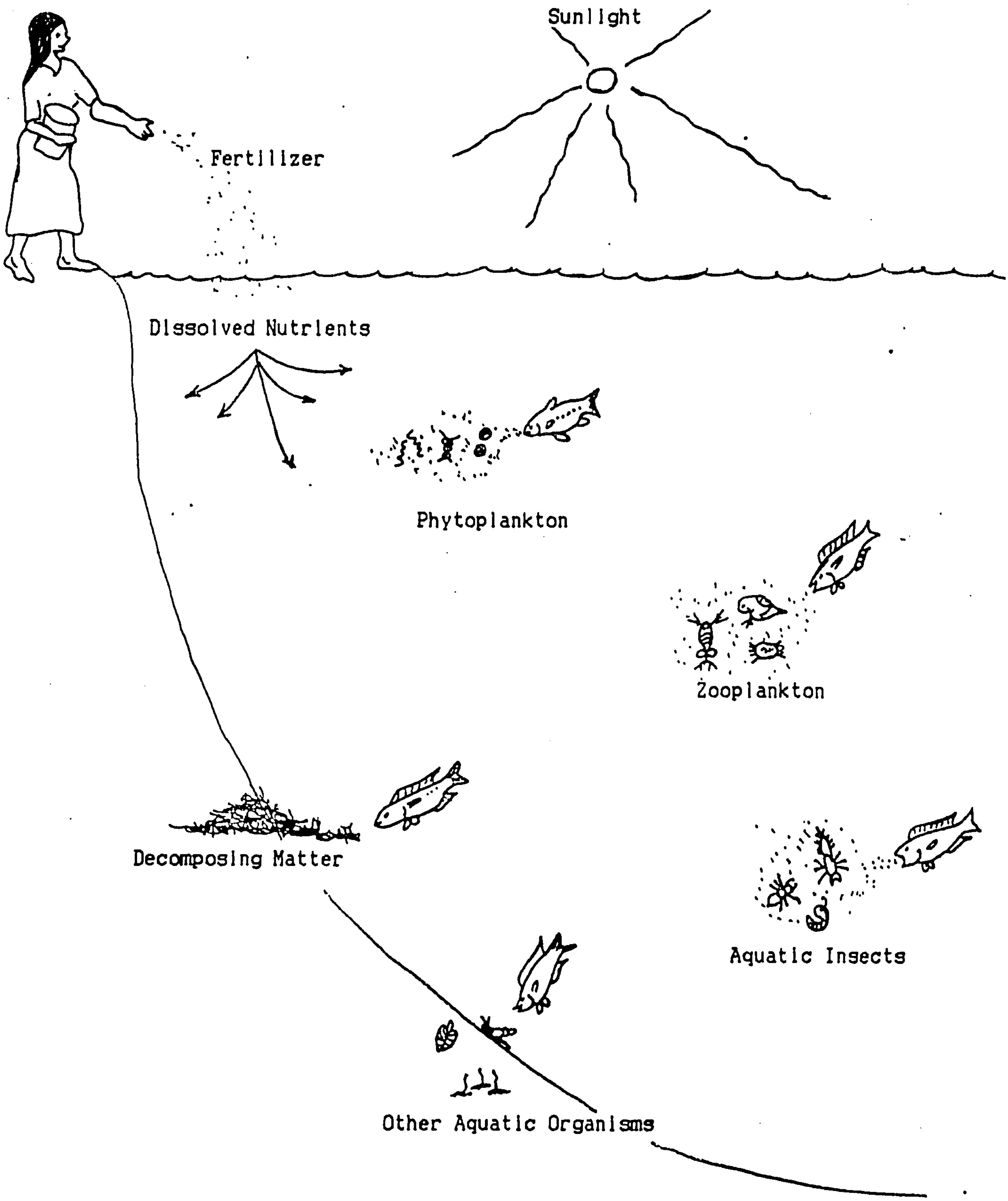


Viewing zooplankton in a jar of pond water through a magnifying glass.

Phytoplankton and zooplankton (collectively called "plankton") also serve as food for larger aquatic organisms.



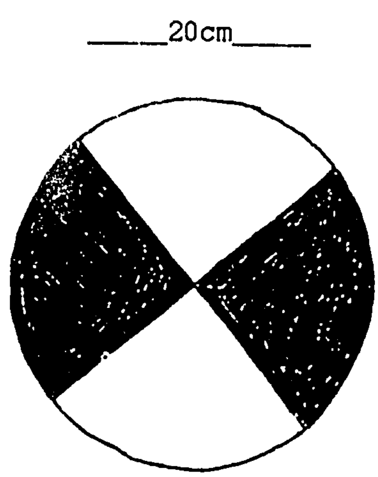
Through a complex chain of interactions fertilizers increase production of natural food organisms eaten by fish. Different fish may have different food preferences. Some can filter plankton, others eat aquatic insects and others may feed on decomposing material. The following diagram illustrates this.



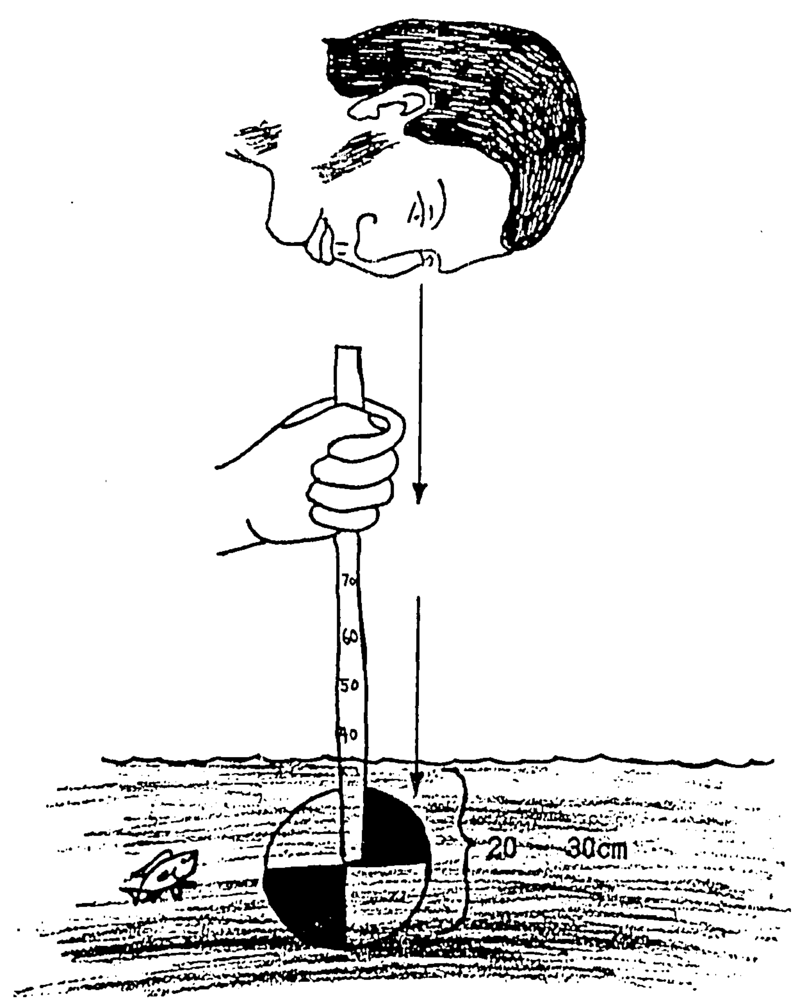
MEASURING THE EFFECT OF FERTILIZATION

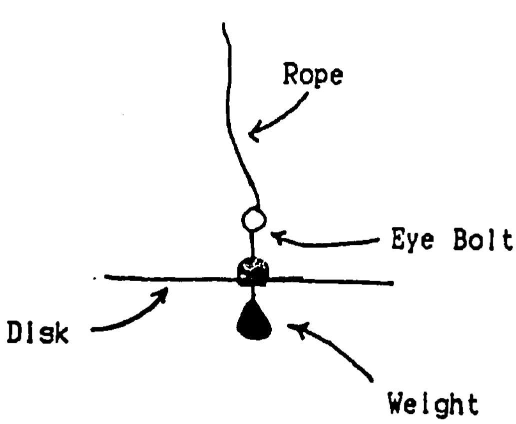
Response to fertilization can be measured by the abundance of phytoplankton. When phytoplankton is abundant, it makes water a turbid green or brownish color. If the pond water is not very muddy, the turbidity caused by phytoplankton can serve as a measure of phytoplankton abundance.

A Secchi disk is a standard way to measure visibility in water. The disk measures 20cm in diameter and is painted black and white in opposing quarters as shown below. A simple disk can be made from a round can lid. The disk is attached to a wooden stick or a rope marked off in centimeters. Measure plankton density by lowering the disk into the water with your back to the sun while viewing the disk from directly above. The depth at which the disk just disappears from sight is the Secchi disk reading.



(TOP VIEW OF A SECCHI DISK)





(SIDE VIEW)

Making and using a Secchi disk.

It is often easier for a farmer to use his arm and hand instead of a Sechii disk. The principle is the same. The person's arm becomes a meter stick and the upturned palm of the hand becomes the disk as illustrated below. Rules on how to interpret the results of either Secchi disk or arm and hand and what management actions to take depend on what fish is being cultured and on what fertilizer is being used.

Measuring phytoplankton abundance by arm and hand.

DIFFERENCES BETWEEN CHEMICAL FERTILIZERS AND MANURES?

Chemical fertilizers are concentrated nutrients for green plants. The qualities that have made them popular in modern agriculture are: 1) they can be stored for a long time, and 2) relatively little is needed since the nutrients are in a concentrated form. These are important advantages over manures if labor and transportation are costly. Two disadvantages of chemical fertilizers, especially for isolated farms operated on a limited budget, are that they are usually expensive and available only from commercial suppliers.

Another important consideration about chemical fertilizers is their potential for being wasted. Adding chemical fertilizer to a pond initially stimulates phytoplankton growth. However, if too much is added plankton can become so dense that sunlight penetration through the water is restricted. When this happens algae cells may have more than enough nitrogen and phosphorus available in the water, but they do not receive sufficient sunlight. No additional plankton will then be produced. Keeping phytoplankton abundance within the limits suggested for Secchi disk or arm measurement helps ensure that excess fertilizer is not applied.

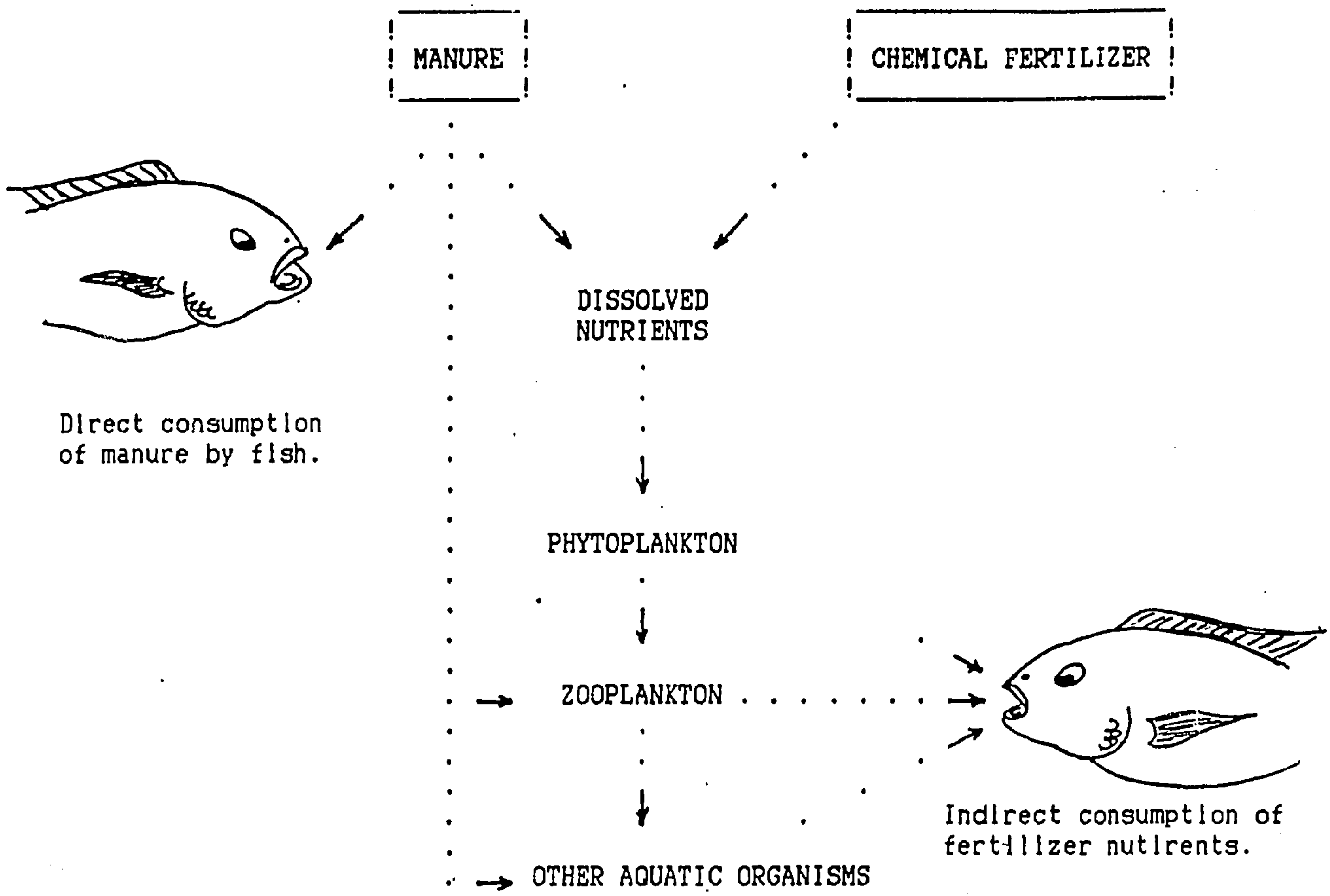
Chemical fertilizer may not be eaten directly by fish. Manure, however, can serve several roles. It releases nutrients for phytoplankton through decomposition; certain fish can digest specific components of manure; fish may digest the bacteria, fungi and other organisms contained in manure even though the manure itself may have no nutritional value.

Large quantities of manure are needed to fertilize ponds. This is its main disadvantage. There is a danger in adding too much manure to a pond at one time. Decomposition may deplete oxygen in the water or cause harmful substances to accumulate. Fish may die as a result. However, with proper management this problem can be avoided or corrected and where manures are available they are often the fertilizer of choice.

FOOD CHAINS

Nutrients in chemical fertilizers are "food" for green plants, and have no direct food value to fish. When chemical fertilizers are added to a pond phytoplankton become more abundant. They may then be eaten directly by fish or by zooplankton and insects which are subsequently eaten by fish. This step-by-step process is called a food chain.

A step in the food chain can be eliminated by adding manure instead of chemical fertilizer to a pond because many fish will consume manure directly. Manure may also be eaten by zooplankton or insects which are later eaten by fish or it may be decomposed by bacteria and other organisms. Decomposition releases nutrients for assimilation by phytoplankton. A simplified food chain illustrating direct and indirect consumption of fertilizer nutrients by fish follows.



Simplified food chain with arrows showing pathways through which fertilizer nutrients are turned into fish flesh.

CONCLUSION

Both chemical fertilizers and manures are used to increase fish yields. Different results may be obtained under different conditions. The Choice of which fertilizer to use will be influenced by local availability, cost and other factors. Read "Chemical Fertilizers For Fish Ponds" and "Organic Fertilizers For Fish Ponds" for more detailed information on fertilizer use.

GLOSSARY OF TERMS

assimilate - to take in and appropriate as nourishment.

chemical/inorganic fertilizers - manufactured fertilizers containing nitrogen, phosphorous and potassium in varying proportions.

decomposition - the decay or breakdown of organic materials into simple compounds available for assimilation by phytoplankton.

fertilizer - a substance added to water to increase the production of natural fish food organisms.

food chain - the pathways through which nutrients added to a pond are converted into fish flesh.

manure/organic fertilizer - animal or plant matter used as fertilizer in ponds.

microscopic - invisible to the eye without the aid of a microscope or magnifying glass.

natural fish food organisms - plankton, insects and other aquatic organisms that fish eat.

organic fertilizers/manure - fertilizers composed of animal or plant materials which must be decomposed to release their minerals and nutrients.

oxygen depletion/low oxygen - a condition, normally occuring at night, in which oxygen dissolved in pond water has been depleted mainly because of the decomposition of organic matter and respiration of organisms in the pond.

phytoplankton - the plant component of plankton.

phytoplankton bloom - an increase in phytoplankton abundance resulting from fertilization.

plankton - the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

Secchi disk - a circular disk measuring approximately 20cm in diameter which is used to measure the abundance of plankton in water.

turbidity - an opaque or unclear appearance imparted to water by the presence of suspended foreign particles (soil, plankton, etc.)

zooplankton - the animal component of plankton.

Communications and editorial comments regarding this technical series should be addressed to:

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WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

CHEMICAL FERTILIZERS FOR FISH PONDS

WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

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.INTRODUCTION

Chemical fertilizers are normally used to improve soil fertility and increase agricultural crop yields. In fish ponds they stimulate phytoplankton production which increases fish yields. They contain inert filler material mixed with three important minerals, nitrogen (N), phosphorous (as P_2O_5) and potassium (as K_2O or potash) which are needed by phytoplankton in fish ponds. A commonly available chemical fertilizer is 12-24-12. It contains 12 percent nitrogen, 24 percent phosphorous and 12 percent potassium. This equals 48% fertilizer and 52% filler material by weight. Fertilizers high in phosphorous are especially good for phytoplankton production in freshwater ponds. New freshwater ponds and salt water ponds also require nitrogen. After several years the organic content in the mud of these ponds will increase and may provide sufficient nitrogen for phytoplankton growth. Only phosphorous may be needed for increased production in aged ponds. Table 1 lists several chemical fertilizers used in fish ponds and their compositions. For more information on fertilizer application see "Fertilizing Your Fish Pond: An Introduction" and "Organic Fertilizers For Fish Ponds".

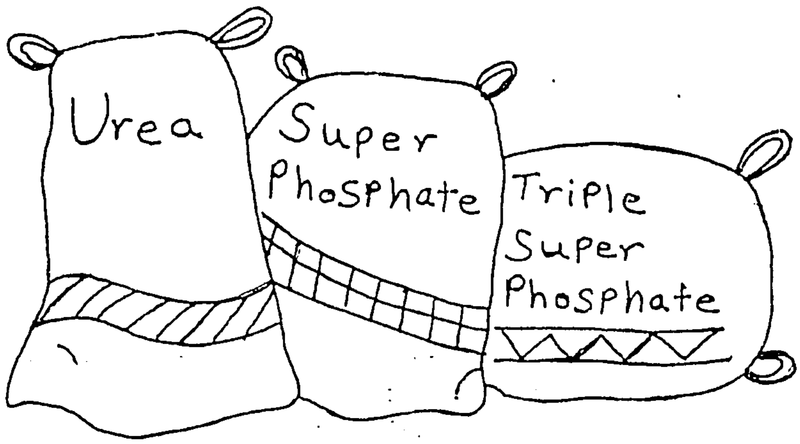


Table 1. NPK composition of several fertilizers used in fish ponds.

	Percent Composition		
	(N)	(P_2O_5)	(K_2O)
Ammonium nitrate	33-35	0	0
Ammonium sulphate	20-21	0	0
Ammonium phosphate	16	20	0
Calcium nitrate	15.5	0	0
Diammonium phosphate	18	48	0
Double superphosphate	0	32-40	0
Muriate of potash	0	0	50-62
Potassium nitrate	13	0	44
Potassium sulphate	0	0	50
Sodium nitrate	16	0	0
Superphosphate	0	18-20	0
Triple superphosphate	0	44-54	0
Urea	42-47	0	0

APPLYING CHEMICAL FERTILIZERS TO PONDS

Weekly application rates for chemical fertilizers may range from 1.25 to 1.75 grams of P_2O_5/m^2 of pond surface area. The amount of fertilizer needed can be calculated using information from Table 1. For example: to calculate the amount of superphosphate needed to give 1.25 grams of P_2O_5/m^2 in a $100m^2$ pond the following calculation is done.

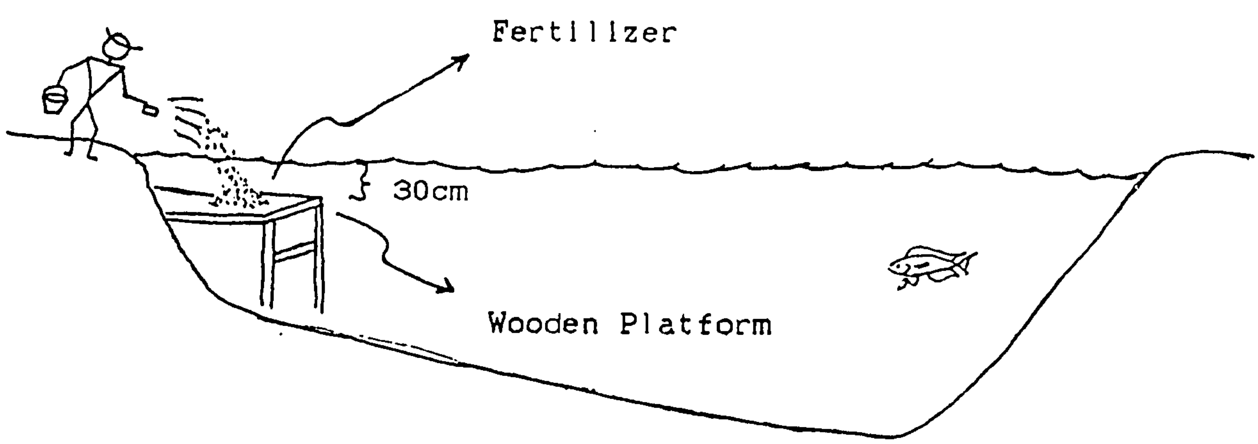
$$\frac{1.25g/m^2}{0.20} \times 100m^2 = 0.625Kg/100m^2/week$$

In this calculation 0.20 (or 20%) is the percent P_2O_5 content from Table 1. The pond would receive an initial application of 0.625kg of fertilizer. The weekly amount would then be increased or decreased as needed based on Secchi disk readings. See "Fertilizing Your Fish Pond: An Introduction" for details on making and using a Secchi disk.

Solid chemical fertilizers should not be thrown into a pond. They will sink to the bottom and nutrients will be lost in the mud. Chemical fertilizers can be applied in several ways to keep them out of the bottom mud.

1. Platform method:

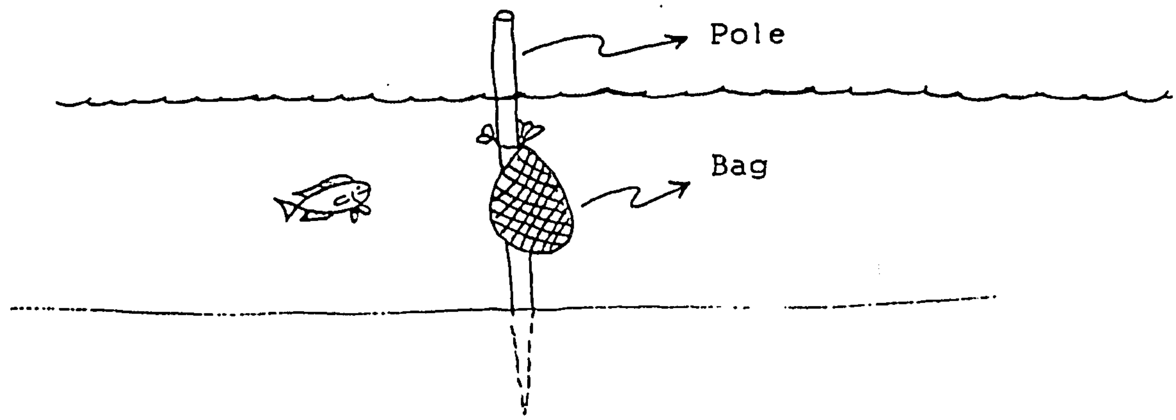
A table or platform may be built of wood, bamboo or zinc sheets. The platform surface rests 30cm below the water surface. Place a two-week dose of fertilizer on top of the platform. Wave action will distribute nutrients as they dissolve. Fertilizer is added as needed to maintain the desired phytoplankton abundance. This usually occurs when the water clears enough to allow the platform to be seen.



A fertilizer platform in a pond.

2. Nylon bag:

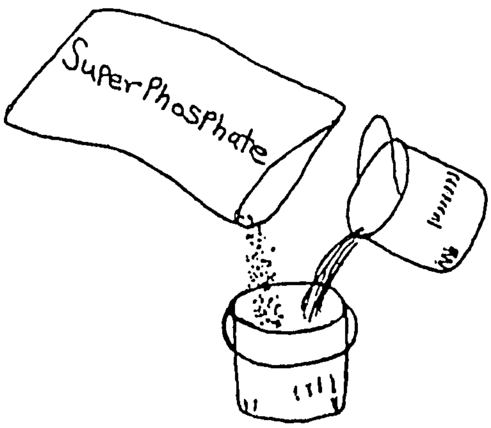
Nylon or cloth bags used to transport fertilizer, onions, rice or flour may be filled with the required dose of fertilizer and tied to a post below the water surface. Begin with a two-week dose of fertilizer. Dissolved nutrients pass through the bag into the water. More than one bag may be needed for large ponds. Add fresh fertilizer periodically and discard undissolved filler material left in the bag.



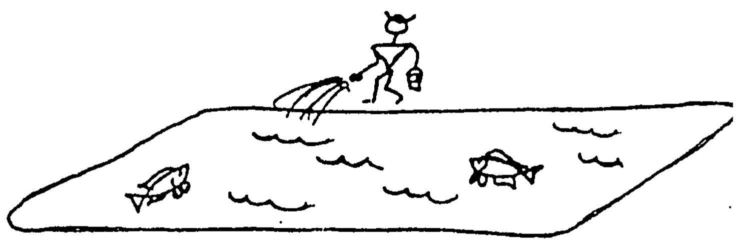
Fertilizer placed in a bag and tied to a pole.

3. Dissolved in water:

The quantity of fertilizer needed may be dissolved in buckets of water. Resulting "liquid fertilizer" is then dipped out of the bucket and splashed over the entire pond surface. This method disperses nutrients into the water column faster than other methods of fertilization and allows a phytoplankton response to be achieved quickly. Best results are obtained by adding liquid fertilizer in daily amounts. Farmers will visit their ponds daily to measure phytoplankton abundance and will be made aware of management needs.



Dissolve fertilizer in water.



Splash liquid over pond surface.

SOME REASONS FOR POOR RESPONSE TO CHEMICAL FERTILIZATION

A pond will respond to fertilization by turning green. This may happen within 24 hours. If a pond does not turn green within one to six weeks of fertilization one of the following factors may be responsible.

1. Muddy water:

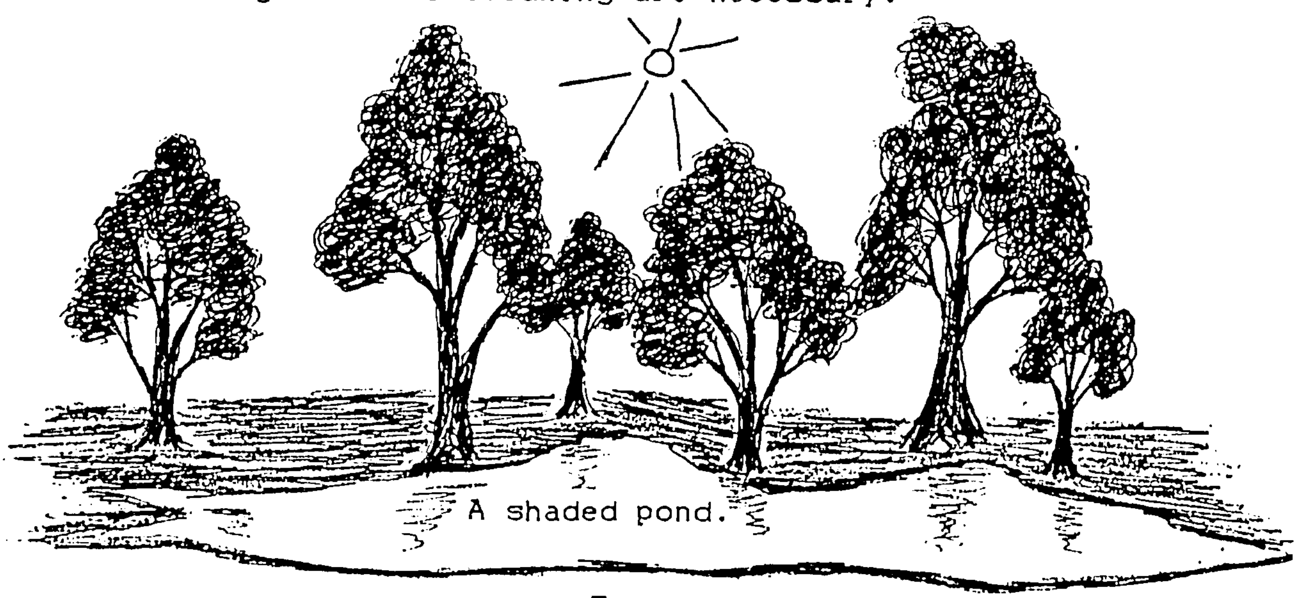
When mud particles are suspended in pond water and sunlight penetration is reduced phytoplankton growth will be inhibited in spite of fertilization. Control the problem by correcting its cause.

a) Plant grass on newly constructed pond dikes to control erosion.
b) Keep the surrounding watershed planted to prevent and control erosion.
c) Channel muddy water away from ponds by building diversion ditches.
d) Do not fill a pond with muddy water.
e) Muddy ponds can sometimes be cleared by adding organic matter and fertilizer to the water. It may take several weeks for organic matter to effectively remove suspeneded mud particles. Once water clears to a depth of 20 to 30cm fertilization may be attempted. Some recommendations include:

    1) Make two to three applications of animal manure at 20kg/100m^2 of pond.
    2) Make one or more applications of 20 to 40kg/100m^2 of hay or straw.
    3) Add 0.75kg of cottonseed meal plus 0.25kg of superphosphate/100m^2 at 2-3 week intervals.

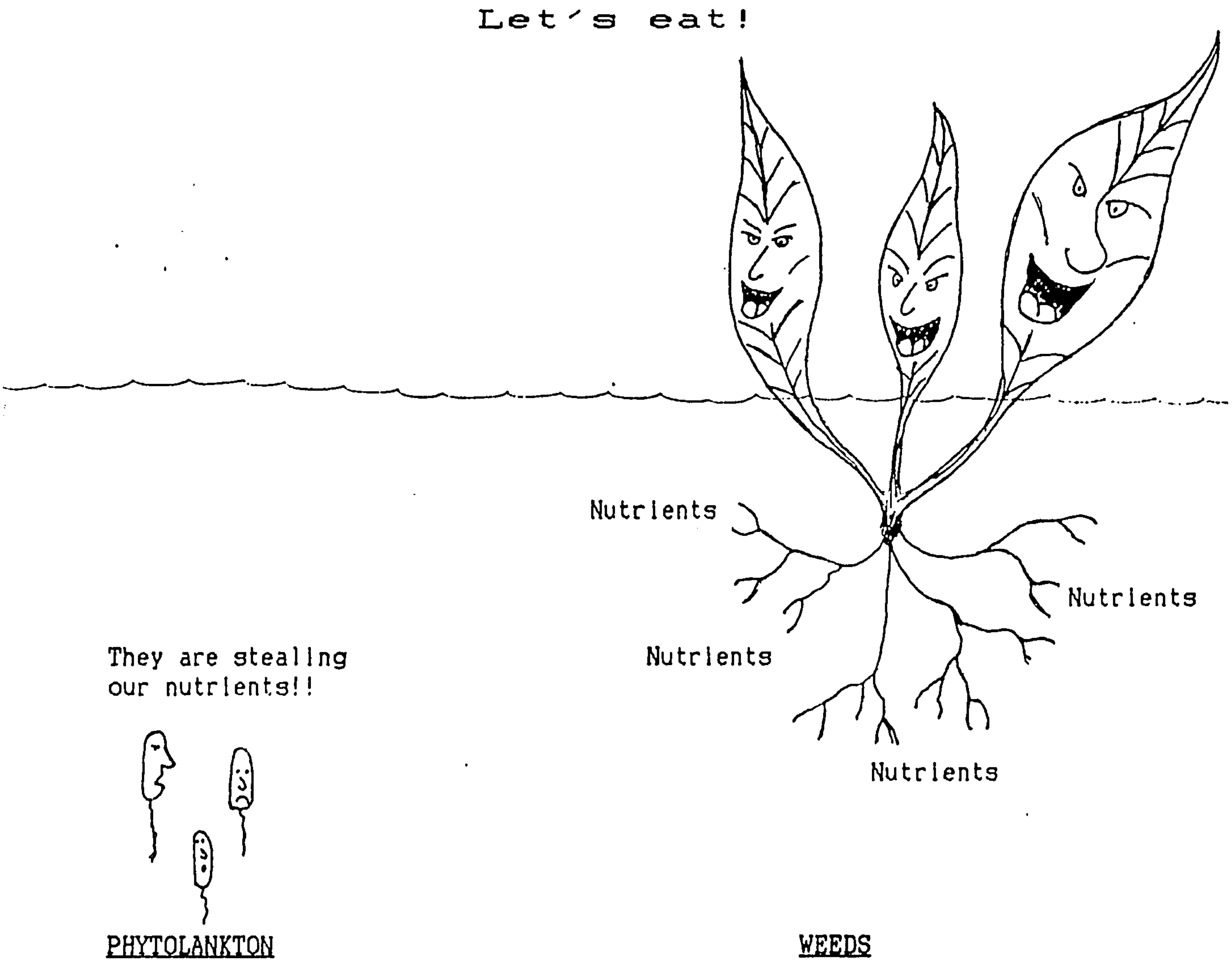
2. Too much shade:

Phytoplankton are green plants and need sunlight for growth. A fish pond shaded from sunlight will not respond to fertilization. Prevent tall plants and trees from shading your pond. Routine branch trimming and dike cleaning are necessary.



3. Water weeds:

DO NOT FERTILIZE WEEDY PONDS! Fertilizer is added to fish ponds to provide nutrients for phytoplankton. If your pond is full of weeds, adding fertilizer will only make the weeds grow faster. Once weeds are established they steal nutrients from the phytoplankton. Weeds also shade the water surface and prevent sunlight penetration which is essential for phytoplankton growth. Remove weeds before fertilizing.

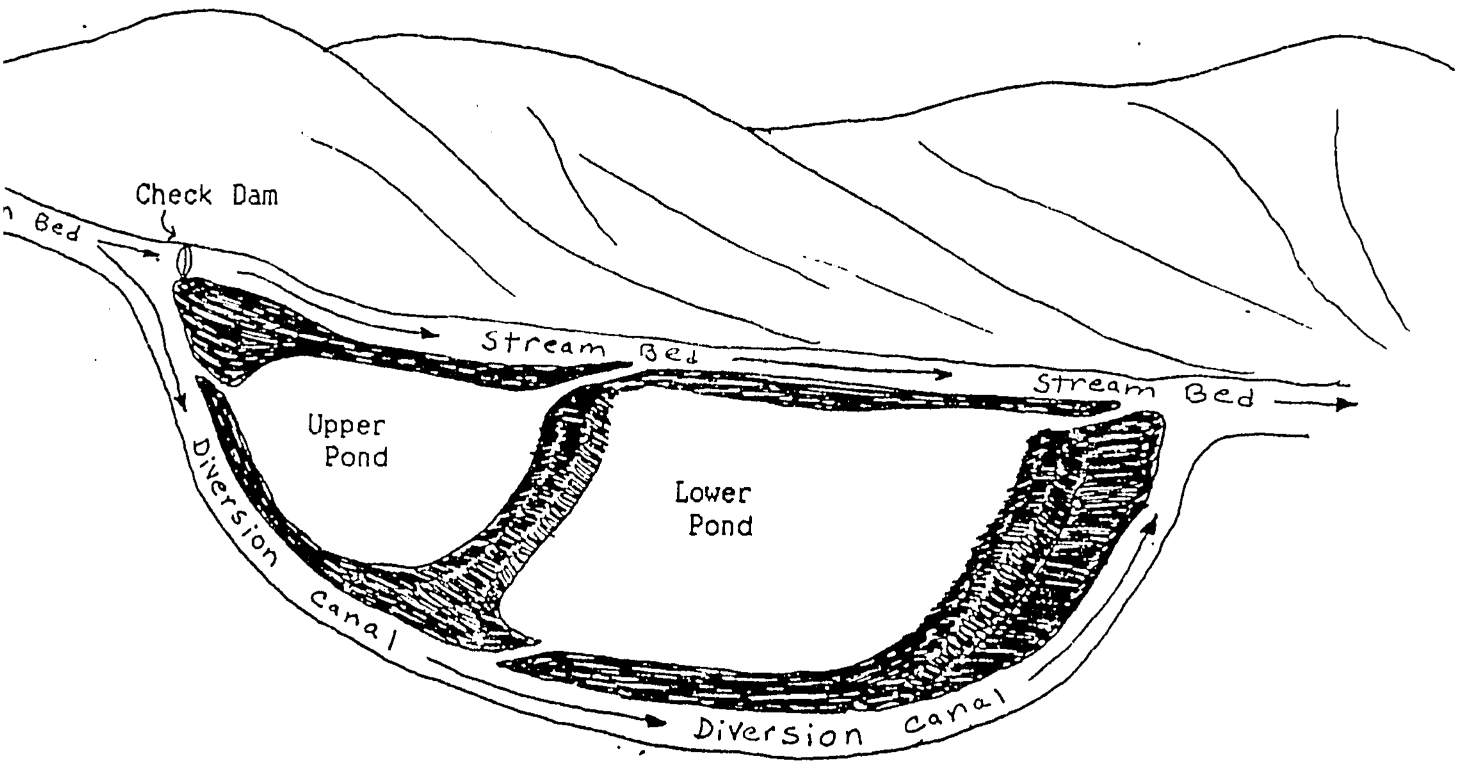


Weeds use nutrients intended for phytoplankton.

4. Excess water flow:

People not familiar with fish culture often think fish should be cultured in constantly flowing water. Flushing water through a pond may help remmedy situations where fish are under stress or appear sick, but this action can also flush fertilizers and nutrients out of a pond. This inhibits phytoplankton growth. To avoid this do not allow a continuous flow of water through the pond. Add only enough water to replace evaporation and seepage, or correct problems. Control excessive water flow by using the following measures as appropriate.

1) Build diversion ditches to channel excess water around the pond.
2) Enlarge the existing pond and/or construct another pond above the existing one in terrace fashion.
3) Build inlet control structures such as valves, flood gates, etc.

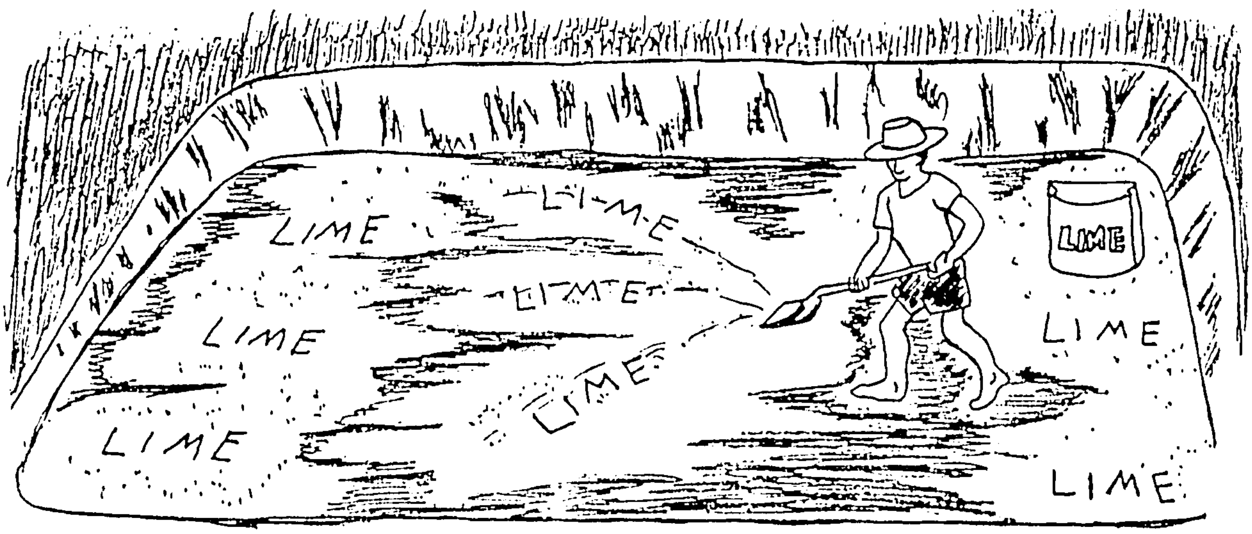


Terraced ponds with a diversion canal to carry excess water around the ponds during high stream flow.

5. Lime may be needed:

In many areas the only water source for ponds is rain that runs off of the surrounding watershed. This water may be acidic. Fish may not survive or grow well in ponds which are filled with this water unless lime is applied to neutralize the acidity. Liming will promote phytoplankton growth and increase fish production.

When applying lime to a pond spread the required amount evenly over the dry bottom before filling it with water. If a pond is already full lime may be spread over the surface with a shovel. In large ponds a boat may be used to spread lime evenly over the surface. Ponds requiring lime should be limed after each draining if lime is available at a reasonable price. If pond soil has a pH above 6.5 lime is not needed. The previously mentioned factors inhibiting response to fertilizer must be corrected before liming can enhance the effect of fertilization.



Spread lime evenly over the pond bottom.

The amount of lime added to a pond depends on the soil acidity. Soil testing laboratories equipped to measure acidity of pond bottom soils can make specific recommendations on the amount of lime required to neutralize acidity. In the absence of such assistance a rule-of-thumb is that 1000 to 2000kg of agricultural lime/ha (this is 10 to 20kg/100m^2) will neutralize soil acidity under most conditions. There are several forms of lime, but finely ground agricultural limestone is best. Quicklime is dangerous. It burns if it is inhaled or touches the skin. Farmers using quicklime should excercise extreme care. Application rates for different liming materials are given below, and may be used where soil testing is not available.

1. Coursely ground agricultural lime:	1000 to 2000kg/ha
2. Finely ground agricultural limestone:	1000 to 1200kg/ha
3. Hydrated (builders or slaked) lime:	600 to 1000kg/ha
4. Quicklime:	500 to 800kg/ha

It will not hurt to add lime if the reason for poor fertilizer response is not clear. Agricultural lime is safe to apply while fish are still in the pond. Applying excess quicklime or hydrated lime can kill fish. Quick or hydrated lime should be applied before stocking fish. If several applications of lime fail to increase production of phytoplankton other actions may be necessary to improve conditions in the pond.

6. Not enough fertilizer:

Sometimes the amount of fertilizer applied is insufficient to stimulate phytoplankton response. If this is suspected increase the amount and/or frequency of application.

STORING CHEMICAL FERTILIZER

Do not store chemical fertilizer longer than necessary. If storage is required place chemical fertilizers in a dry, well protected location. Excess humidity can damage the fertilizer. Bags of fertilizer can be stored on simple wooden or bamboo platforms elevated above ground.

Store the fertilizer in a dry place.

SOME GENERAL CONSIDERATIONS

1) Buy the fertilizer you need. Some companies sell a variety of fertilizers. Inquire from extensionists and other farmers which fertilizers they recommend for fish ponds. Fertilizer grades are usually marked on the bag or box containing the fertilizer. Some companies guarentee this analysis. For example, a 20-20-5 grade should mean that the fertilizer contains 20% nitrogen, 20% phosphorous and 5% potassium by weight. Buy chemical fertilizer from a reputable dealer.

2) It is difficult to determine when chemical fertilizer is no longer usable. Nitrogen in chemical fertilizer can volatilize when it comes in contact with moisture. The container holding the fertilizer becomes wet if this happens. Other nutrients may be leached out during this process. Fertilizer bags and boxes usually have an inner plastic liner to gaurd against damage from moisture. Do not buy fertilizer in containers which appear wet or which have been stored in a damp area.

GLOSSARY OF TERMS

aquatic weeds - unwanted plants which grow in ponds.

chemical fertilizers - manufactured fertilizers containing nitrogen, phosphorous and potassium in varying proportions.

compost - organic material (especially plants) which has been decomposed and is suitable for use as fertilizer.

fertilizer - a substance added to water to increase the production of natural fish food organisms.

leach out - to be drawn out do to the presence of moisture.

oxygen depletion/low oxygen - a condition, normally occuring at night, in which oxygen dissolved in pond water has been depleted mainly because of the decomposition of organic matter and respiration of organisms in the pond.

phytoplankton - the plant component of plankton.

plankton - the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

Secchi disk - a circular disk measuring approximately 20cm in diameter which is used to measure the abundance of plankton in water.

volatilize - to turn into a gas and escape into the atmosphere.

watershed - an area of sloping land down which water drains after rains.

zooplankton - the animal component of plankton.

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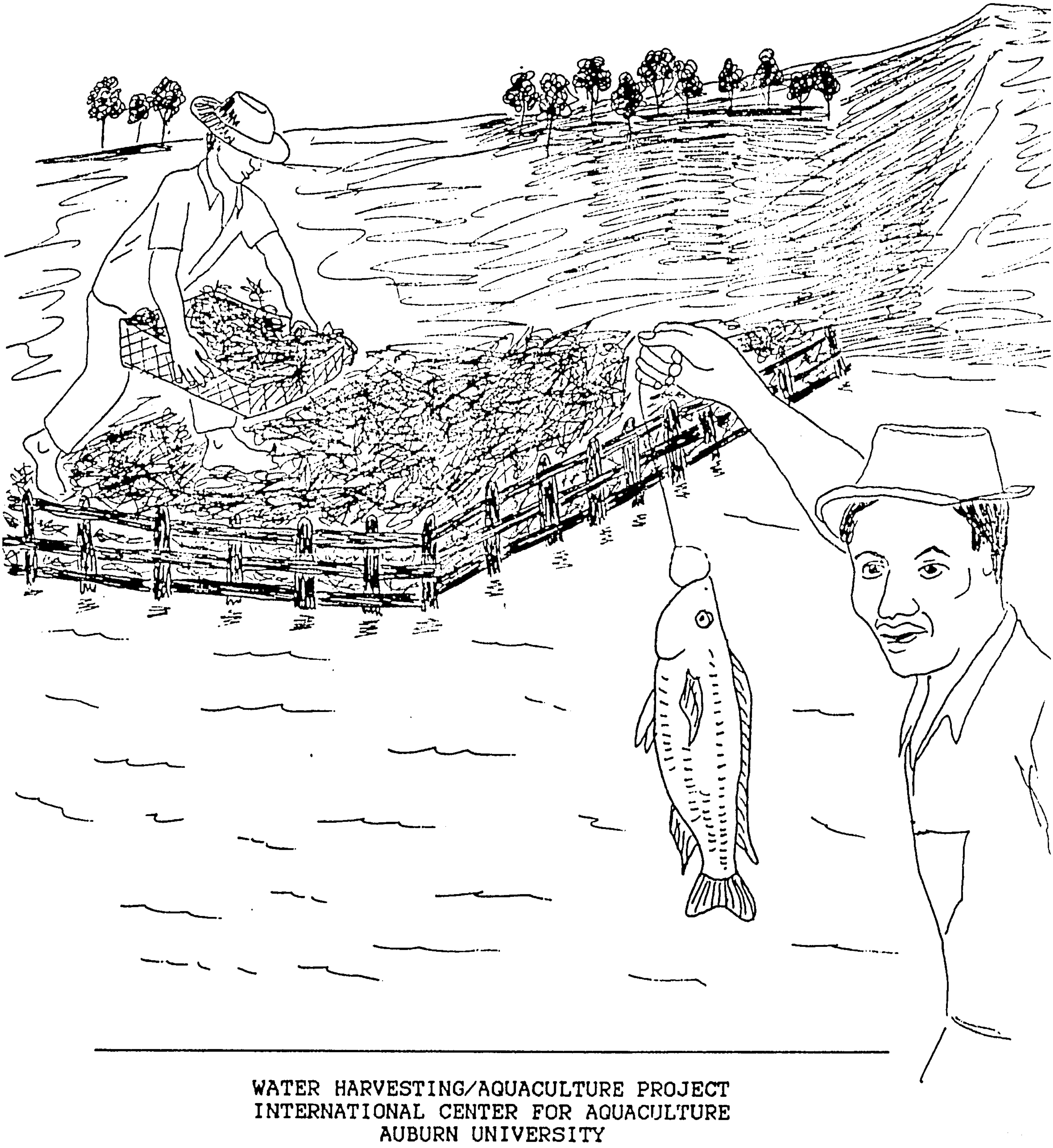
WATER HARVESTING AND AQUACULTURE FOR RURAL DEVELOPMENT

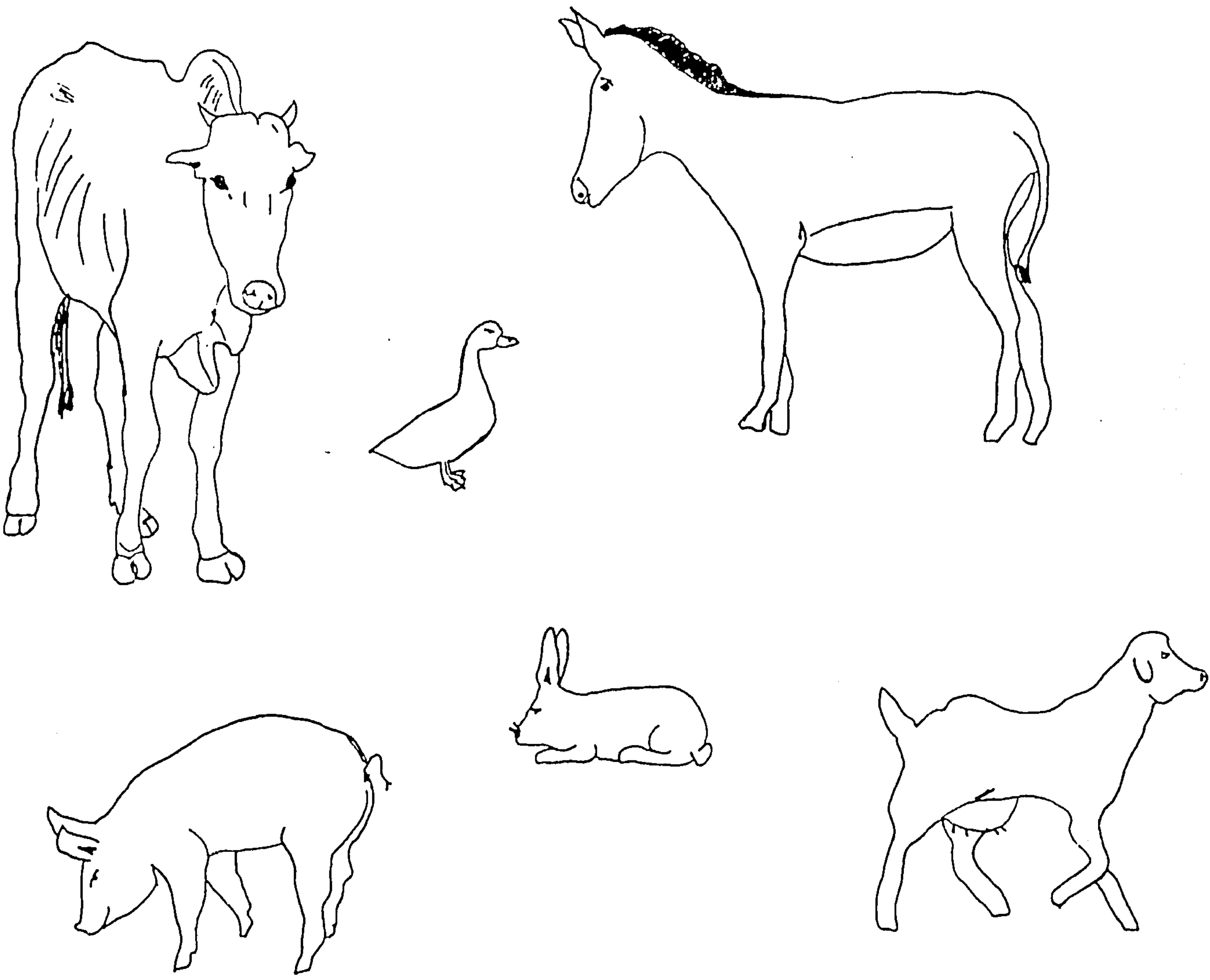
ORGANIC FERTILIZERS FOR FISH PONDS



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Organic fertilizers are uasually animal manures or plant wastes and cuttings ("green manure"). Manure from chickens, goats, sheep, ducks, pigs, rabbits, cattle and horses are excellent fertilizers for fish ponds. Other examples of organic fertilizers suitable for ponds are digested sludge from biogass generators, molasses from sugar cane factories, composted vegetation, table scraps and waste water from animal slaughter houses. Examples of materials that are NOT good organic fertilizers are rice hulls, sugar cane stalks, sawdust or other materials that require a long time to decay.



Animal manure makes good fish pond fertilizer.

HOW DO ORGANIC FERTILIZERS WORK?

1. Organic fertilizers decompose and release nitrogen, phosphorous and potassium which are used by phytoplankton for growth and reproduction. In this way more natural food organisms are produced for fish to eat.

2. Organic fertilizers, especially animal manures, provide nutrients and attachement sites for bacteria and other microscopic organisms. These organisms provide nourishment for fish even though in some cases the manure itself may have no direct food value when eaten.

3. Many "green manures" and the undigested food in animal manures are digestable and provide direct nutrition when eaten by fish. This is in addition to their effect as fertilizers and attachement sites for fish food organisms as described above. The result is enhanced fish production.

HOW MUCH MANURE TO USE

1. Animal manures:

Manures vary in nutrient quality depending on the quality of food eaten by the animals. For example, animals like pigs and chickens which are given high quality commercial rations will have manure higher in nutrient quality than animals like horses and cattle which feed on grasses. The amount of pig or chicken manure needed for a pond is therefore less than the amount of cattle or horse manure to achieve equivalent results. The moisture content of the manure also affects its quality. Dry manure will have more of some chemical nutrients than an equal weight of wet manure because it is more concentrated, but the food value may be lower because bacteria and other organisms may have already removed much of the digestable material.

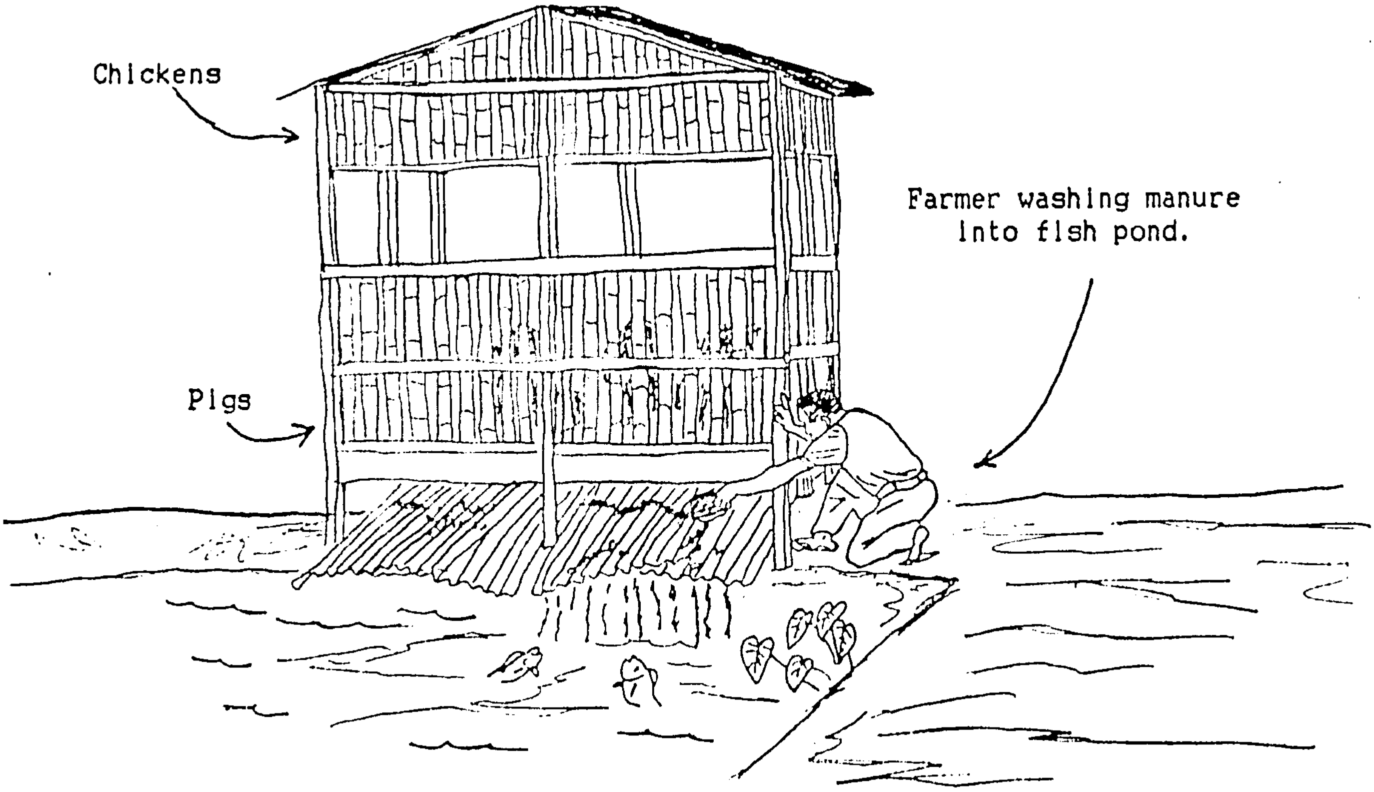
Animal manures are usually applied to ponds on the basis of weight per area of pond surface (kilograms of manure per hectare, per 100 square meters, etc.) or on an animal per area basis such as one pig per 100 square meters of pond surface area. Use Table 1 as a rule-of-thumb to determine approximately how many kilograms of manure or how many animals are needed for the desired effect. The amount of dissolved oxygen in the water and phytoplankton abundance as measured by the techniques described in the brochure entitled "Fertilizing Your Fish Pond: An Introduction" are the final indicators of "how much is enough".

Table 1: Animal manure application rates and the number of animals needed to supply manure to 100m2 of pond.

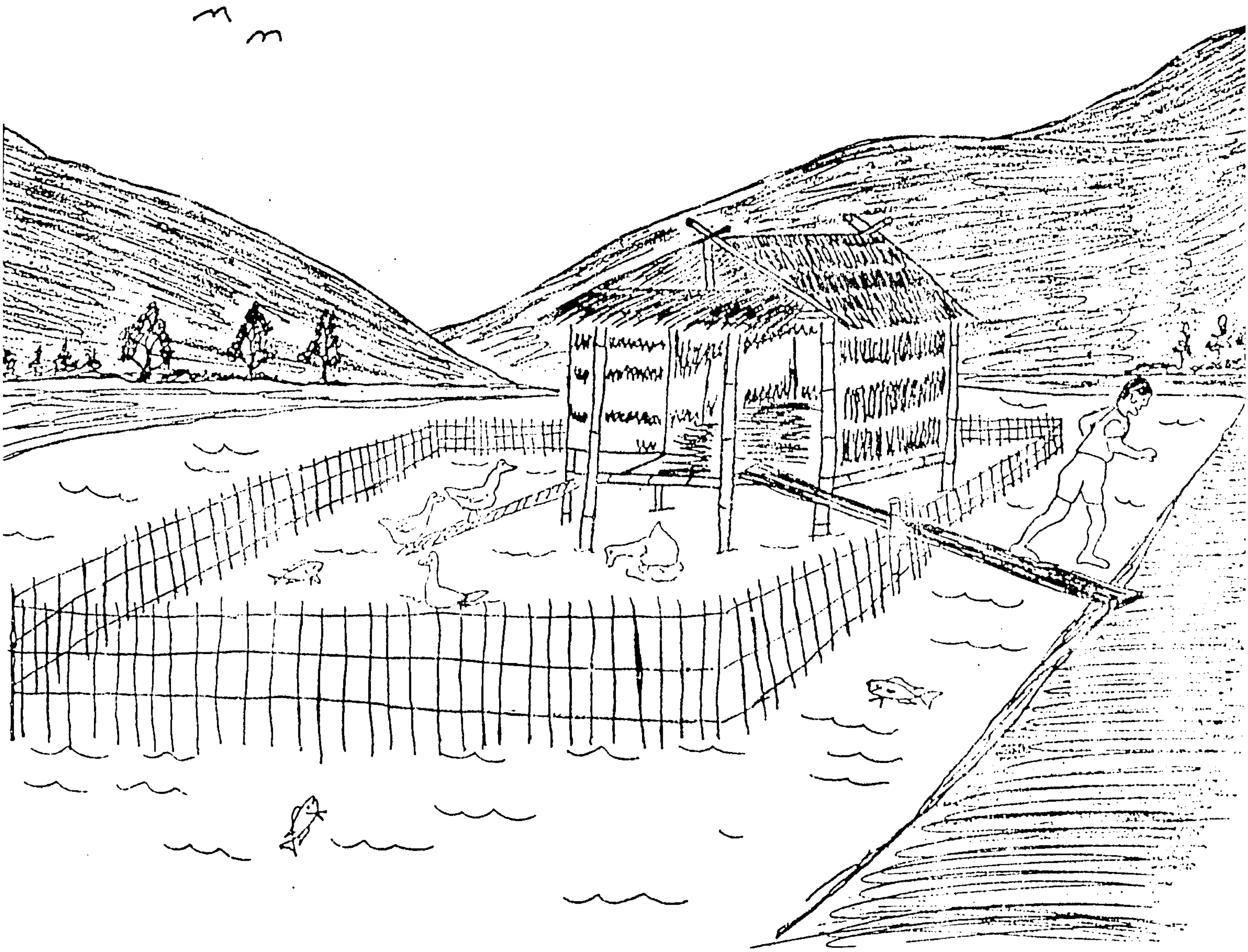
MANURE SOURCE	APPLICATON RATE (Kg/100m2/week)		NUMBER OF ANIMALS PER 100M2 OF POND
cattle	10	----	0.3 (all day)
		----	0.6 (night only)
chicken	6 - 8		10 - 15
duck	6 - 8		10 - 15
goat/sheep	10	----	4 (all day)
		----	8 (night only)
horse/donkey	10		0.5
pig	6 - 8		0.5 - 1

By dividing the weekly dose into daily applications, low oxygen problems will be less likely to occur and food in the manure will be more effectively utilized by fish.

Chickens, pigs and ducks may be confined and fed a commercial ration. Chickens may be raised over pig pens which are built over fish ponds. Uneaten food and manure can then be washed or fall directly into fish ponds. The following diagrams illustrate two designs for integrating pig, chicken and duck raising with fish culture.



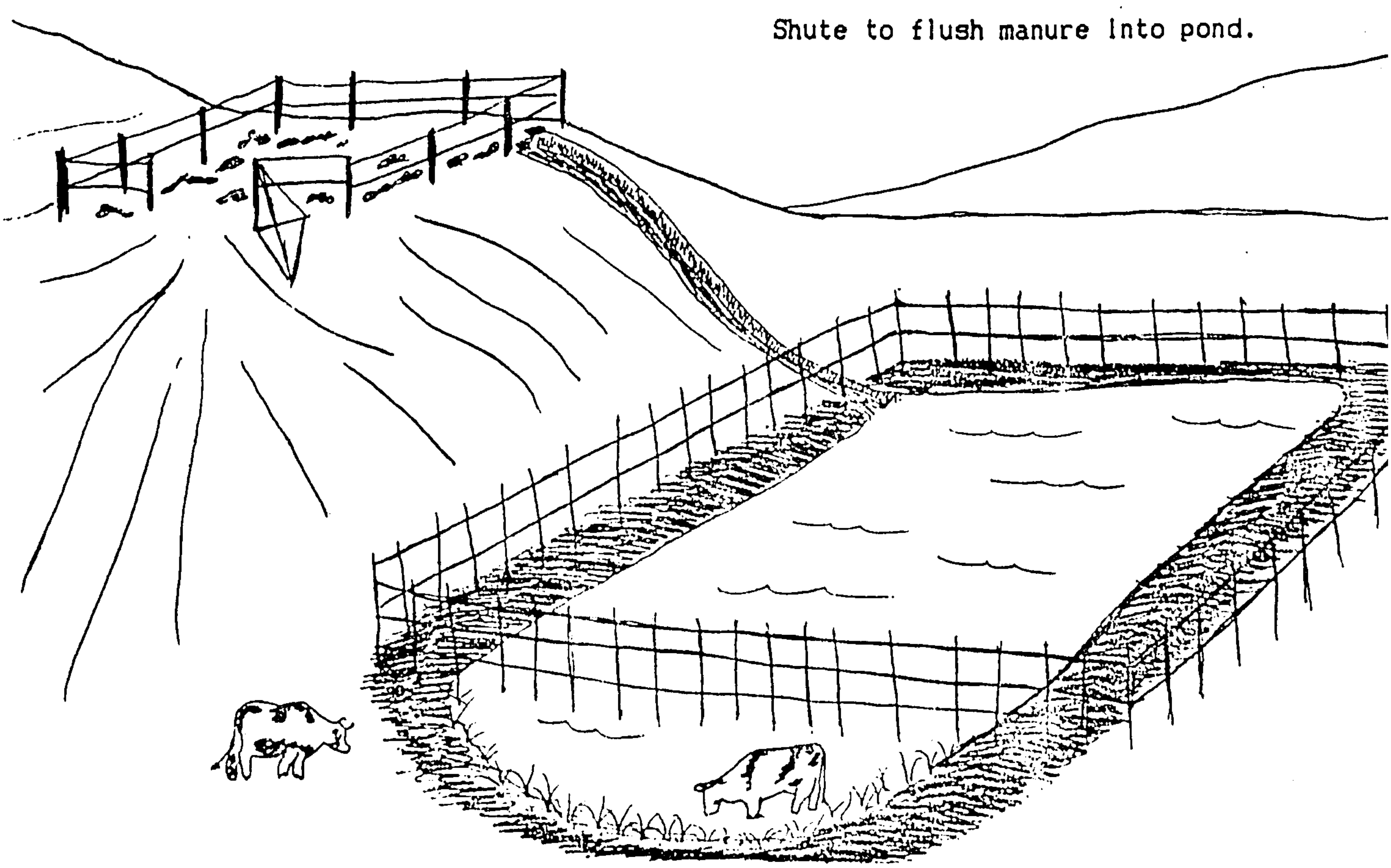
Galvanized iron sheets catch the manure and direct it to the pond.



Duck house built over a fish pond.

Cattle, buffalo, sheep and goats are normally pasture-fed. Their manure falls in the fields where it is difficult to collect and apply to ponds. If these animals are corralled and fed near ponds, manure can be easily collected or flushed into ponds. Animals may be corralled constantly or only at night. Less manure will be available if the animals are confined only at night. More animals will therefore be needed per pond surface area than if constant confinement is used.

Large animals should not have unrestricted access to ponds because their hooves will break down pond dikes causing shallow weedy areas to develop. These areas become mosquito breeding grounds. Ponds should be protected with a fence and access of large animals limited to one small area of pond shoreline. Manure and urine will be concentrated there and flushed into the pond during rains. The following drawing illustrates these principles.



This pond is fenced off to restrict access by cattle.

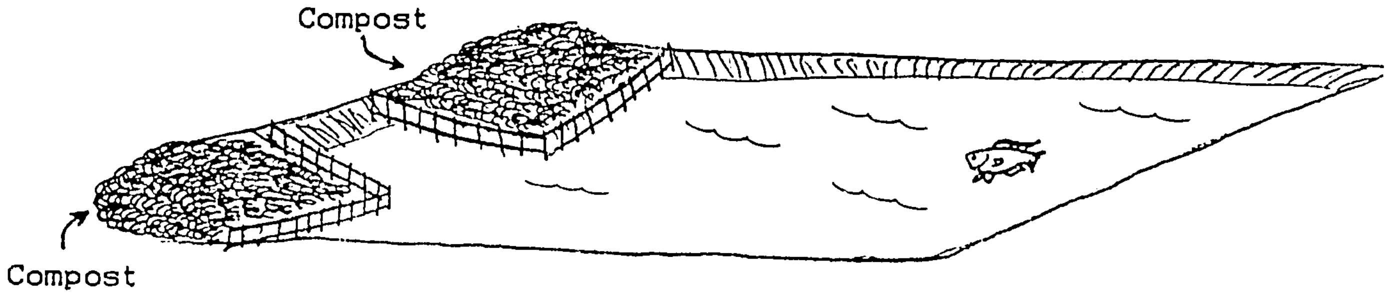
2. Plant or "green" manures

Vegetable matter, grasses, garden weeds, spoiled fruits and vegetables and other plant wastes can be used as fish pond fertilizer. They may be chopped into small pieces and mixed together into a compost pile. A mixture of animal and green manures provides a good fertilizer.

Compost should be kept moist, not saturated or dry, so it rots quickly. To control acidity 2.5kg of finely ground lime may be mixed with 100kg of compost material. Compost piles should be turned and mixed weekly to promote aeration and rapid decomposition. Compost piles shrink as the material decomposes.

Apply compost to fish ponds at rate of 20 to 25kg/100m^2 of pond surface area every ten days as a rule-of-thumb. In practice phytoplankton abundance, as measured by methods described in "Fertilizing Your Fish Pond: An Introduction" determines how much compost is actually applied. Compost is an effective fertilizer for small ponds. The size of pond that can be effectively fertilized depends upon the quantity of compost available.

Place compost material into corrals built of bamboo or wood measuring at least two meters long by one meter wide. Pile cut weeds, grasses and other soft plants and scraps inside the frame. Stir the pile weekly to promote continued decompostion. Compost can be withheld and/or removed from corrals if low oxygen develops until the problem is corrected.



A fish pond with two compost corrals in the corners.

OXYGEN PROBLEMS CAUSED BY ORGANIC FERTILIZERS

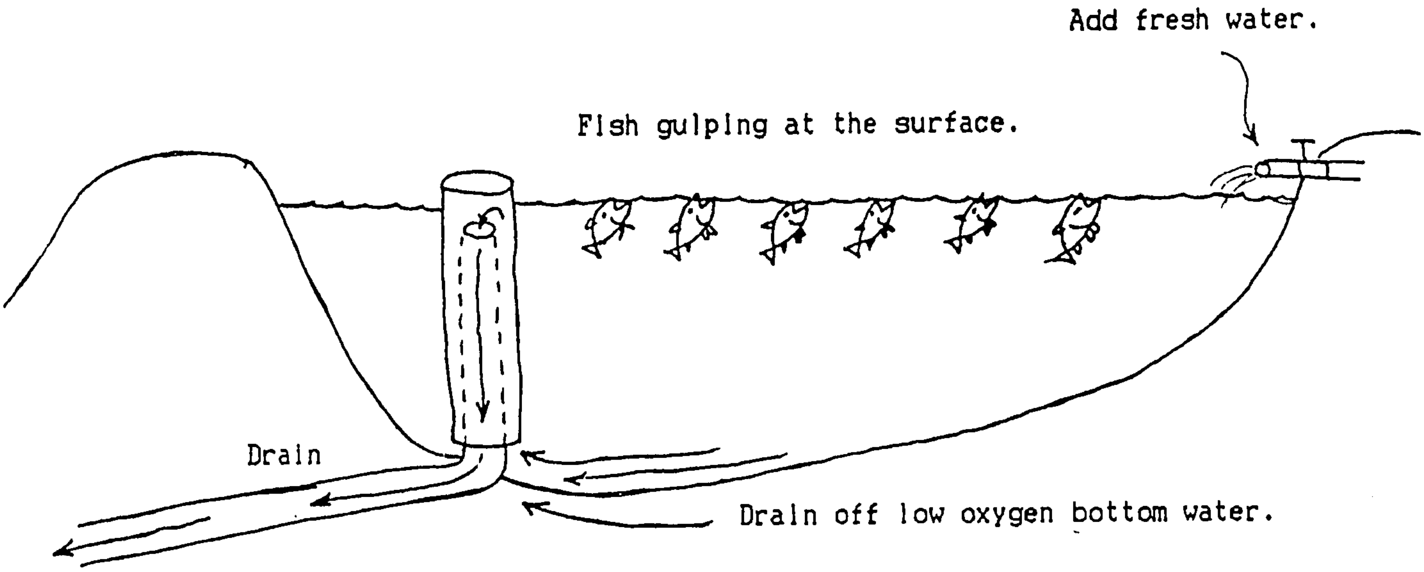
Oxygen depletion frequently occurs after large doses of manure are added to a pond at irregular intervals. This is the most serious problem with using organic fertilizers. As manure decomposes oxygen is consumed from the water.

When oxygen is low fish come to the surface of the water and appear to be gulping air. They are trying to breath. This would be similar to a person who has been breathing under a cover for an extended time. Oxygen is used up and the cover must be removed to let in fresh air.

In ponds low oxygen usually occurs at night and is lowest just before dawn because phytoplankton have not produced oxygen during the night. Low oxygen can also become a serious problem when Secchi disk readings fall below 20cm indicating that plankton are too abundant. See details on reading a Secchi disk in "Fertilizing Your Fish Pond: An Introduction". Low oxygen can kill fish. If only a few fish die every day the problem may be disease. If large numbers die suddenly at night low oxygen is probably the cause. Even if fish do not die from low oxygen, they are weakened and more likely to become sick.

AVOIDING AND CORRECTING LOW OXYGEN PROBLEMS

1. Suspend fertilizer application until the low oxygen problem has been corrected and fish stop gulping at the water surface.
2. Add fresh water to the pond immediately to revive the fish, and continue adding water until the fish stop gulping at the surface.
3. While adding fresh water, drain some of the old water off the pond bottom. The bottom layers of water have the least oxygen.



A fish pond with low oxygen.

APPLICATION RULES FOR ORGANIC FERTILIZERS

1. The first application may be made two weeks prior to stocking fish to increase natural food abundance. When using manure provided by enclosed livestock, place the animals in their pens and begin feeding them two weeks prior to stocking fish. This is especially true if the pond was not previously manured.

2. Do not overfertilize. Manure should be applied to ponds to keep plankton abundance within recommended limits. See "Fertilizing Your Fish Pond: An Introduction".

3. Avoid adding large doses of manure at irregular intervals. Maintain a scheduled routine for adding manure based on observations of water quality. This allows decomposition to procede at a slower rate and avoids oxygen depletion.

4. Organic fertilizer can be used in combination with chemical fertilizers. If the pond is muddy add manure first to precipitate suspended soil particles. This will enhance the effectiveness of chemical fertilizers in increasing phytoplankton abundance.

5. Keep Secchi disk readings of plankton abundance within the range of 20 to 30cm and check the pond before sunrise to detect oxygen problems. Have fresh water available for flushing a pond if low oxygen develops. Suspend or reduce fertilization until the low oxygen problem is corrected.

6. Remember that many organic fertilizers are also eaten by fish. Weekly amounts of manure can be divided into smaller daily doses to facilitate this. Daily doses are best applied at mid-morning to avoid creating oxygen problems.

GLOSSARY OF TERMS

assimilate - to take in and appropriate as nourishment.

chemical fertilizers - manufactured fertilizers containing nitrogen, phosphorous and potassium in varying proportions.

compost - organic material (especially plants) which has been decomposed and is suitable for use as fertilizer.

decomposition - the decay or breakdown of organic materials into simple compounds available for assimilation by phytoplankton.

dissolved oxygen - oxygen that is dissolved in water and which is respired by aquatic organisms.

fertilizer - a substance added to water to increase the production of natural fish food organisms.

food chain - the pathways through which nutrients added to a pond are converted into fish flesh.

green manure - manure composed of green plant matter.

manure/organic fertilizer - animal or plant matter used as fertilizer in ponds.

microscopic - invisible to the eye without the aid of a microscope or magnifying glass.

natural fish food organisms - plankton, insects and other aquatic organisms that fish eat.

nutrient quality - the amount and condition of nutrients (nitrogen, phosphorous and potassium) available in a given fertilizer.

organic fertilizers/manure - fertilizers composed of animal or plant materials which must be decomposed to release their minerals and nutrients.

oxygen depletion/low oxygen - a condition, normally occuring at night, in which oxygen dissolved in pond water has been depleted mainly because of the decomposition of organic matter and respiration of organisms in the pond.

phytoplankton - the plant component of plankton.

plankton - the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

Secchi disk - a circular disk measuring approximately 20cm in diameter which is used to measure the abundance of plankton in water.

zooplankton - the animal component of plankton.

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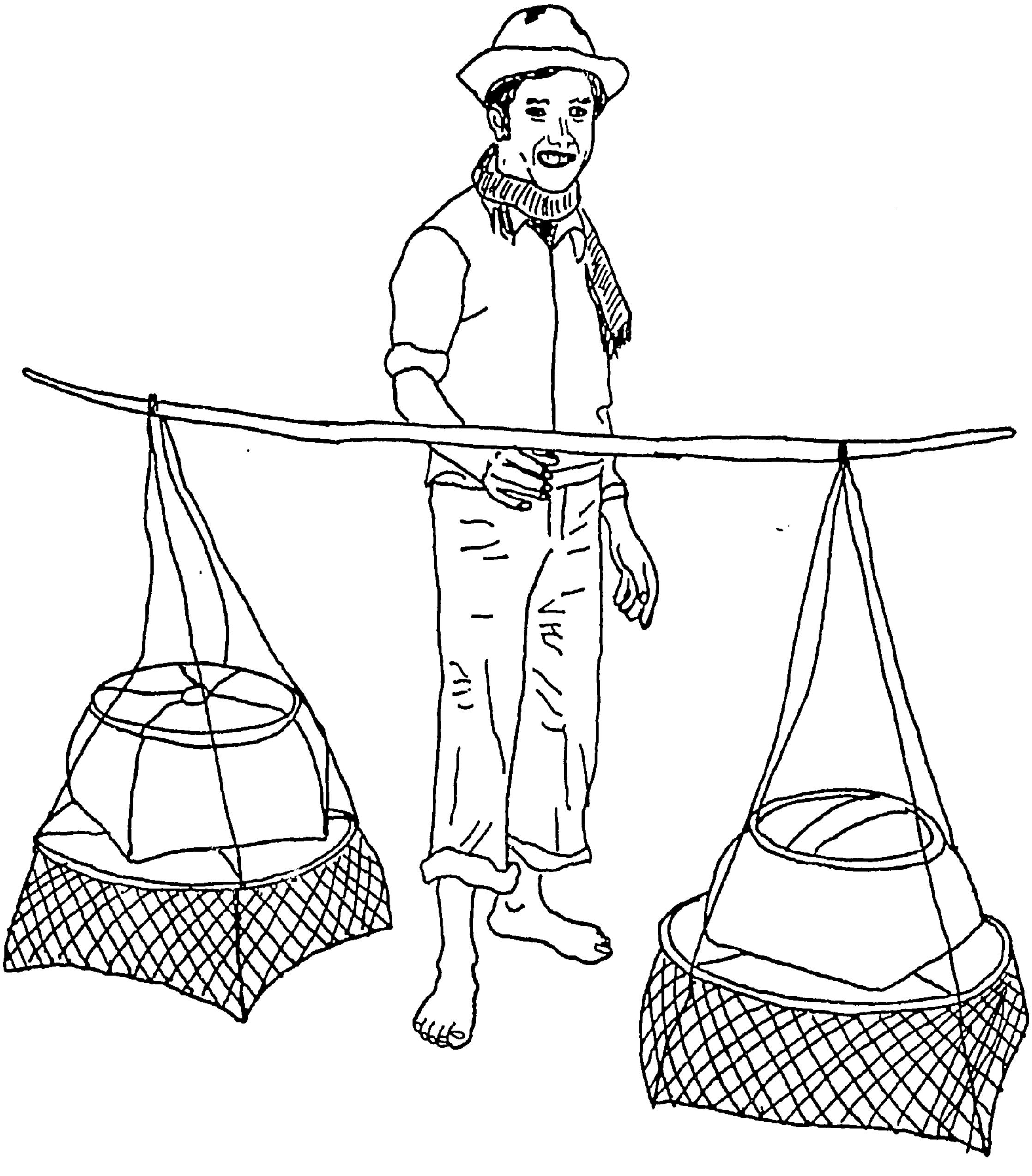
WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

TRANSPORTING FISH



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Transporting fish is a very important part of fish culture. Fry and fingerlings must be transported from hatchery to pond for stocking. Brood fish are sometimes transported into the hatchery to spawn. It may even be necessary to transport live harvested fish to the market for sale. Many methods for fish transport have been developed. Several of these methods are described here.

Fish are generally transported in containers such as cans of different sizes, pots of ceramic or metal, wooden or metal buckets, vats, barrels, plastic bags, styrofoam boxes, bottles, jugs, animal skins and bamboo sections. In fact, almost any clean, water proof container may be used.

Certain containers provide good insulation from heat, for example wood or styrofoam. Containers like metal or plastic are poor insulators and may have to be wrapped with wet towels or packed with ice to keep temperatures down.

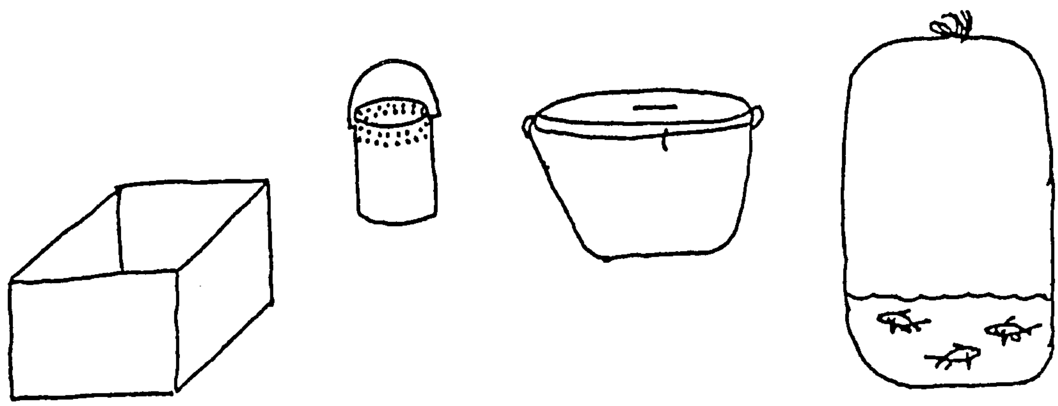


Figure 1: Various containers are used to transport fish.

Once fish have been placed in their transport container they are brought to their destination by the quickest possible means that will provide a relatively smooth and direct route. This may be by foot, animal cart, bicycle, boat, motorized land vehicle, train or plane.

CONSIDERATIONS FOR FISH TRANSPORT

Fish transport must be done carefully in order to be successful. A poorly organized effort may easily result in death of fish. The following factors directly influence fish transport.

Tolerance to transport.

A famous saying in fish culture is that "fish are not potatoes". They need tender loving care if they are to remain strong and healthy. Tolerance of fish to transport is related to their ability to resist or adapt to stressful conditions. Their resistance also changes as they pass through various life stages. Larvae are very delicate as are brood fish which are ready to lay eggs. The table below indicates stress tolerance levels of some commonly cultured fish.

tilapia	- high tolerance
catfish	- high tolerance
gourami	- high tolerance
carps	
common	- high tolerance
bighead	- medium tolerance
grass	- medium tolerance
silver	- low tolerance
mud	- high tolerance
black	- high tolerance
Indian carps	- medium tolerance

Presence of food in the intestines.

Fish survive transport better if they have no food in their intestines. For this reason, they are not fed for 1 to 2 full days prior to the time they will be transported. Brood stock are often conditioned for transport to spawning facilities by crowding them up in a seine net and releasing them. This procedure is done for 2 consecutive days before moving them from their pond to the hatchery for spawning. The fish stop eating and this helps them adapt to the stress of artificial spawning.

Fish can also be harvested and held in net enclosures or tanks for 24 to 48 hours with clean, preferably gently running, water. The fish pass food out of their intestines and will be in good condition for transport. If the fish have disease or parasites they can also be treated easily in tanks prior to transport.

Age and size of fish.

A lower weight of small fish can be transported per unit volume of water than large fish. This guide classifies fish broadly into four main groups according to what life-cycle stage they are in. Newly hatched fish are called larvae or sac fry. They are slow moving and possess a yolk sac which provides them with at least a 24 hour food supply after hatching.

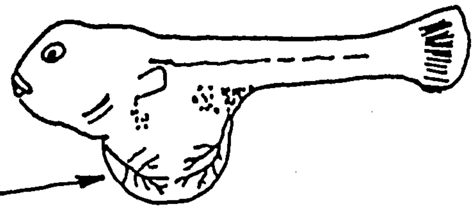


Figure 2: A sac fry with yolk sac.

Post larvae do not have a yolk sac and are commonly called fry. Fry weigh less than 1g. A 3 to 4 week old fish weighing more than 1g may be called a fingerling. Sexually mature fish are often called brood stock. Table 1 provides a "rule-of-thumb" guide to determine how many fish of a given age group may be transported. These figures are based on transporting fish in sealed plastic bags containing oxygen and about 4 liters of clean water at approximately 18°C. These numbers are only a rough guide and may not work under all conditions or for all kinds of fish. Tanks or containers must be used to transport fish if plastic bags are not available. Table 2 gives recommendations for transporting different sized fish in tanks with diffused oxygen at approximately 18°C.

Table 1: Quantities of different sized fish that can be transported in sealed plastic bags (18 inch x 32 inch) with approximately 7.6 liters of water and pure oxygen.

Fish Size		Duration of Transport 1HR		12HR		24HR		48HR
LARVAE (newly hatched) (grams/l)	-	120	-	80	-	40	-	10
1/4 inch (0.64cm) FRY (grams/l)	-	60	-	50	-	40	-	20
1 inch (2.54cm) FINGERLING (grams/l)	-	120	-	100	-	75	-	40
2 inch (5.08cm) FINGERLING (grams/l)	-	120	-	105	-	90	-	40
3 inch (7.62cm) FINGERLING (grams/l)	-	120	-	105	-	90	-	40
Larger Fish (grams/l)	-	480	-	180	-	120	-	60

Table 2: The weight of fish per liter of water transported in tanks with diffused oxygen.

Fish Size	1HR	Duration of Transport 6HR	12HR	24HR
LARVAE AND FRY	--------- NOT RECOMMENDED ----------			
1 inch FINGERLING	120.0	60.0	30.0	30.0
2 inch FINGERLING	240.0	180.0	120.0	120.0
3 inch FINGERLING	360.0	240.0	120.0	120.0
8 inch FINGERLING	360.0	360.0	240.0	180.0
Larger Fish	480.0	480.0	360.0	240.0

Methods used for transporting fish.

It is essential to maintain adequate oxygen in the water while transporting fish. The technique recommended for oxygenating water during fish transport is use of pure bottled oxygen. It may be bubbled continuously into an unsealed container during transport, or injected into a plastic bag containing water and fish which is then sealed air-tight for transport.

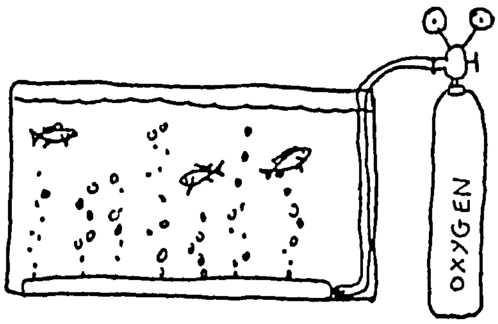


Figure 3: Continuous oxygen flow.

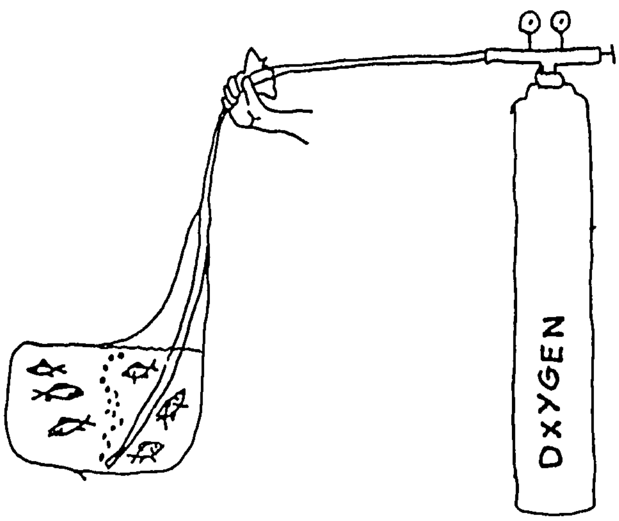


Figure 4: Oxygen sealed in a plastic bag.

When plastic bags are used, oxygen is added after water and fish. One fourth of the bag usually contains water and fish and three fourths contains oxygen. After adding oxygen the bag is sealed shut with a twisted rubber band, string or other material. As a precaution against leakage, the first plastic bag should be placed inside a second bag whenever possible. The sealed double bag of fish is then placed in a box, woven grass bag or other container for added protection and loaded onto a vehicle for transport. If properly packaged and insulated from heat, these containers can transport fish for 24 to 48 hours without water exchange. The following figures illustrate the use of plastic bags and bottled oxygen in fish transport.

Making and using plastic bags

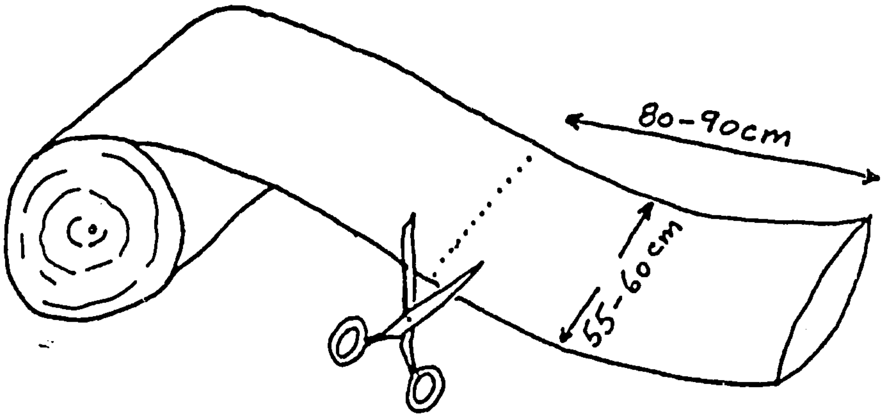


Figure 5: Cut the plastic bag material to the dimensions shown.

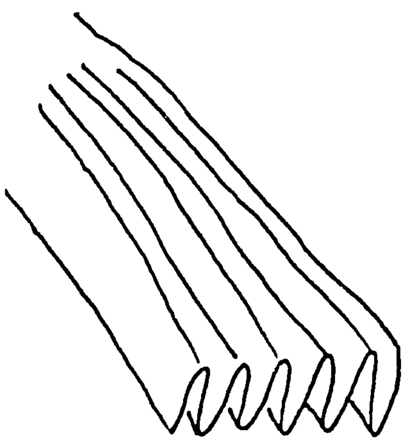


Figure 6: Fold one end.

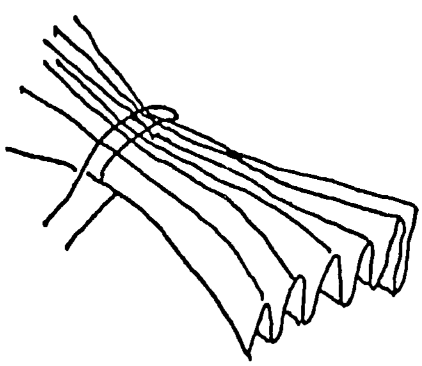


Figure 7: Tie it.

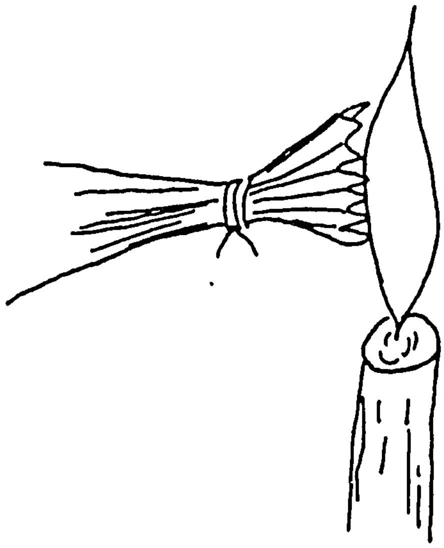


Figure 8: Melt and fuse the tied end.

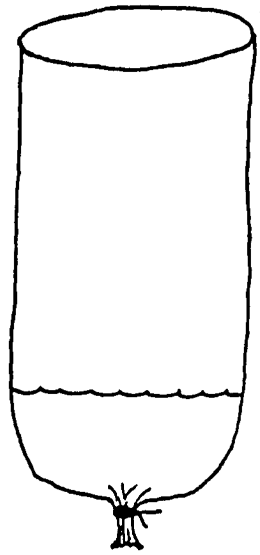


Figure 9: Fill 1/4 with water to check for leakage.

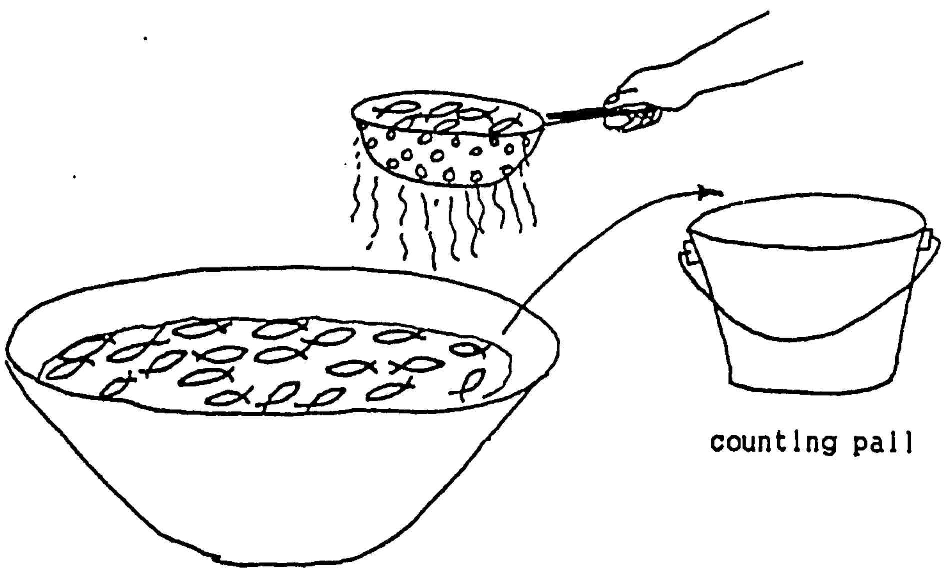


Figure 10: Counting fish into the plastic bag.
- a. Count the number of fish in 4 or 5 scoops.
- b. Divide the number of fish by the number of scoops to get the average number of fish per scoop.
- c. Estimate the number of fish needed for stocking a pond, cage, rice paddy or transport container.
- d. Divide c by b to get the number of scoops needed.

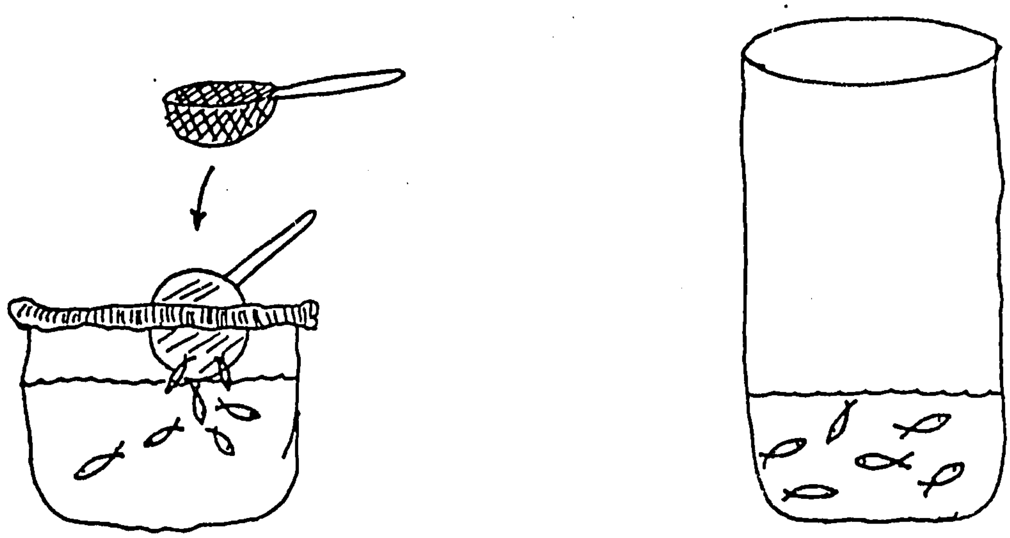


Figure 11: A predetermined weight or number of fish are placed in each bag.

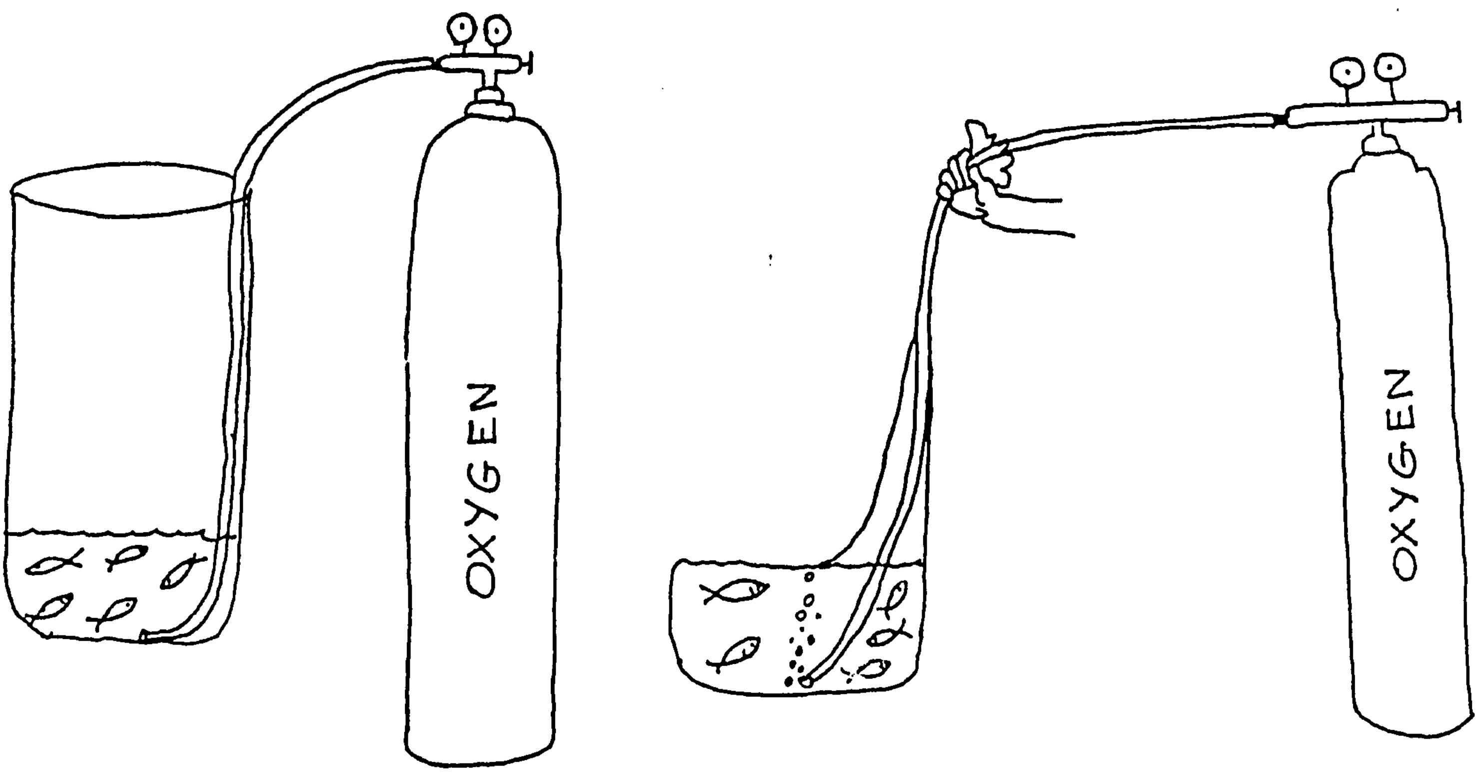


Figure 12: Insert oxygen hose into bag, depress bag to force out atmospheric air and slowly bubble pure oxygen through the water.

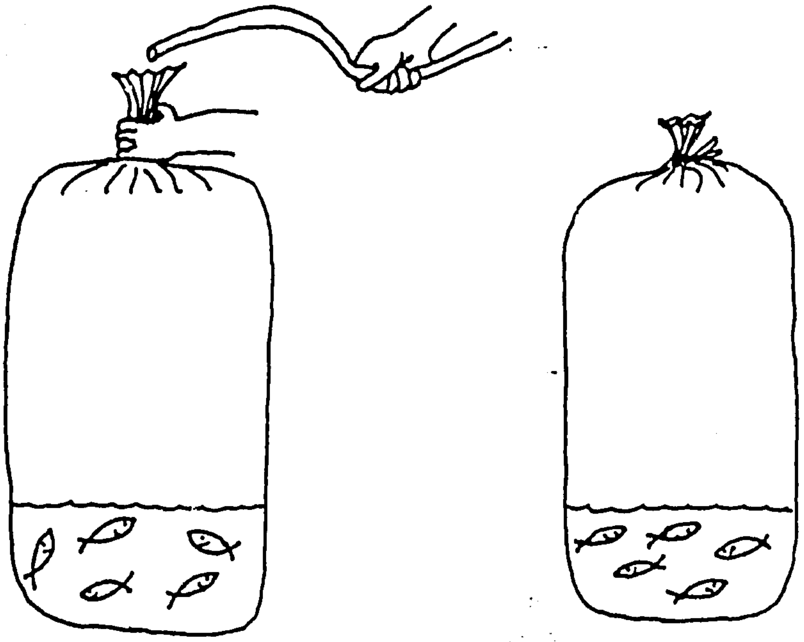


Figure 13: Squeeze bag closed while removing oxygen hose, and tie bag securely.

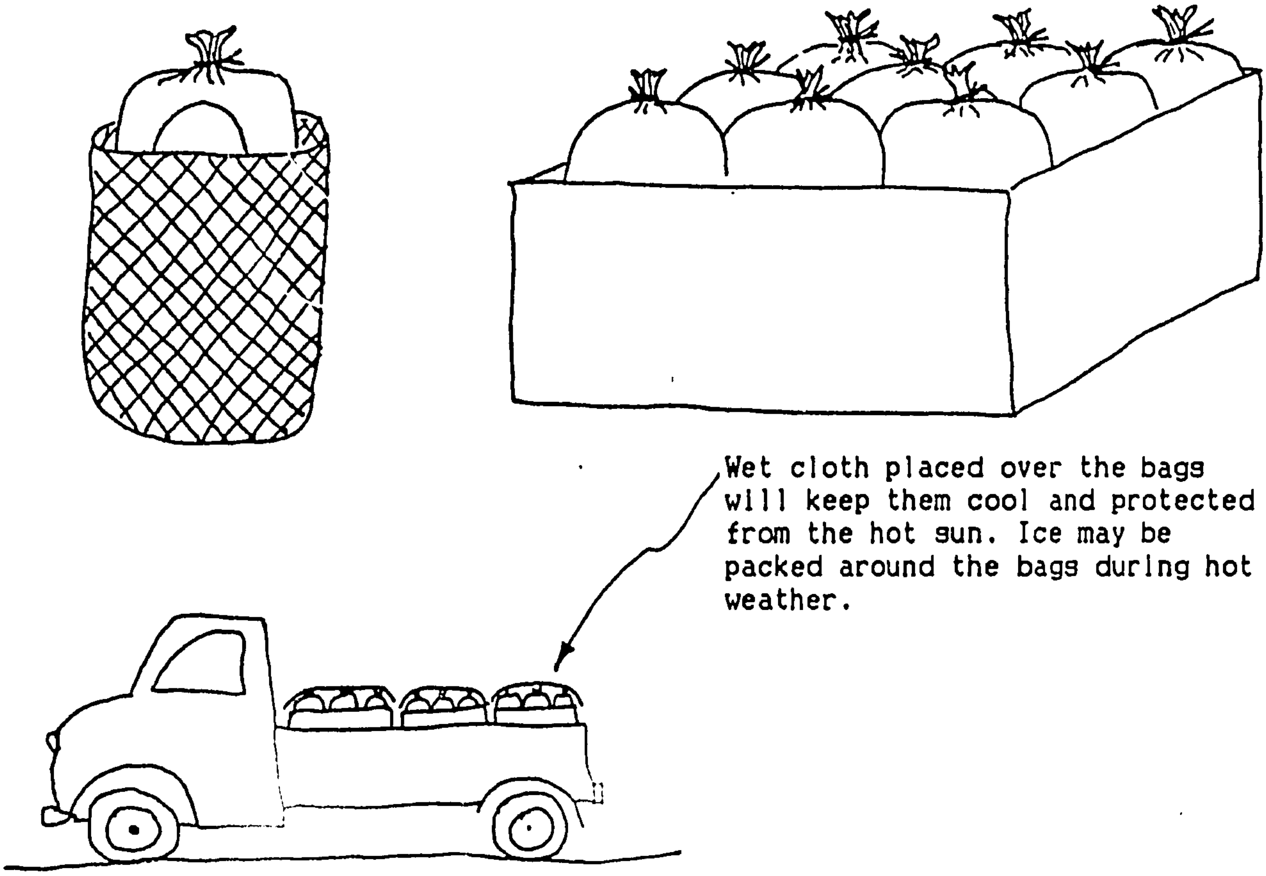


Figure 14: Place sealed bags into woven grass sacs, cardboard, wood or styrofoam boxes for protection during transport.

Changing water partially or completely.

Other procedures may be used in emergencies when bottled oxygen is unavailable. During hot weather or long trips, fish may rise to the surface and start gasping for air. This means oxygen in the water has been depleted and the water should be changed.

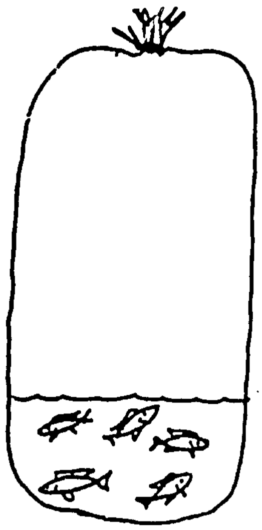


Figure 15: Adequate oxygen

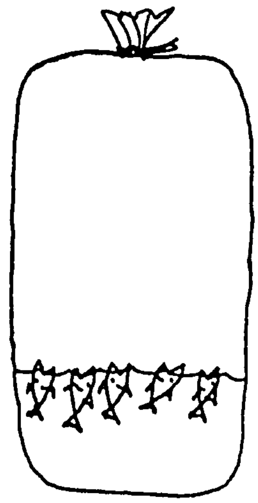


Figure 16: Depleted oxygen

When adding fresh water to a container of fish or when transferring fish into fresh receiving water, exercise the following precautions.

1. The new water should be clean, not muddy, and should be free of chemical pollutants. Avoid acidic or "peaty" water. Water from clean, clear-running springs or streams is best.
2. Poorly aerated water from wells, storage vats or reservoirs should be avoided because it is low in oxygen.
3. New water should be the same temperature as the original water.

To change water, empty half of the old water from the transport container and then refill with new water of the same temperature. This is easily done if the container has a screened drainage spout or overflow. Plastic bags are squeezed around the neck and tilted to allow water but not fish to escape. Siphon tubes are used to remove dirt and fish waste from the bottom of the transport container. DO NOT add new water quickly into the container. This may injure fish. Add it carefully. After 10 minutes change all of the water. Several exchanges may be necessary.

Pumping air into the transport water can be done continuously from the start of travel or as an emergency measure. The finest air bubbles possible should be pumped into the water. Oxygen diffuses faster through fine bubbles. Large bubbles forcefully pumped into the water may also injure fish. Equipment which can be used includes bicycle tire pumps, battery operated aerators from aquarium shops, air filled inner tubes with air being squeezed through a regulated nozzle and any other locally built device.

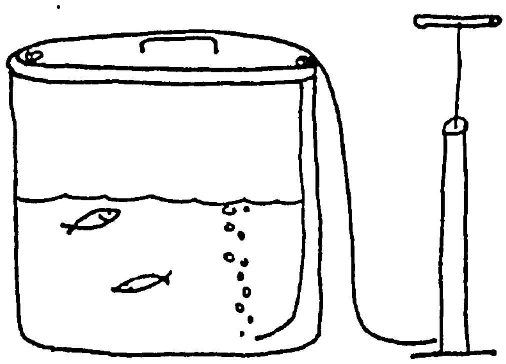


Figure 19: Pumping air into a transport container.

Agitation can be done simultaneously with aeration. However, these are only temporary measures and will not keep the fish alive very long. They may be tried until the water can be exchanged. DO NOT bubble your breath through the water. It contains carbon dioxide not oxygen. You will only hasten the death of your fish by doing this.

USE OF HYDROGEN PEROXIDE AS AN OXYGEN SOURCE

Large capital outlay is required for tanks and other specialized equipment used in fish transport with pure bottled oxygen. A practical method for hydrogen peroxide use in fingerling transport has been developed by N. Innes Taylor and L.G. Ross at the Institute of Aquaculture, University of Stirling, Stirling FK9 4LA (Great Britain). Hydrogen peroxide decomposes to yield oxygen and water. It is available from pharmacies in most countries. Though expensive, it does not require a large capital outlay if small quantities of fish are being transported. The system is described below.

1) Dip a 2-l capacity (26cm x 26cm) plastic bag in clean water several times to get it wet. Then, shake it to remove excess water.
2) Place 1g of fish liver in the bag.
3) Crush the liver by hand.
4) Add 40ml of 6% weight per volume hydrogen peroxide.
5) Expell all air from the bag, and seal it with an elastic band.
6) Shake the bag to facilitate oxygen release. The bag should fill with oxygen in approximately 5 minutes.
7) Oxygen is squeezed into a transport bag containing water and fish through a plastic tube, as shown in the following diagram. Liquid in the oxygen bag may kill fish and should not be squeezed into the transport bag. A pump is used to fill the transport bag completely.

The temperature of new water should not differ from that of the transport water by more than 3 degrees centigrade. If it does, replace only one fourth of the old water initially and wait 10 minutes. Then replace one fourth of the water again and wait 10 minutes before completely changing the water.

Transport water can be aerated by agitation or air can be pumped into it during emergencies when water exchange is impossible and fish are clearly under stress. Agitation can be done in several ways. A small quantity of the old water can be removed and poured repeatedly from a height of 30 to 50cm through a screen, grate or porous cloth back into the transport container.

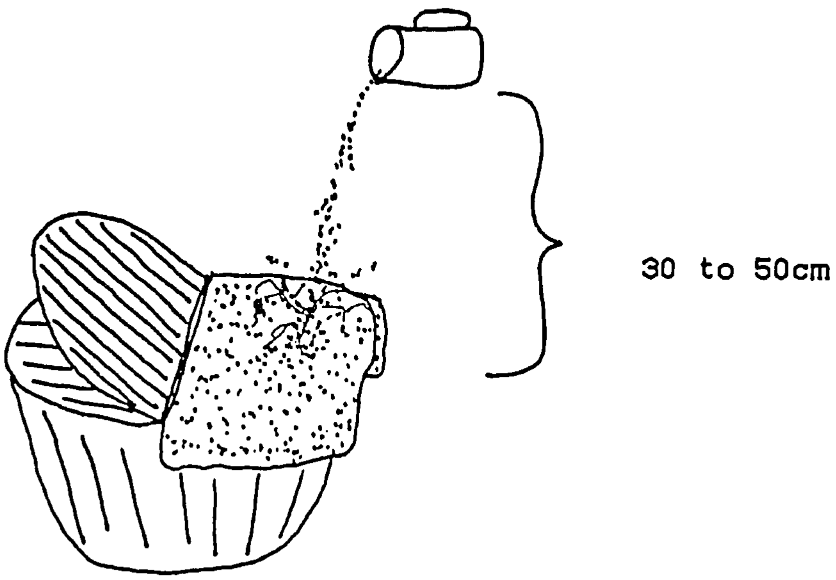


Figure 17: Pouring old water back into the transport container.

A person can also stick his hand into the water submerged up to the knuckles with fingers spread, and briskly wave back-and-forth. Electrical devices are also used for agitation.

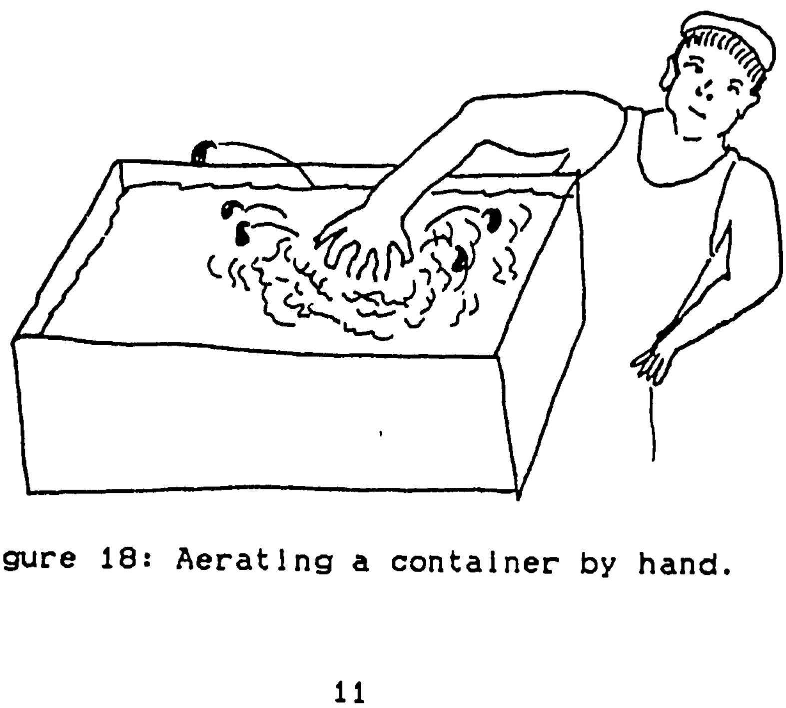


Figure 18: Aerating a container by hand.

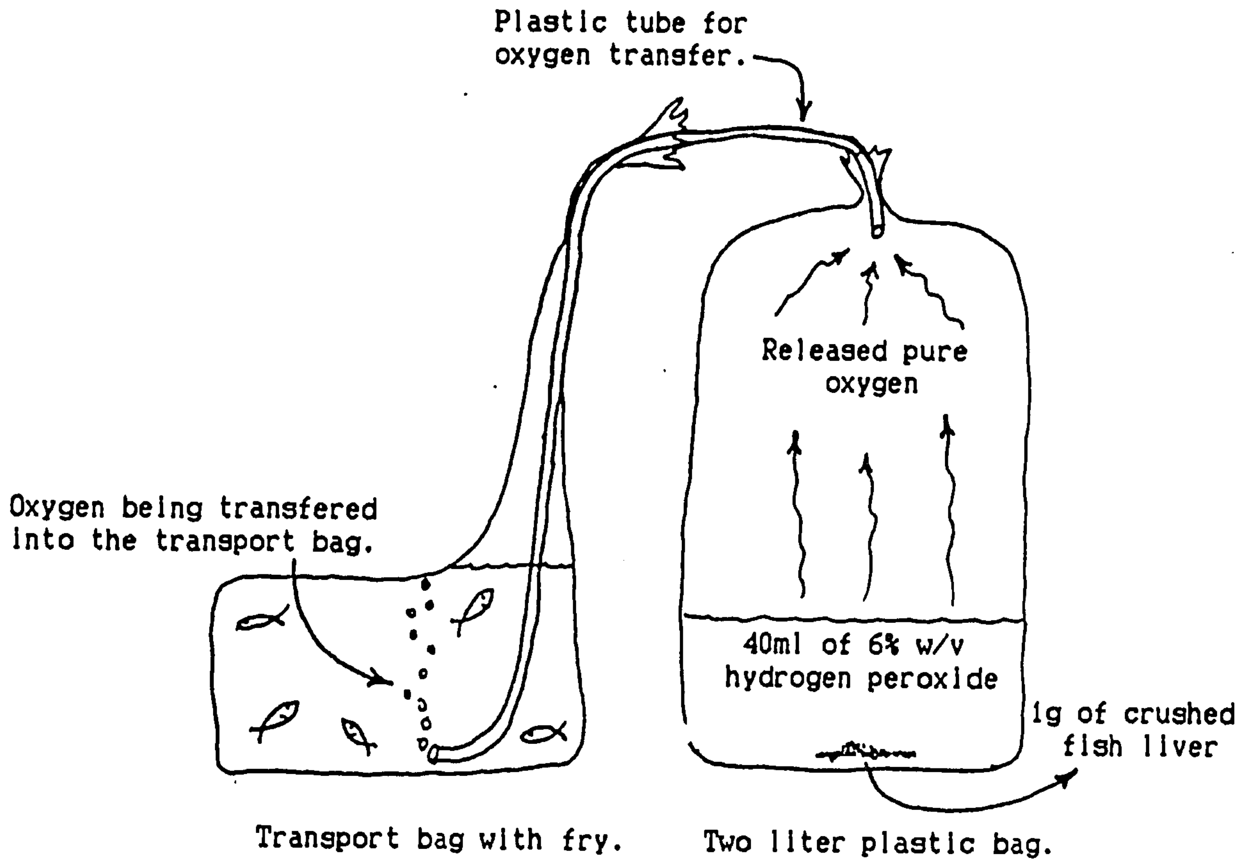


Figure 20: Producing pure oxygen from hydrogen peroxide for fish transport.

Temperature of transport water.

Water temperatures ranging from 18 to 28 degrees centigrade are suitable for transporting warm-waterfish. The ideal temperature is 21 to 25 degrees centigrade.

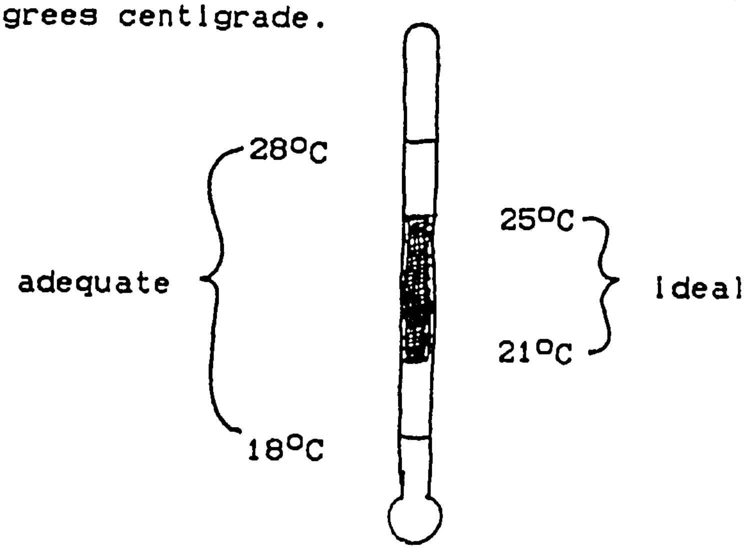


Figure 21: Temperature range for transporting warm-water fish.

Warm water holds less oxygen than cool water. Respiratory requirements of fish are also greater at higher temperatures. Thus, fewer fish can be transported per unit volume of warm water. The GOLDEN RULE of fish transport is to always maintain sufficient oxygen in the transport water. This can be done in several ways.

Keep transport containers cool. They should always be kept shaded and out of direct sunlight. As water warms it holds less oxygen, so prevent rapid warming of the transport containers. Ice may be packed around containers on long trips. DO NOT add ice directly to the water containing the fish. A wet cloth may also be wrapped around containers to reduce temperature by evaporative cooling if ice is not available. Be careful to prevent water temperature in the transport container from dropping below 18 degress centigrade when using ice.

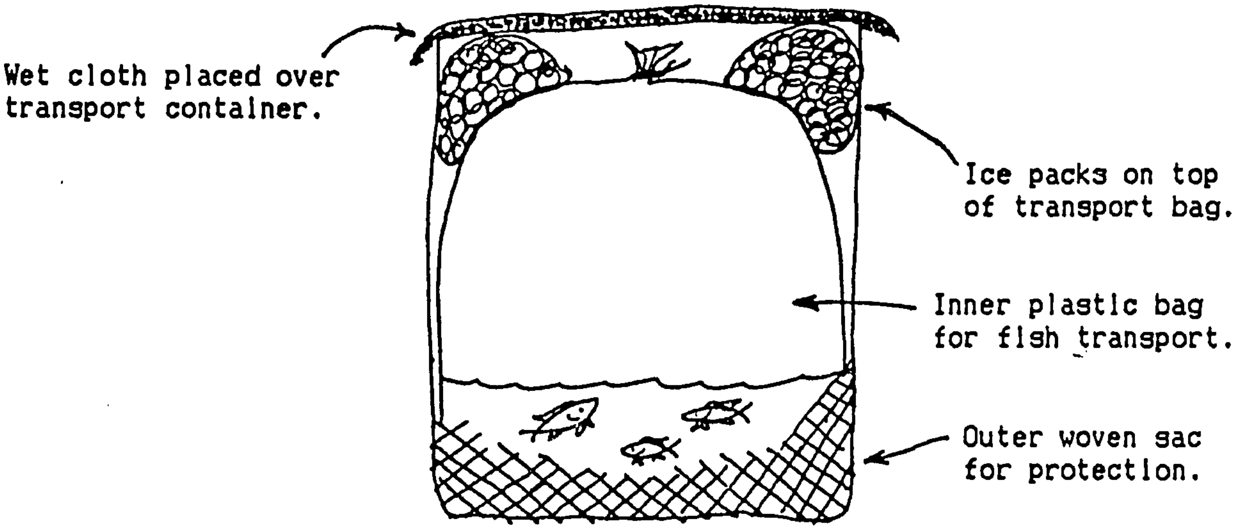


Figure 22: Packing ice around a plastic bag used for fish transport.

Duration of transport.

More fish can be transported per unit volume of water if the duration of transport is short. Fewer fish can be transported on long trips.

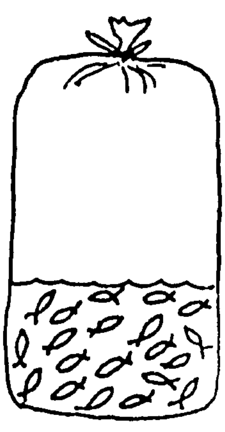


Figure 23: Short trip.

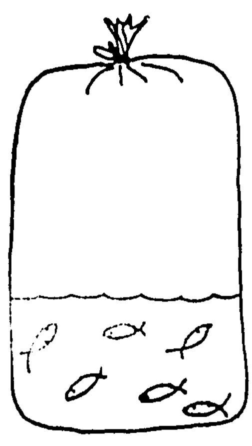


Figure 24: Long trip.

Mode of transport.

Use the fastest, smoothest and most direct means of transport possible. Some bumping and surging is useful in agitating water in containers. However, a rough ride with long stops greatly decreases the ability of fish to survive transport. Good communications can not be overemphasized in planning fish transport.

Climatic conditions.

Fish should be transported during the coolest part of the day or at night in hot weather.

STOCKING PROCEDURES

Stocking your fish into their new home after transport can be the most critical aspect of the transport procedure. Temperatures of the transport water and water where the fish are to be stocked must be equalized before stocking the fish. This usually requires 15 to 30 minutes. A temperature difference no greater than 3 degrees centigrade is tolerable. When fish arrive at their destination, the special procedures used to change water during transport must be followed to acclimate them to the new water. This allows water temperatures in the transport container to equalize with the new water, and allows fish to adjust to changes in ionic quality of the new water.

Plastic bags should be floated on the water surface where the fish are to be released while the water exchange and acclimation procedure is done. Fish are then allowed to swim out of the bags into their new surroundings. Fish transported in containers which can not be set into the new water may be transferred with a soft net, or dipped out with a scoop or bucket. DO NOT pour fish from any height into their new environment. They will be weak after transport and can easily be injured by rough handling at this stage. Allow them to swim slowly into new water.

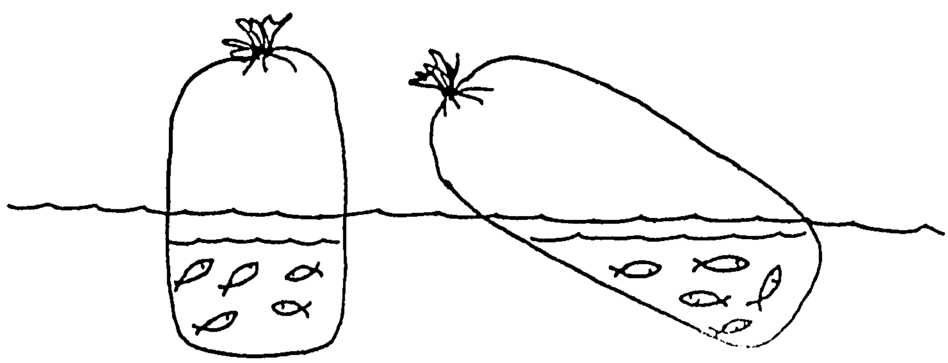
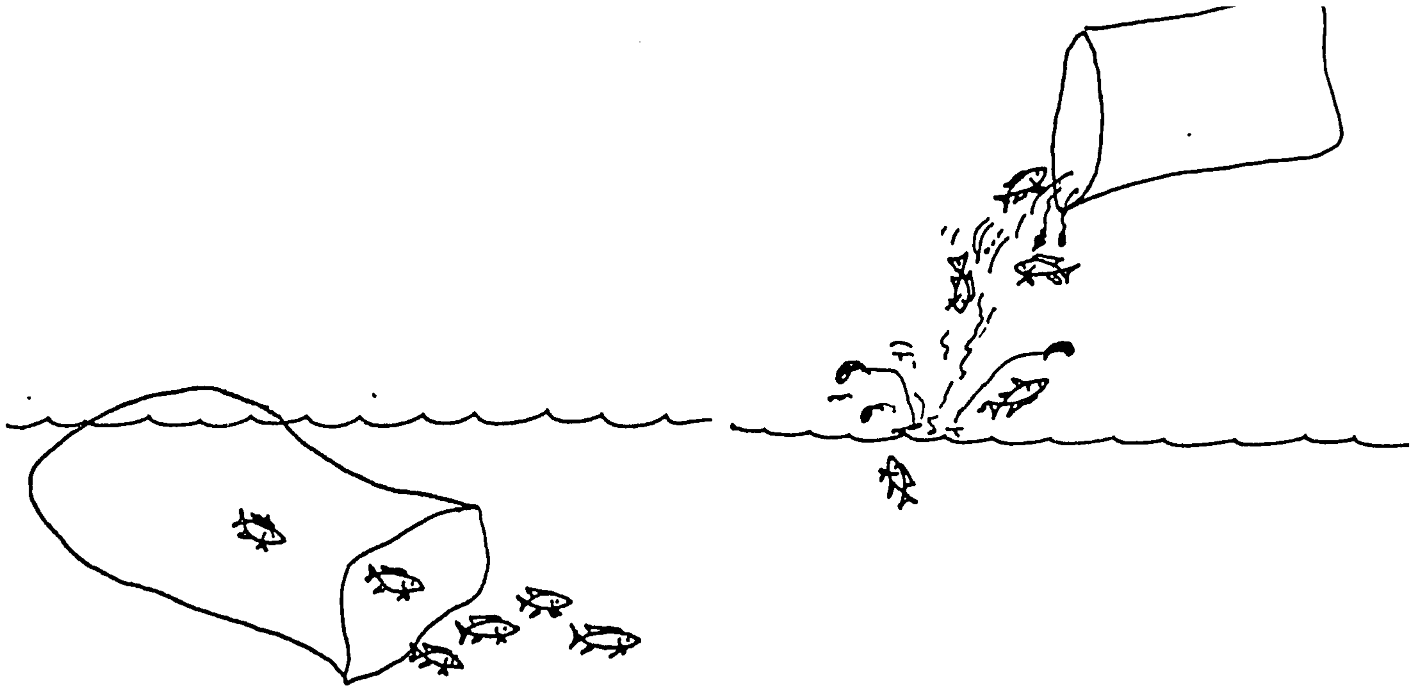


Figure 25: Float transport bags where the fish will be stocked.



Correct　　　　　　　　　　Incorrect

Figure 26: Immerse the bag and allow fish to swim out. This is better than scooping them out with a net. DO NOT dump or pour the fish in.

Summary

1. Stop feeding fish 24 to 48 hours prior to transporting them.
2. Prepare all transport containers, oxygen and other equipment.
3. Harvest fish during the coolest part of the day. (Very early morning).
4. Quickly, but gently, load harvested fish into a transport container.
   - DO NOT OVERSTOCK.
   - USE BOTTLED OXYGEN IF POSSIBLE.
5. Insulate from heat during transport.
6. Transport fish on the fastest, smoothest, means of transportation available.
7. Upon arrival at their new home, adjust fish to their new surroundings slowly by gradually exchanging water to avoid temperature and ionic shock.

GLOSSARY OF TERMS

aeration - the process of adding pure oxygen or air into water for the purpose of increasing the dissolved oxygen content.

agitation - the process of increasing the amount of oxygen in water by stirring, pouring, shaking or some other mechanical means.

brood fish/stock - sexually mature fish selected for reproduction.

diffused oxygen - oxygen that is introduced into water as finely diffused bubbles from a tank of pure oxygen.

fry/post larvae - recently hatched fish which weigh less than 1g or measure less than 2.5cm in total length.

hydrogen peroxide - an antiseptic, commonly available in pharmacies, which may be used to produce oxygen for fish transport.

ionic shock - a condition resulting when fish are transported and, without acclimation, stocked into new water having chemical properties differing greatly from the transport water.

larvae - recently hatched fish which are still too young to feed.

pure bottled oxygen - high quality oxygen used by hospitals and welders that is contained in a tank or bottle and is also used in fish transport.

sac fry - the stage in a fish's life cycle at which it has a yolk sac.

spawning - the act of depositing eggs and producing young.

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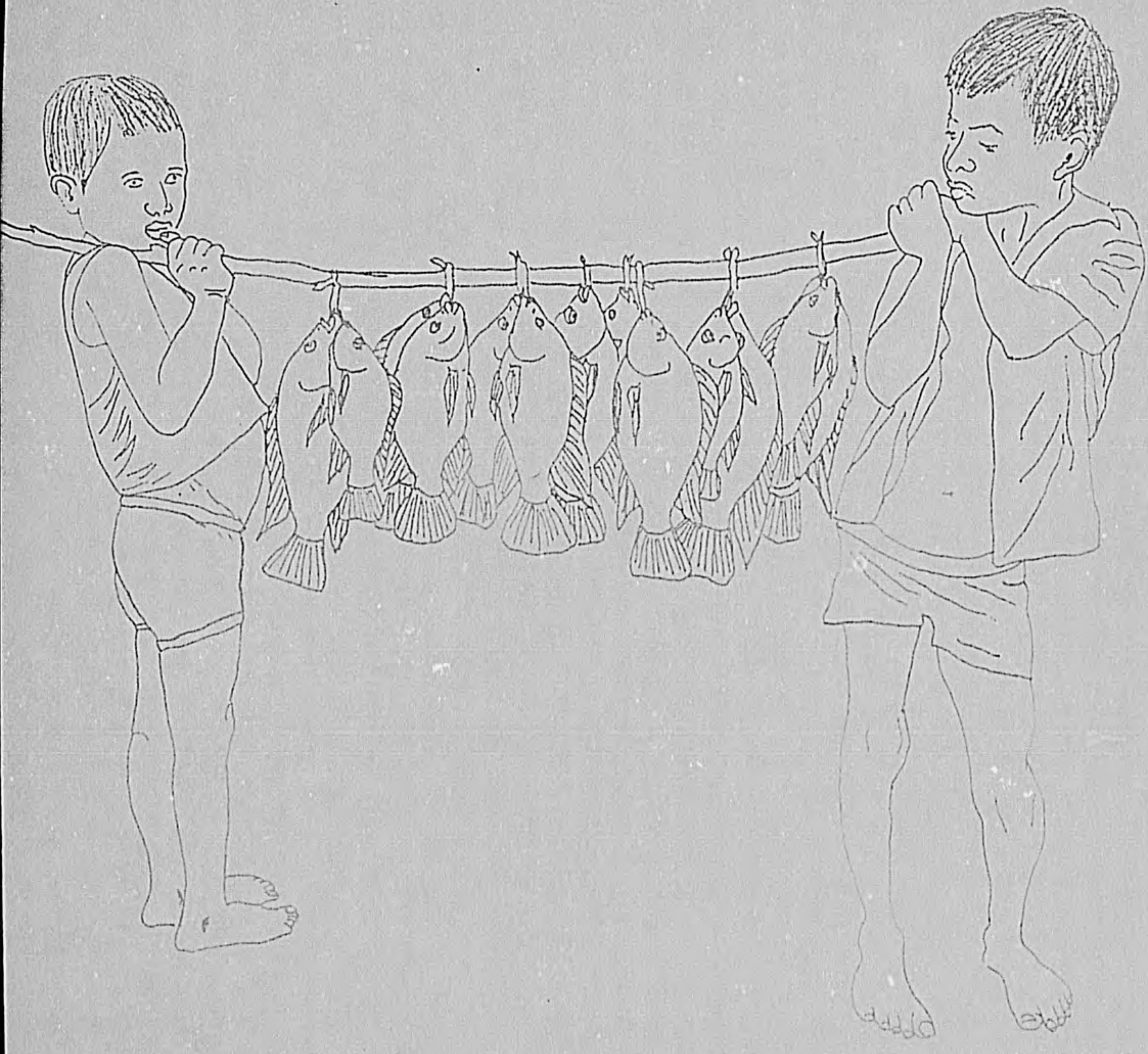
WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

AN INTRODUCTION TO TILAPIA CULTURE



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Tilapia are native to Africa, but have been introduced in many countries around the world. They are disease resistant, reproduce easily, eat a variety of foods and tolerate poor water quality with low dissolved oxygen levels. Most will grow in brackish water and some will adapt to full strength sea water. These characteristics make tilapia suitable for culture in most developing countries. They are most often grown in ponds, cages and rice fields. A brief guide listing characteristics for the important tilapia species is included at the end of this manual.

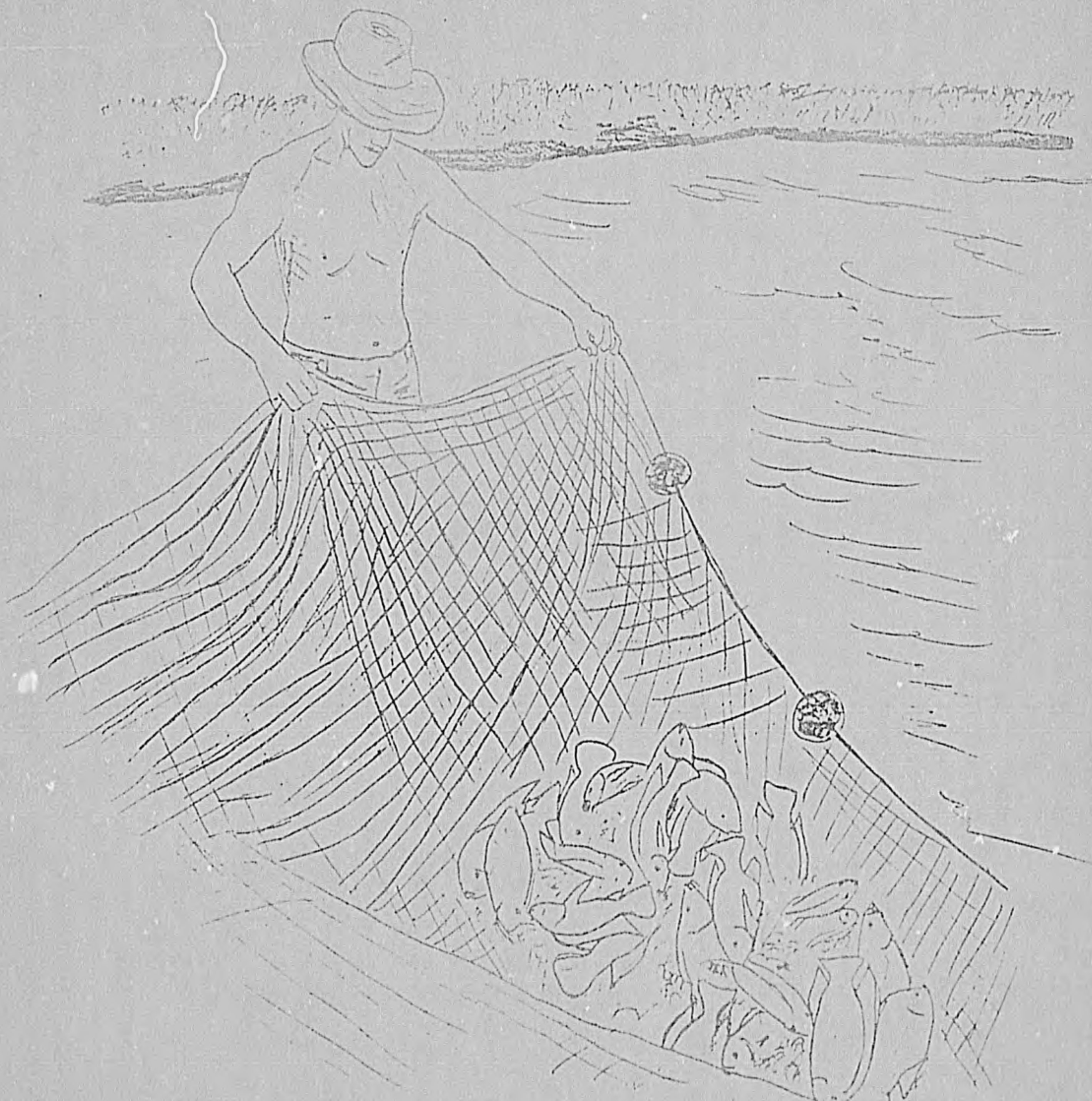


Figure 1: Culture in ponds.

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Figure 2: Culture in floating or anchored cages.

Figure 3: Culture in rice paddies.

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THE PROBLEM OF OVERPOPULATION IN PONDS

Natural reproduction of cultured tilapia species occurs in one of two ways. The species *T. aurea*, *T. mossambica*, and *T. nilotica* are called mouth-brooders. The female incubates and hatches her eggs in her mouth after they are laid and the male fertilizes them.

The species *T. rendalli* and *T. zillii* are called substrate spawners because eggs are laid and hatched on bottom substrates in a nest dug by the male and female. Parents guard their eggs and fry, but do not protect them in their mouths.

The ease with which tilapia spawn and produce off-spring makes them a good fish to culture. However, this trait also creates problems. Survival of young is high and grow-out ponds can become crowded. Fish become stunted as the supply of natural food organisms in the pond is depleted. Nearly 75% or more of the stock may be less than 100 grams in such cases. This may not present a serious problem in the Orient where even tiny fish are eaten. However, if fish larger than 150g are preferred by the market, special culture techniques may be required to grow them. These technologies require different levels of skill and management and yield varying degrees of success in producing large tilapia. Some may be combined for efficiency in resource use.

METHODS FOR CONTROLING TILAPIA REPRODUCTION

The following seven methods are used to control tilapia reproduction. Figure 4 is a flow chart showing where these methods fit into different production systems.

1. Periodic harvesting of tilapia fry and fingerlings with nets to reduce competition for food.
   - effective in small ponds.
   - labor intensive.
   - requires little skill.

2. Separation of sexes after an initial growth period (monosex culture).
   - males grow faster than females.
   - hard to do for large ponds because the number of fish needed is large and the process is tedious.
   - mistakes are made and sexing is about 90% efficient.
   - requires trained labor.

3. Stocking hybrid "all-male" fingerlings.
   - males grow faster than females.
   - requires pure strains of broodstock.
   - requires special hatchery facilities and skilled labor.
   - hybrid fingerlings are expensive to produce.

4. Culture in cages which are suspended above the pond bottom.
   - spawned eggs fall through the cage mesh and die preventing overcrowding.
   - cage materials may be expensive.
   - requires intensive feeding with high quality ration.

5. Culture at very high densities in ponds or raceways.
   - crowding reduces the urge to reproduce.
   - Intensive feeding with a high quality ration is required.
   - good water supply must be available.
   - requires electric, gas or diesel aeration devices.
   - requires skilled management.

6. Stocking predacious fish as fingerlings or adults in the tilapia pond.
   - controls excessive reproduction.
   - produces two different kinds of fish.
   - large tilapia must be stocked initially or they will be eaten.
   - often difficult to get adequate numbers of predator fingerlings

7. Feed tilapia fry with male hormones to produce "all-male" fingerlings.
   - hormones are difficult to obtain.
   - hatchery facilities and skilled labor are required.

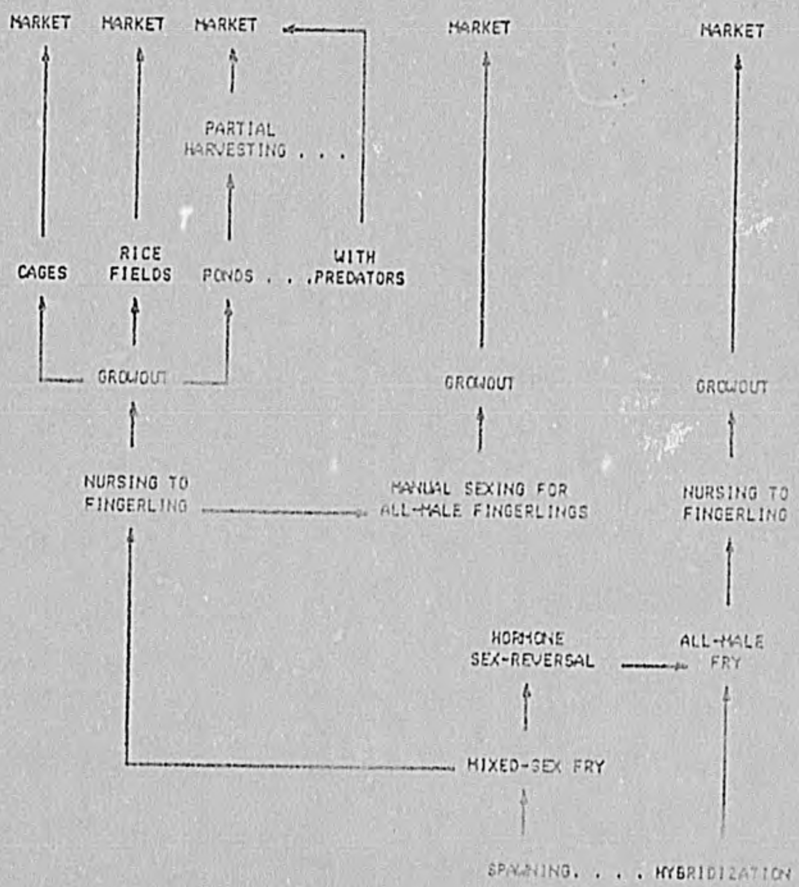

Figure 4: Flow chart showing the points in a production system where different methods for tilapia population control are used in obtaining marketable fish.

SUMMARY OF CONSIDERATIONS FOR TILAPIA CULTURE

The following table summarizes the main considerations for tilapia culture in ponds, cages and rice fields. It is intended as a checklist for those interested in tilapia culture.

Consideration	Culture Area: Pond	Cage	Rice Field
1. Culture methods...........			
- mixed sex	yes	yes	yes
- monosex	yes	yes	yes
- polyculture with other fish	yes	yes	yes
- integrated with crops	yes	no	yes
- integrated with livestock	yes	yes/no	yes
2. Minimum recommended size for culture unit..............	$100m^2$	$1.0m^3$	$100m^2$
3. Stocking rates for different culture methods*..........			
- no fertilization or feeding	-----	-----	0.3
- fertilization only	1 - 2	50 - 100	0.3 - 0.5
- feeding only	1 - 2	250 - 500	0.3 - 0.5
- fertilization and feeding	2	250 - 500	1 - 2
4. Size of tilapia to stock**.			
- mixed-sex culture	5 - 15g	10 - 15g	5 - 15g
- monosex culture	20 - 40g	20 - 40g	20 - 40g
5. Culture period in months...	4 - 6	4 - 6	variable
6. Average yield per harvest+	1 - 4tons	5 - 50kg	300 - 500kg
7. Average harvest size.......			
- mixed-sex culture	50 - 100g	80 - 150g	50 - 100g
- monosex culture	150 - 300g	150 - 300g	100 - 200g

* Ponds and rice fields are stocked on the basis of fish per square meter of water surface area and cages on a per cubic meter basis.

** Tilapia at least 20g are needed for monosex culture.

\+ Ponds and rice fields are computed on a per hectare basis and cages on a per cubic meter basis.

SHORT GUIDE TO CULTURED TILAPIA SPECIES

There are many tilapia species but only a few are cultured widely around the world today. The following list broadly groups important tilapia species into mouth-brooders and substrate spawners.

1) _Tilapia rendalli_ biology and culture.

a. Reproduction:

1. Both parents dig a nest and incubate the eggs and fry.
2. Optimum temperature 25 to 30 degrees centigrade.
3. Spawning may occur at 7-week intervals with 12,000 to 20,000 eggs produced per year.
4. Eggs hatch in 5 days.

b. Food:

1. Fry eat zooplankton.
2. Adults eat aquatic weeds, insects, algae and manufactured food.

c. Culture:

1. Optimum temperature is 28 degrees centigrade.
2. Low temperature tolerance is 12 to 13 degrees centigrade.
3. Can tolerate brackish water.

2) _Tilapia zillii_ biology and culture.

a. Reproduction:

1. Both parents dig a nest and guard the eggs and fry.
2. Optimum temperature 22 to 26 degrees centigrade.
3. Six spawnings per year possible with about 6000 to 42,000 eggs produced per year.
4. Eggs hatch in 3 to 5 days.

b. Food:

1. Fry eat zooplankton.
2. Adults eat phytoplankton, leaves, stems, rooted aquatic vegetation and manufactured food.

c. Culture:

1. Optimum temperature is 28 degrees.
2. Lower temperature tolerance is 8 to 9 degrees centigrade.
3. Grows well in full strength sea water.

GLOSSARY OF TERMS

brackish water - a mixture of fresh and salt water.

fertilizer - a substance added to water to increase the production of natural fish food organisms.

fry - recently hatched fish which weigh less than 1g or measure less than 2.5cm in total length.

grow-out po[illegible] - a po[illegible]ther facility used to grow aquatic an[illegible]rketable [illegible]

integrated aquaculture - aquaculture systems integrated with livestock and/or crop production. For example, using animal manures to fertilize a pond to enhance fish production and water from the pond to irrigate a garden.

Mouth-brooders

1) Tilapia aurea biology and culture.

a. Reproduction:

1. Female incubates eggs in her mouth.
2. Optimum temperature 23 to 28 degrees centigrade.
3. Spawn 3 or more times per year with 1500 to 4300 eggs produced per year.
4. Eggs hatch in 3 to 5 days and female guards fry for an additional 8 to 10 days after hatching.

b. Food:

1. Fry eat zooplankton.
2. Adults eat zooplankton and phytoplankton, and graze on bottom organisms. They also eat manufactured food.

c. Culture:

1. Prefers temperatures of 25 to 30 degrees centigrade.
2. Low temperature tolerance 8 to 9 degrees centigrade.
3. Grows well up to salinities of 16 to 20 parts per thousand.

2) Tilapia mossambica biology and culture.

a. Reproduction:

1. Female incubates eggs in her mouth.
2. Optimum temperature 23 to 28 degrees centigrade.
3. Can breed 6 to 12 times per year with 2000 to 10,000 eggs produced per year.
4. Eggs hatch in 2 to 5 days and the female guards the young for an additional 8 to 10 days.

b. Food:

1. Fry eat zooplankton.
2. Adults eat zooplankton, phytoplankton and manufactured food.

c. Culture:

1. Optimum temperature is 25 to 30 degrees centigrade.
2. Low temperature tolerance is 10 to 12 dergrees centigrade.
3. Spawn and grow well in full strength sea water.

3) Tilapia nilotica biology and culture.

a. Reproduction:

1. Female incubates eggs in her mouth.
2. Optimum temperature 25 to 29 degrees centigrade.
3. Average of three spawns per year with about 750 to 6000 eggs produced per year.
4. Eggs hatch in 3 to 5 days and female guards young for an additional 8 to 10 days after hatching.

b. Food:

1. Fry eat zooplankton.
2. Adults eat phytoplankton, zooplankton, insects and other bottom organisms. They also eat manufactured food.

c. Culture:

1. Optimum temperature is 25 to 30 degrees centigrade.
2. Lower temperature tolerance is 11 degrees centigrade.
3. Grow well in water up to 20 parts per thousand salinity.

<u>male hormone</u> - a substance that, when fed to tilapia fry, induces undifferentiated tissue to develop into male gonads (testes).

<u>manual sexing</u> - examining a fish to determine its sex.

<u>manufactured food</u> - commercially processed food for fish or livestock.

<u>mixed-sex culture</u> - culture of males and females in the same grow-out facility.

<u>monosex culture</u> - culture of all-male fish for market.

<u>mouth-brooder</u> - a fish that hatches its eggs in its mouth.

<u>partial harvesting</u> - periodic harvesting of a portion of the fish from a culture facility during a culture cycle.

<u>phytoplankton</u> - the plant component of plankton.

<u>plankton</u> - the various, mostly microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

<u>polyculture</u> - simultaneous culture of two or more aquatic species with different food habits.

<u>predacious fish</u> - a fish species that eats other fish as food.

<u>spawning</u> - the act of depositing eggs and producing young.

<u>substrate spawner</u> - a fish that lays its eggs on some form of substrate or surface where they will hatch.

<u>zooplankton</u> - the animal component of plankton.

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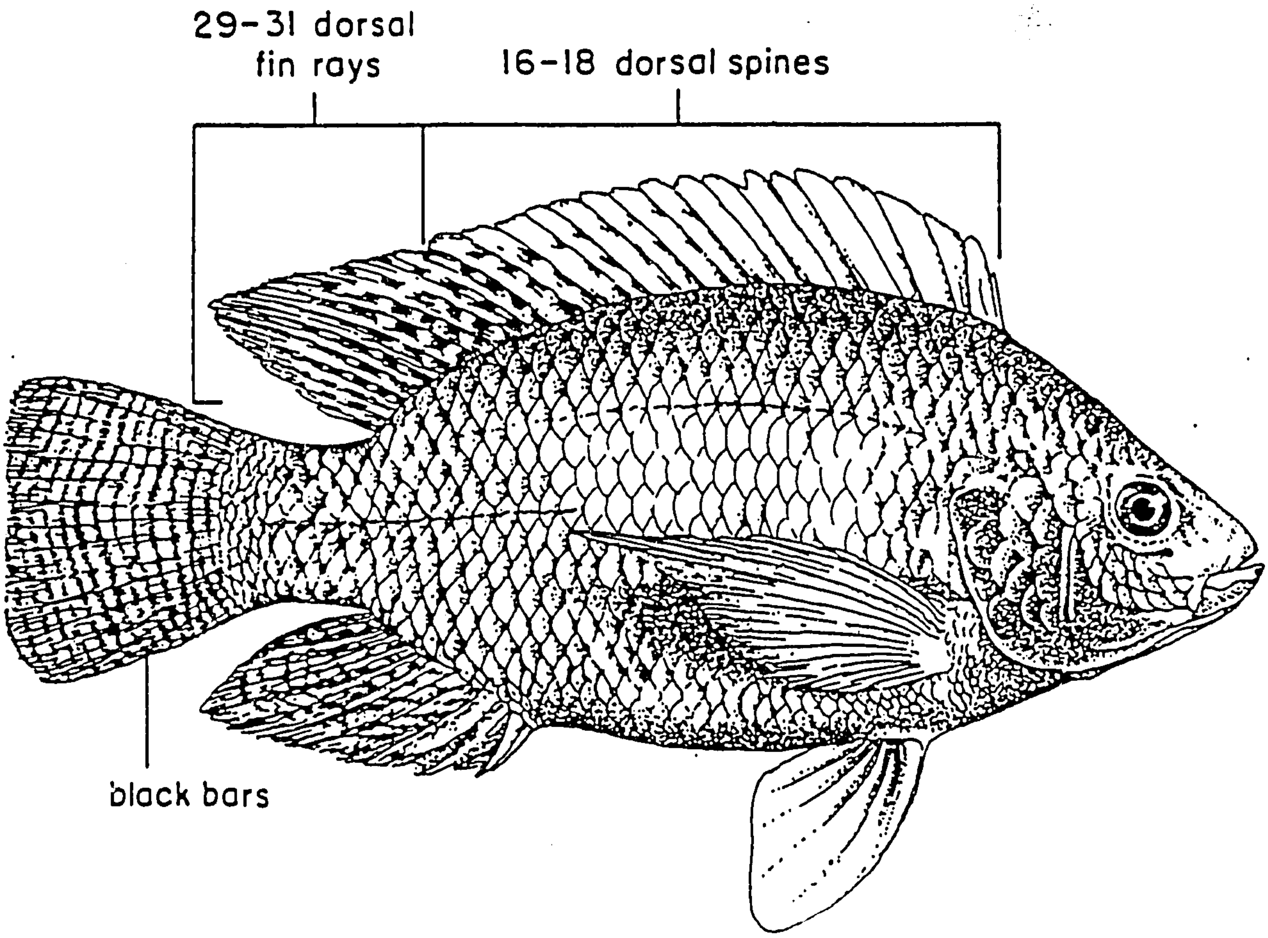
TECHNICAL SERIES ON WATER HARVESTING AND AQUACULTURE FOR RURAL DEVELOPMENT

REPRODUCTIVE BIOLOGY OF TILAPIA NILOTICA

WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Tilapia nilotica is native to most major Northern and Central African river systems and have been distributed widely throughout the tropical world. The following figure shows distinguishing features used to identify this species.



Tilapia nilotica

CHARACTERISTICS AT SEXUAL MATURITY

The following table summarizes important requirements and characteristics of sexually mature, pond-raised *Tilapia nilotica*.

AGE	4 to 6 months
WEIGHT	50 to 100g
LENGTH	10 to 12cm
SPAWNING TEMPERATURE	
- OPTIMUM	25 to 30 degrees C
- MINIMUM	21 degrees C
EGG PRODUCTION PER FEMALE	
- RANGE	100 to 2000 eggs/ spawn
- AVERAGE	200 to 400 eggs/ spawn
- A 200g FEMALE	250 to 500 fry/4 to 5 weeks
BEST SIZE FOR BROOD STOCK	100 to 200g

SPAWNING SEQUENCE FOR TILAPIA NILOTICA

The following sequence characterizes the mating behavior of <u>Tilapia nilotica</u> in captivity. Figures 1 through 6 on the following pages illustrate this behavior.

1. Brood stock become acclimated to their surroundings 3 to 4 days after stocking.

2. Males define and defend territories on the bottom, and form a nest by cleaning a circular area 20 to 30cm wide. In ponds with soft bottoms the nest is excavated 5 to 8cm deep by digging with the mouth.

3. The female is attracted to the nest where she is courted by the male.

4. The female lays her eggs in the nest after which they are fertilized by the male.

5. The female picks up the fertilized eggs in her mouth and leaves the nest. The male continues to guard the nest and attract other females for mating. Courtship and spawning require less than a day.

7. Eggs are incubated for 3 to 5 days in the female's mouth before they hatch. Young fry stay with their mother for an additional 5 to 7 days. They hide in her mouth when danger threatens. The female does not eat while incubating her eggs or caring for the new fry.

8. The female will be ready to mate again about one week after she stops caring for the fry.

9. Fry form schools after leaving their mother and can easily be harvested with small mesh nets at this time. Large schools of fry may be seen 13 to 18 days after brood stock have been introduced to their new surroundings.

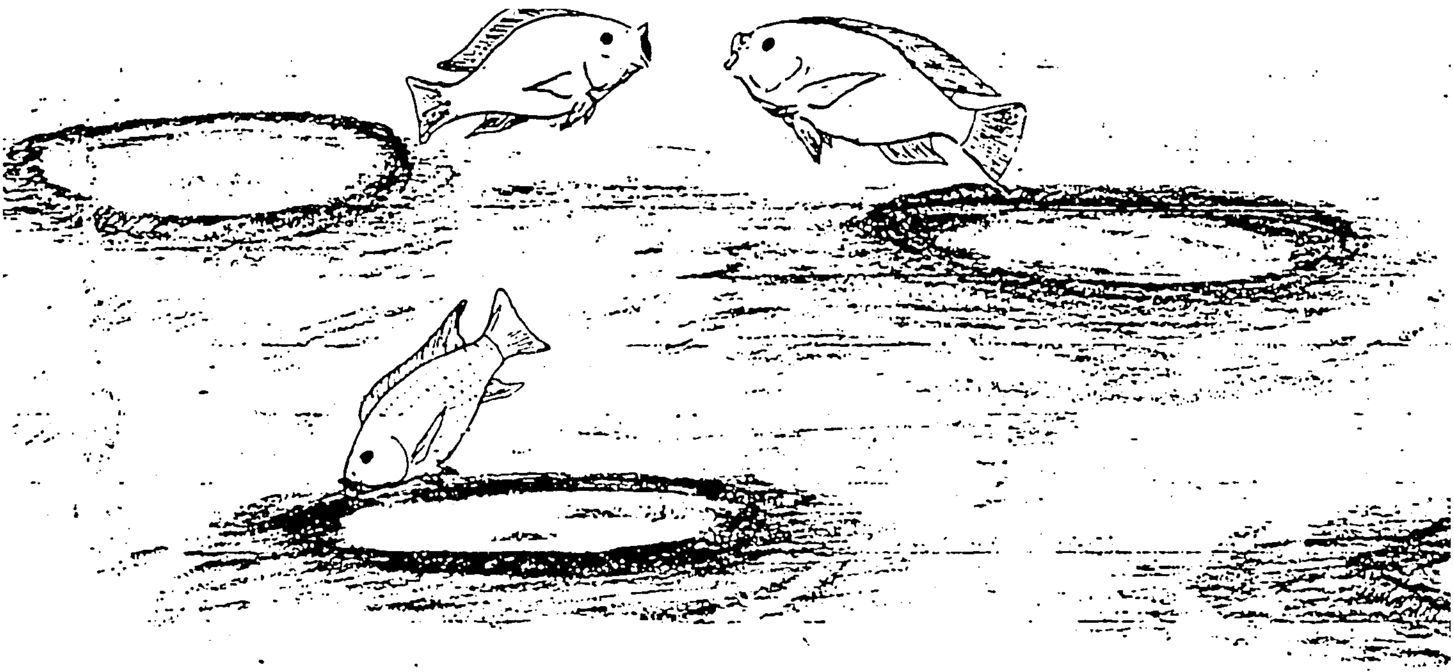


Figure 1: Rival males defending their nests, above. While below, a male cleans and builds a nest.

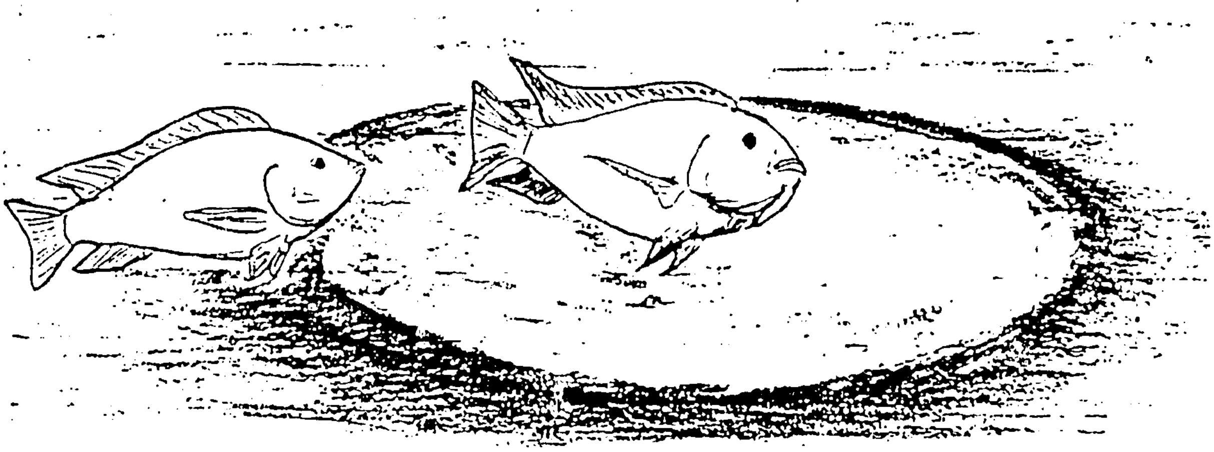


Figure 2: Male performing courtship display to attract a female into his nest for mating.

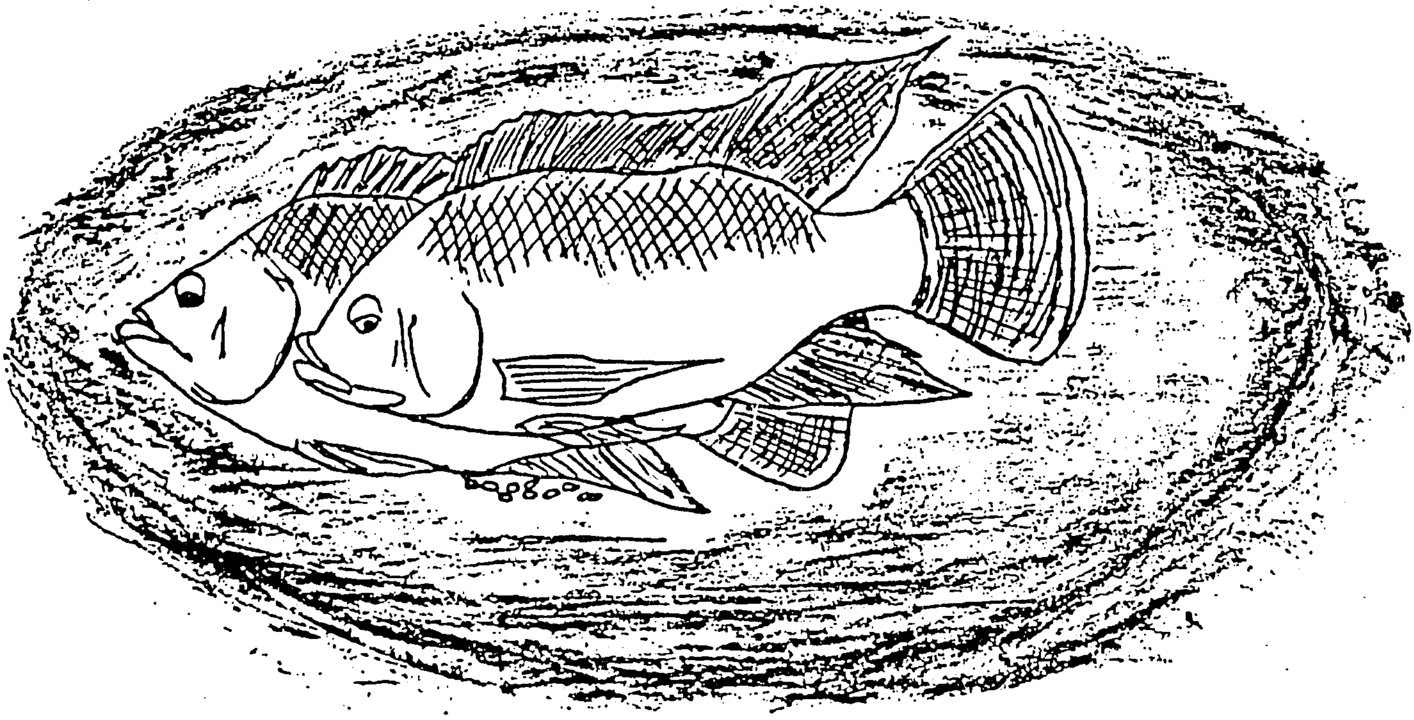


Figure 3: A mating pair of <u>Tilapia nilotica</u>. The female lays her eggs while the male stands ready to fertilize them.

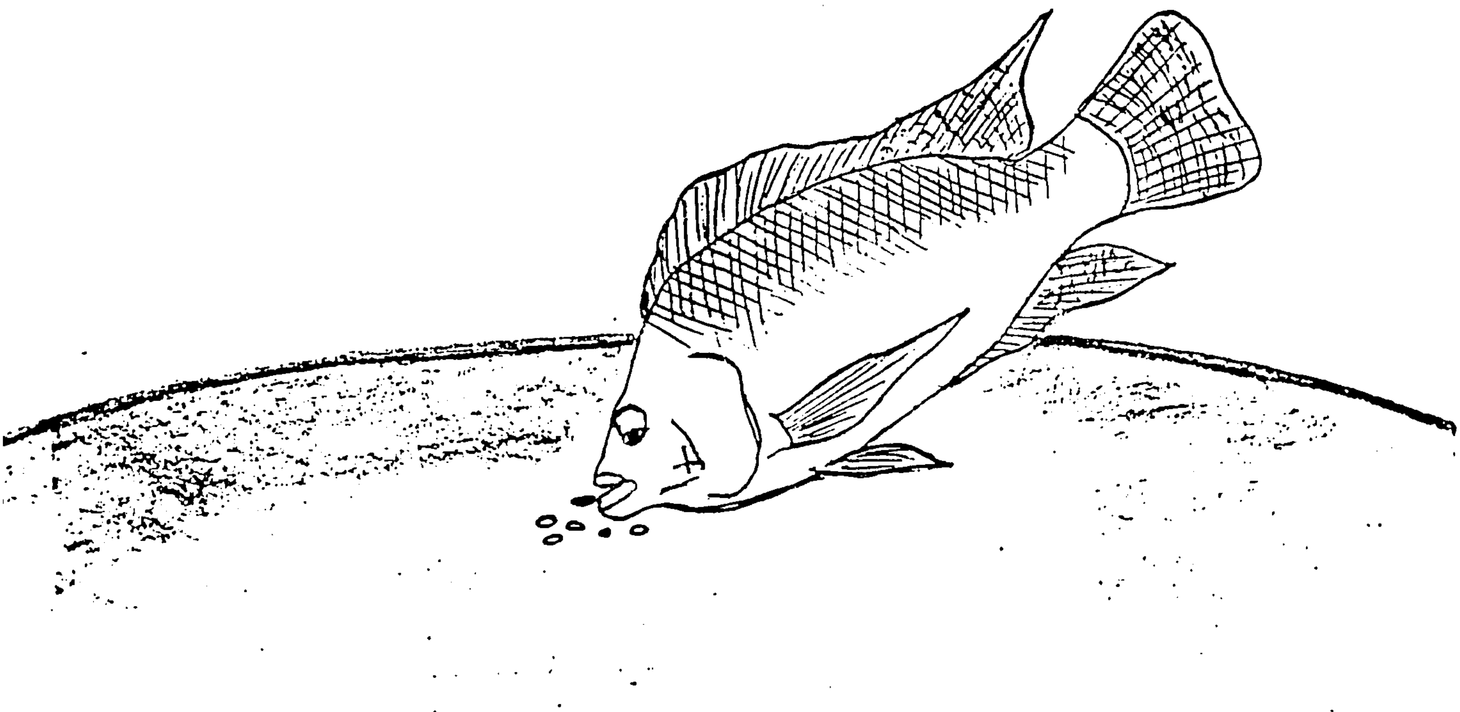


Figure 4: After the male fertilizes the eggs the female picks them up with her mouth for incubation.

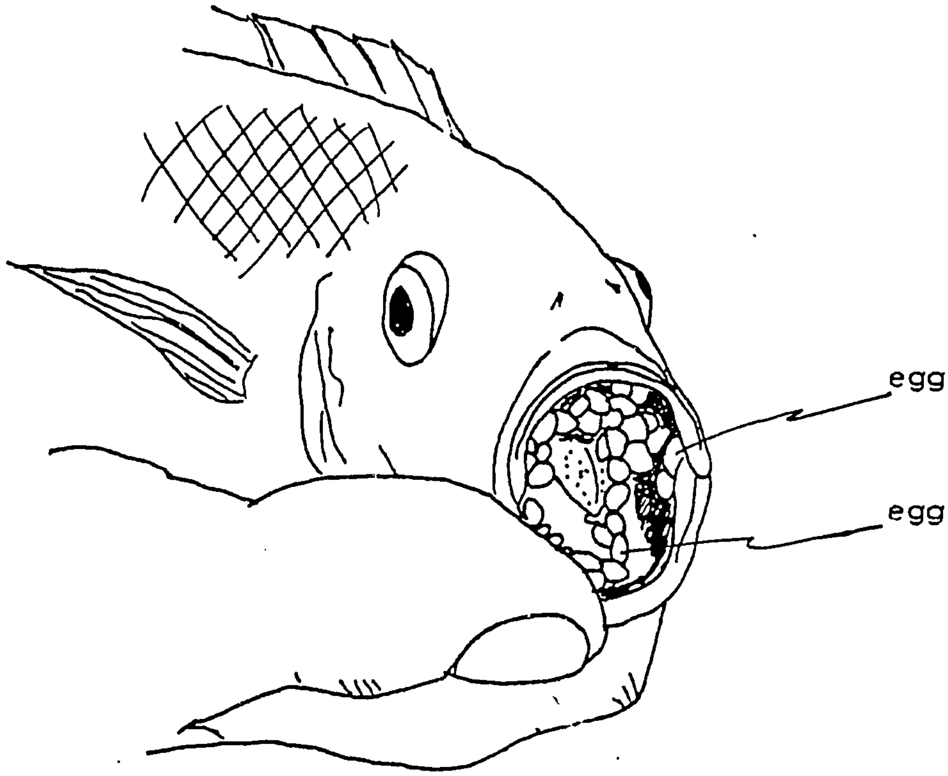


Figure 5: A female incubates eggs in her mouth. They will hatch in 3 to 5 days. Note the distended throat where the eggs are kept.

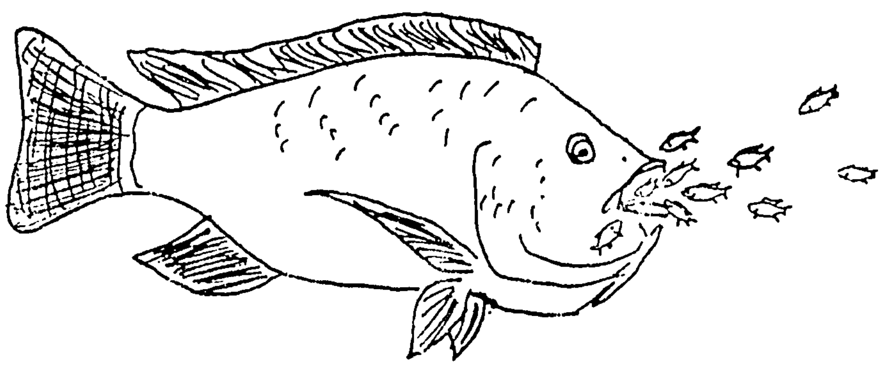


Figure 6: A female guards her young for 5 to 7 days. They hide in her mouth when danger threatens.

GLOSSARY OF TERMS

brood stock - sexually mature animals selected for reproduction.

spawning - the act depositing eggs and producing young.

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WATER HARVESTING AND AQUACULTURE
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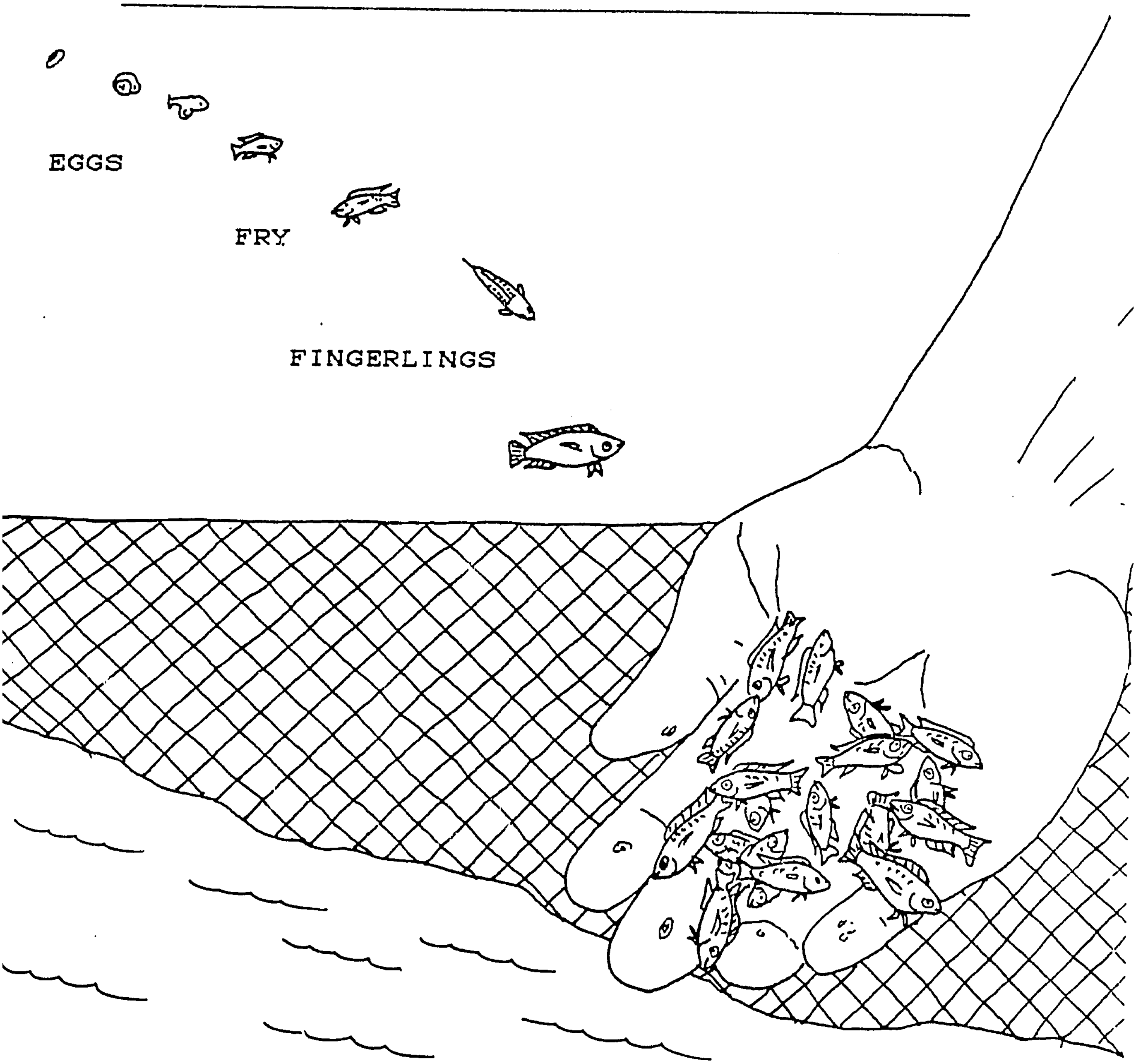
AN INTRODUCTION TO TILAPIA NILOTICA FRY AND FINGERLING PRODUCTION SYSTEMS



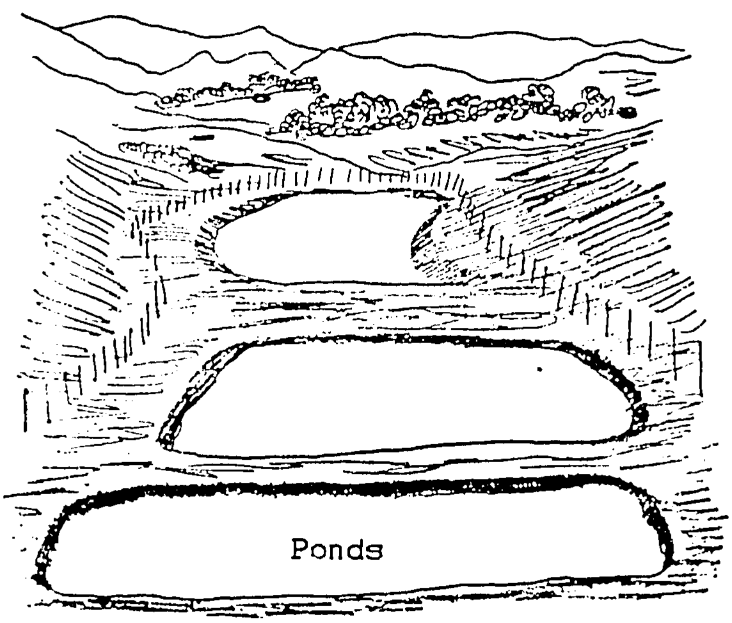
WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

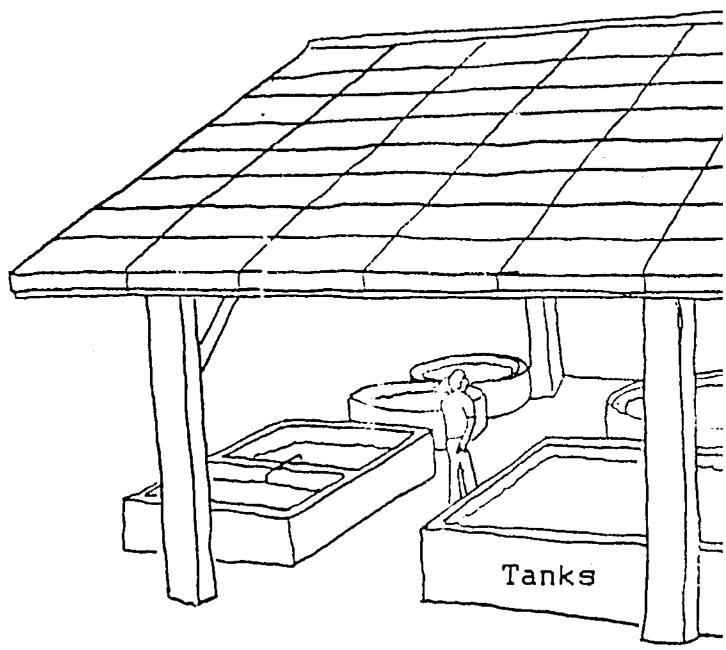
INTRODUCTION

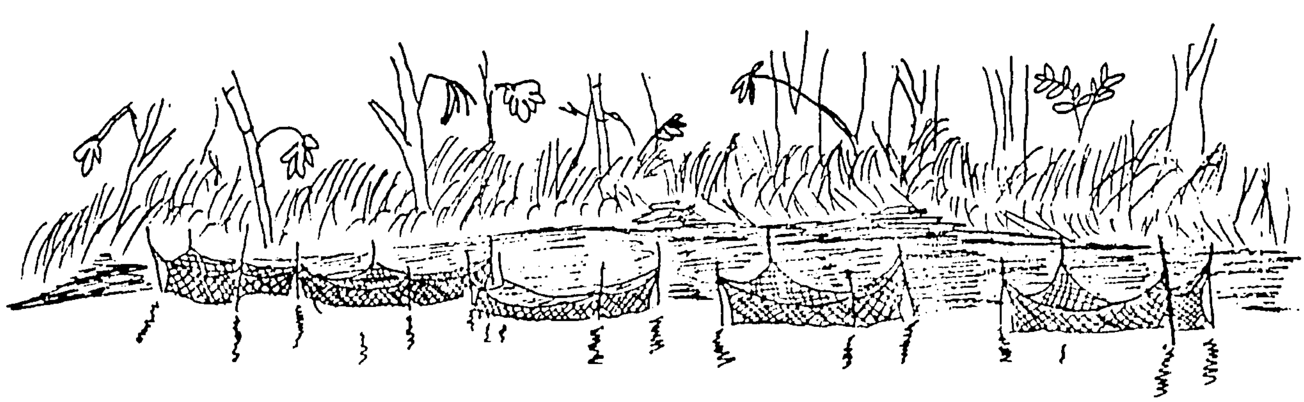
Fish culture is an important component of many rural development projects in areas suffering from protein shortages. *Tilapia nilotica* is often chosen for its good cultural characteristics. However, an adequate supply of fingerlings is not always available through established hatcheries. Farmers can produce their own tilapia fingerlings for sale or culture using one or more of the methods introduced in this publication.

FACILITIES FOR FINGERLING PRODUCTION

Tilapia fingerlings are most widely produced in ponds. However, net enclosures called hapas, aquaria and tanks made of wood, fiberglass, metal, plastic or concrete are also used. Choice of facility will depend on available resources and the demand for fingerlings.







Net Enclosures (Hapas)

SYSTEMS FOR PRODUCING TILAPIA FRY AND FINGERLINGS

The following systems are used for producing tilapia fry and fingerlings. Table 2 provides estimates of the numbers of fry and fingerlings which may be produced with each system. These numbers are not exact. They are affected by many variables including environmental factors such as temperature and water quality, the management practices and skills of the producer, fish health and others. Numbers presented here are only estimates which provide a crude basis for comparison among systems.

System 1: Single grow-out pond system

This system is the simplist and requires only one pond. Fingerlings are stocked in a pond and cultured for a full production cycle. Some reproduction occurs in the pond during this time and the resulting fingerlings are restocked into the same pond for grow-out after the food fish are harvested. Fingerling holding facilities are required while the grow-out pond is being prepared for restocking. One production cycle ranges from 4 to 6 months. Numbers of fry and fingerlings produced in this system are low because of crowding and cannibalism.

System 2: Reproduction pond system

This system employs a separate pond for reproduction. Brood fish averaging 100g are initially placed in this pond to spawn. Fry produced in the pond grow to fingerlings weighing from 1g to 15g. Fingerling harvests begin 5 to 7 weeks after stocking the brood fish. Fingerlings are then partially harvested with a net at 1 to 2 week intervals and transferred to other facilities for culture to a larger size. Net mesh size ranges from 6 to 12mm depending on the fingerling size desired. The reproduction pond is drained, dried and restocked with brood fish every 6 to 8 months.

Fingerlings obtained from this system are of more uniform age and size, and of better quality than fingerlings produced using the "single grow-out pond system". "Partial harvesting" results in increased fngerling numbers and growth due to reduced cannibalism and overcrowding. This system is practical for small scale farmers with potential for limited fingerling sales. Two production cycles per year are possible.

System 3: Multiple pond system

The objective of this system is to produce 20g male fingerlings in nursery ponds. The multiple pond system requires at least 2 ponds. A reproduction pond produces 1 to 2g mixed-sex fingerlings which are harvested and stocked into a nursery pond for culture to approximately 20g. They are then harvested and sorted by sex. Males are used in monosex tilapia culture where food fish of at least 200g are preferred by the market. This system is designed for commercial operations with high fingerling requirements where control of reproduction in grow-out ponds is desireable, and for specialized markets where the additional expense of producing fast growing, all-male fish is justified. Two to three production cycles per year are possible.

System 4: Net enclosure or "hapa" system

Brood fish are stocked into net enclosures called "hapas" for reproduction. Fry are collected and transferred to other hapas, ponds or tanks for further culture into fingerlings or food fish. Complete removal of fry from the breeding hapa eliminates cannibalism by parent fish and siblings. Fry are concentrated in a small area so maximum recovery rates are achieved. Total fry production per unit area is much higher than previous systems. Hapas may be moved and set up in a variety of locations, but are especially well suited to lakes and ponds. Continuous production is possible.

System 5: Tank system

Tank production of tilapia fry and fingerlings is practical where space for ponds is limited or expensive to develop. Cement tanks are common, but other materials, such as fiberglass or plastic lined pools, may be used. Greater control over water management and routine maintenance is possible than with other systems. Fish may be easily collected with dip-nets or a small seine, and well-built tanks can last a lifetime. Continuous production is possible. Fry yields per unit area are higher than all the reproduction systems described except for net enclosures.

WHICH METHOD IS BEST?

A farmer must choose which production method is best suited to his situation. Table 1 provides a rough guide to determine which system to use.

TABLE 1: Characteristcs of different fry and fingerling production systems.

	SYSTEM				
DECISION FACTOR	1	2	3	4	5
FINGERLING SALES UNIMPORTANT	+	-	-	-	-
SUBSISTENCE LEVEL FARMING	+	+	-	-	-
ONLY A SINGLE POND AVAILABLE	+	-	-	-	-
SIMPLE METHODS AND EQUIPMENT	+	+/-	-	-	-
FINGERLINGS OF UNIFORM AGE AND SIZE PRODUCED	-	-	+	+	+
COMMERCIAL FINGERLING SALES	-	+	+	+	+
ALL-MALE FINGERLING PRODUCTION	-	-	+	+	+
PRACTICAL IN UNDRAINABLE AREAS	-	-	-	+	-
FRY COLLECTION VERY EASY	-	-	-	+	+
EASY WATER MANAGEMENT AND ROUTINE MAINTENANCE	-	-	-	-	+

BASIC REQUIREMENTS FOR PRODUCING FRY AND FINGERLINGS

1. Culture facilities require sufficient, good quality water free of harmful chemical substances.

2. All facilities should be cleaned and maintained on a routine basis. Hapas require periodic scrubbing to remove organisms and debris which clog the netting and prevent water circulation.

3. Ponds and tanks should be built where they will not flood. Pond inlets and outlets should be screened to keep out predators.

4. Ponds should be exposed to sunlight so that adequate plankton can be produced as natural food.

5. Reproduction and nursery ponds should be dried after each production cycle to eliminate small tilapia, wild fish or other undesirable organisms.

6. Ponds and tanks for commercial fingerling production should be completely drainable and have catch basins.

Table 2: Guide to the approximate numbers of fry and fingerlings produced in each system.

System 1

a) 3000 to 5000 fry and fingerlings produced per $100m^2$ of pond for each 4 to 6 month production cycle.

System 2

a) 1300, 1g fingerlings per $100m^2$ per week
b) 300, 5 to 15g fingerlings per $100m^2$ of pond per week with 2 production cycles per year.

System 3

a) reproduction phase - 1300, 1g fingerlings per $100m^2$ per week
b) nursery phase - 350, 25g all-male fingerlings per $100m^2$ per 9 weeks
c) 2 to 3 production cycles per year

System 4

a) 1000 fry per $4m^2$ hapa per week with continuous production possible.

System 5

a) 6000 to 8000, 1g fingerlings/$8m^2$ tank per month with continuous production possible.

GLOSSARY OF TERMS

brood fish - sexually mature fish selected for reproduction.

fingerling - a fish ranging in weight from 1g to 25g or greater than 2.5cm in total length.

food fish - fish cultured and marketed for human consumption.

fry - recently hatched fish which weigh less than 1g or measure less than 2.5cm in total length.

grow-out pond/facility - a pond or other facility used to grow aquatic animals to marketable size.

hapa - an enclosure of fine mesh net used for breeding fish and nursing fry.

monosex culture - culture of all-male fish for market.

nursery pond/facility - a pond or other facility used to culture aquatic animals to a size suitable for stocking into a grow-out facility.

partial harvesting - periodic harvesting of a portion of the fish from a culture facility during a culture cycle.

plankton - very small or microscopic, aquatic organisms (plants and animals) that serve as food for larger aquatic animals and fish.

reproduction pond/facility - a pond or other facility used for fish breeding.

spawning - the act of depositing eggs and producing young.

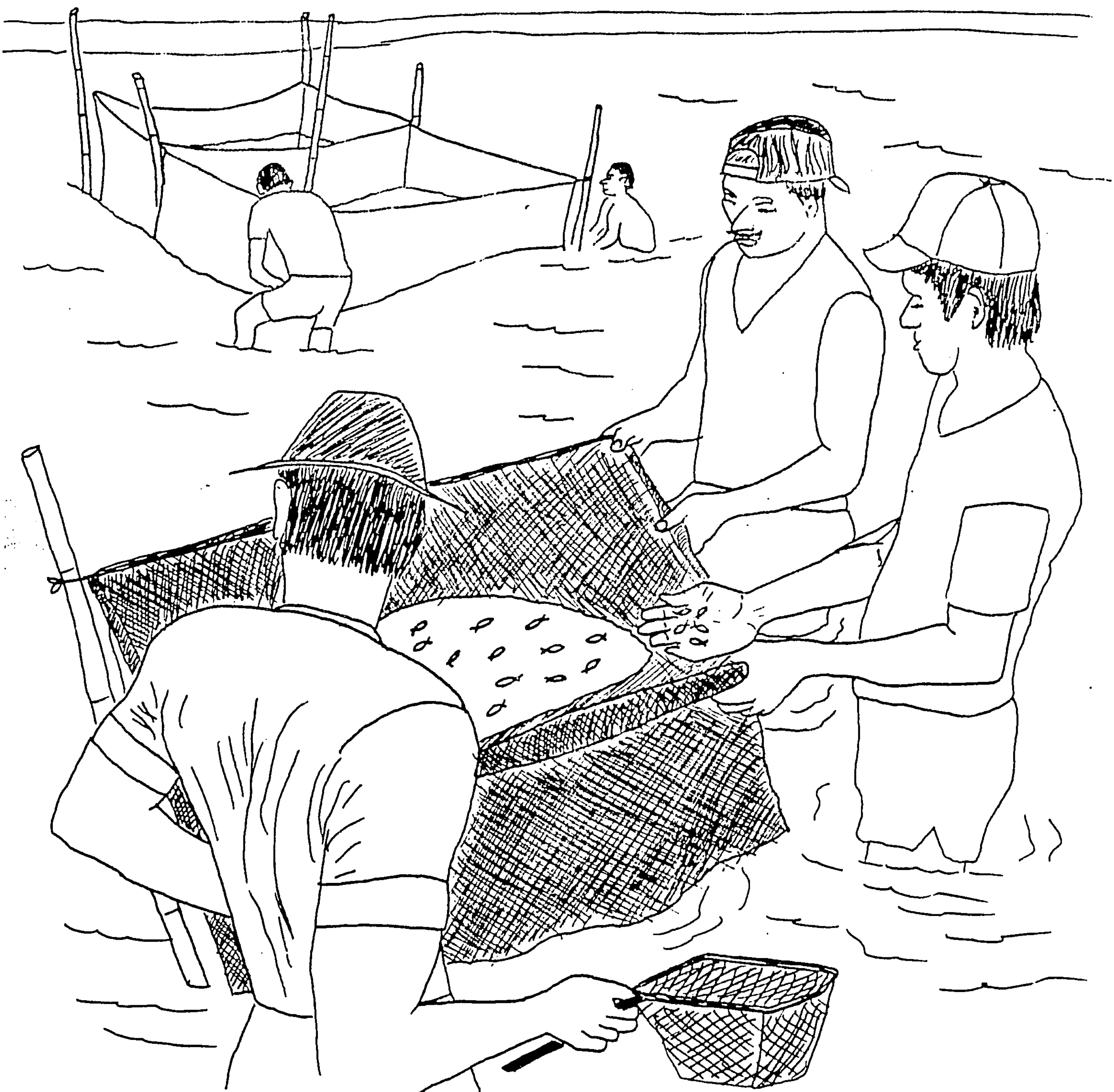
NOTE:

Fry and fingerling production systems outlined in this guide are covered in more detail in other titles of this series.

Communications regarding these and other technical brochures on water harvesting and aquaculture should be addressed to:
Water Harvesting/Aquaculture Project
Swingle Hall
Auburn University, Alabama USA 36849

WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

THE NET ENCLOSURE SYSTEM FOR TILAPIA NILOTICA FRY AND FINGERLING PRODUCTION



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

Net enclosures can be used in every phase of tilapia culture from fry production to growing market size food fish. In Southeast Asia the "hapa" net system for Tilapia nilotica fry and fingerling production is very popular. Hapas protect tilapia from predators and allow high fry survival. Produced fry are transferred to ponds, other hapas or tanks for grow-out to fingerling and food fish size.

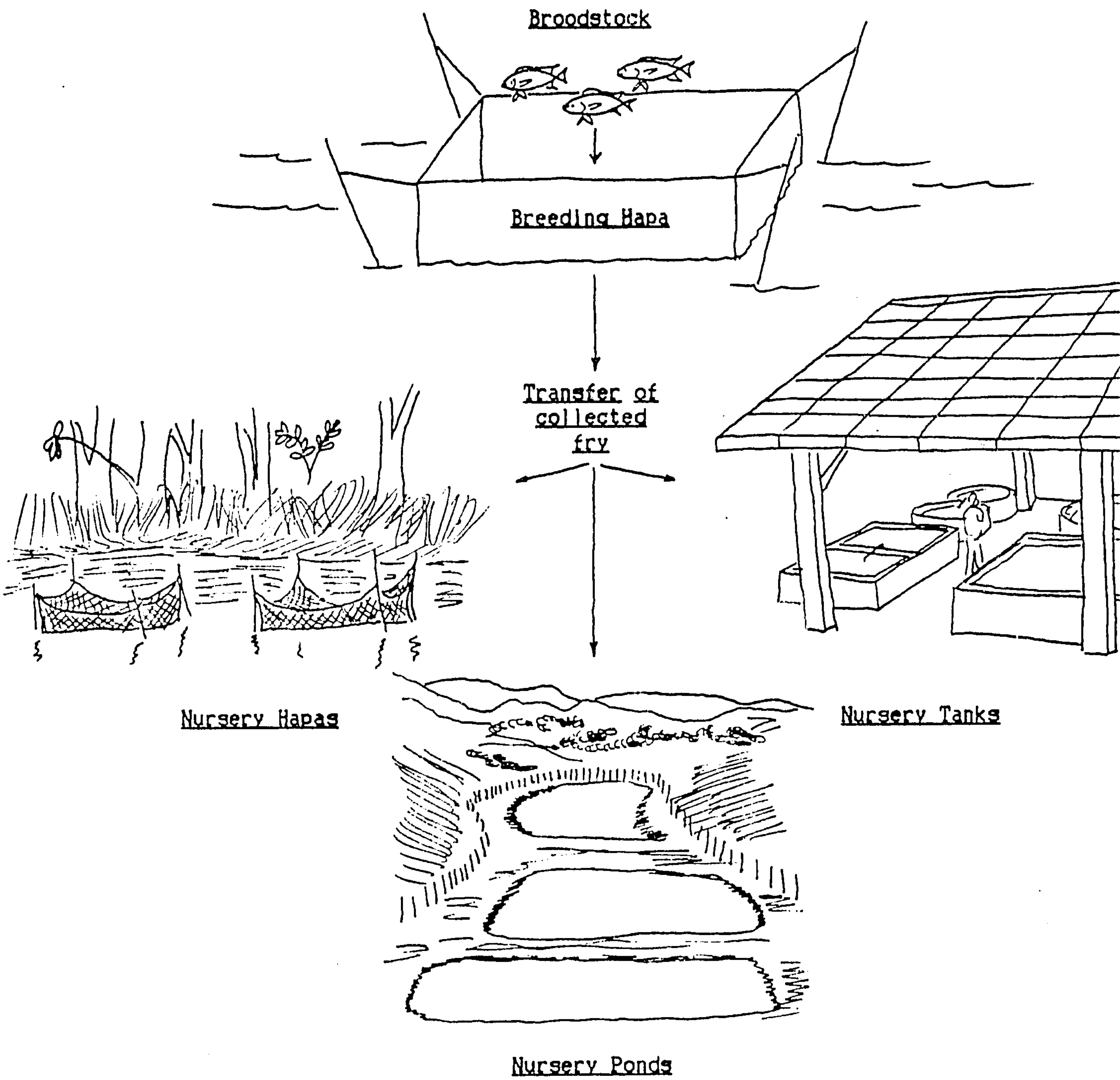


Figure 1: Tilapia fry production in hapas for transfer to nurseries.

WHAT IS A NET ENCLOSURE OR "HAPA"?

Hapas are constructed of netting material which is sewn together to form a square or rectangular enclosure. Hapas differ in size and mesh according to use. Breeding hapas hold tilapia broodstock and are constructed of netting which has a mesh size of 1.6 to 2.0mm. Inverted mosquito nets are often used for this purpose, but the fine mesh will become clogged with plant growth if not cleaned frequently. Clogging prevents fresh water from circulating into the hapa and can result in a low oxygen condition which kills fish. Larger mesh sizes allow greater water exchange in the hapa, and are used for nursing fingerlings stocked at high densities. Figure 2 illustrates the kind of hapa frequently used in Latin America. A cover is often attached over the hapa to prevent brood fish from jumping out and keeps predatory birds from injuring fish. Figure 3 illustrates a hapa typical of Southeast Asia. The support frame is lacking and a cover may be absent.

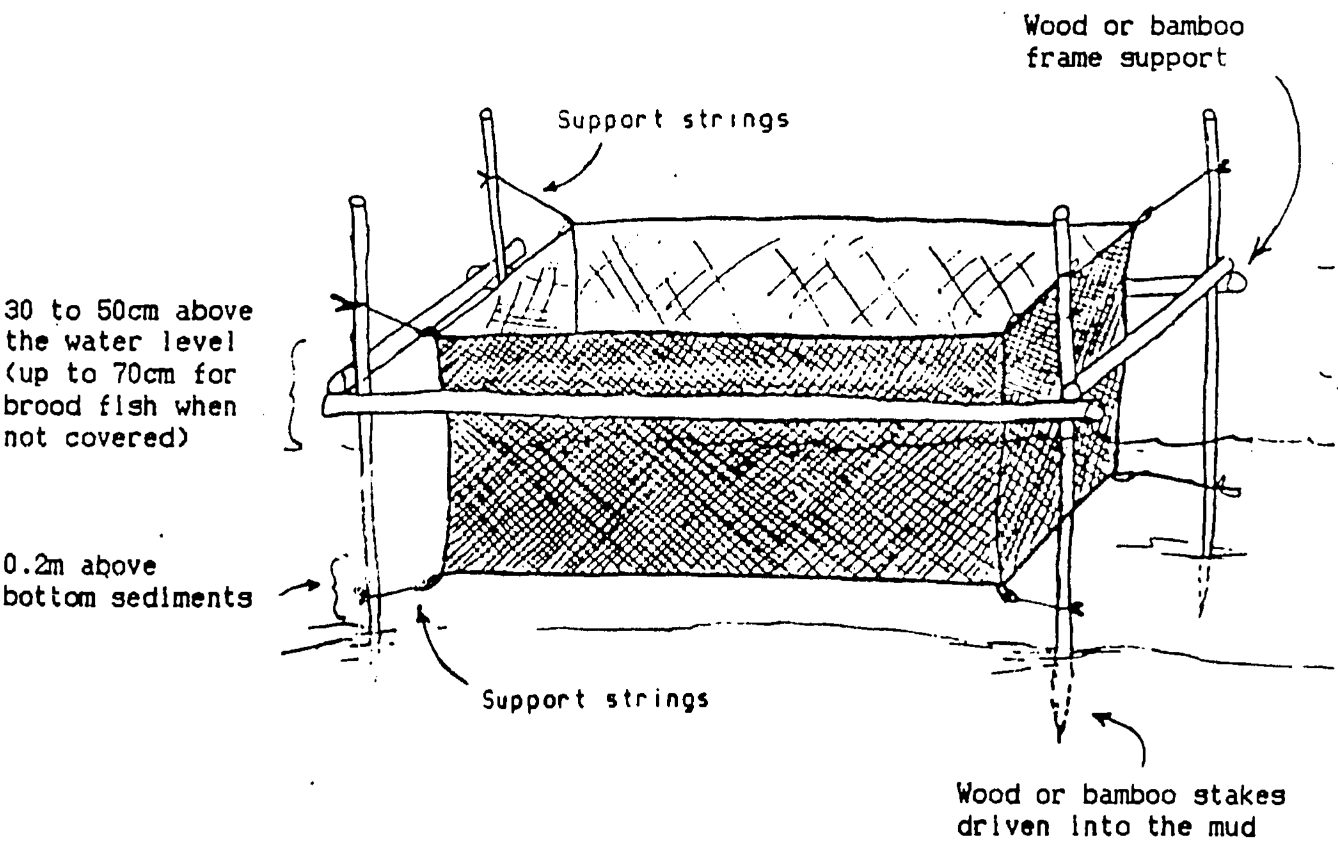


Figure 2: A typical hapa and support frame used in Latin America.

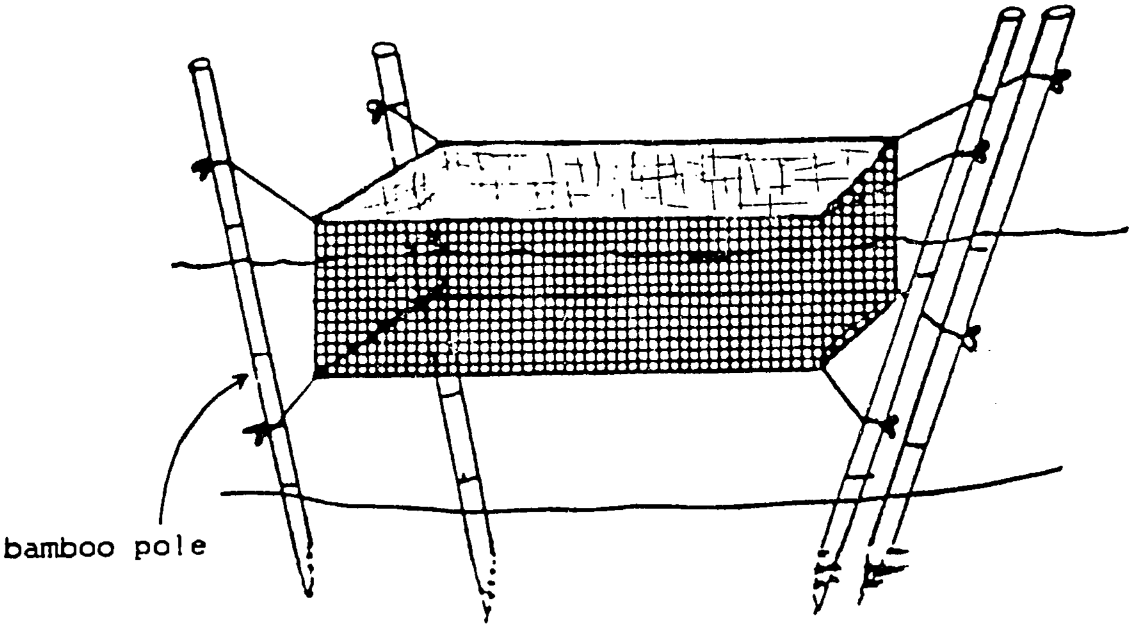


Figure 3: A hapa typical of Southeast Asia.

HOW DOES THE TECHNIQUE WORK?

Step 1: Determine where to place the breeding hapas.

Breeding hapas are placed in shallow, protected areas of ponds, lakes and slow moving rivers. Water should be at least 60cm deep and the hapa tied with the rim at least 30 to 70cm above the water line. This prevents fish from escaping when water levels rise during floods, and prevents brood fish, which can jump 50cm, from escaping. The hapa floor should be tied at least 20cm above the bottom sediments in ponds with soft mud bottoms. If sudden changes in water level of more than 20 to 30cm are likely to occur from flooding or drainage, hapas may be tied to a floating frame rather than to stakes driven into the mud.

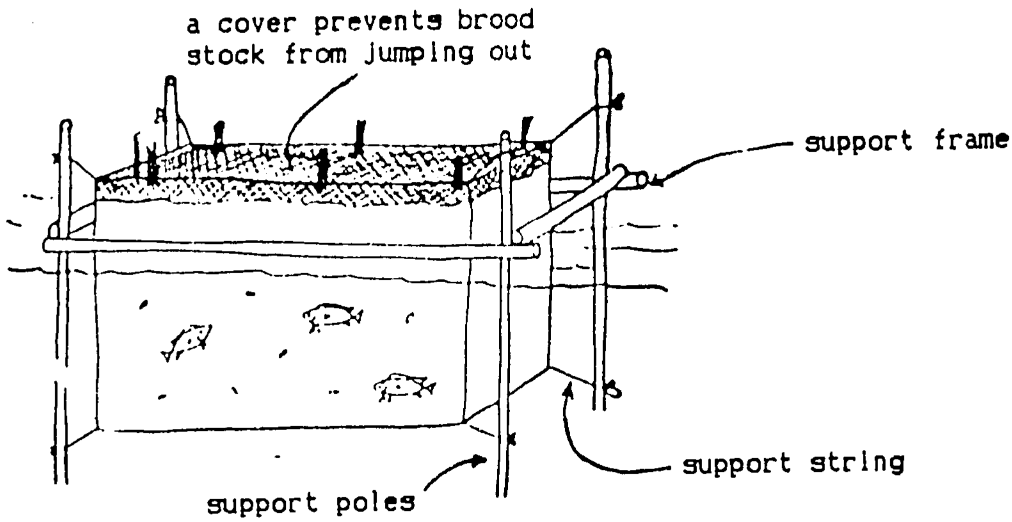


Figure 4: Hapa tied to support stakes contains broodstock and fry.

A female tilapia will lay eggs on the hapa floor, and pick them up in her mouth for incubation after the male has fertilized them. If the mesh size of the floor netting is larger than 1.6mm (1/16 inch), the eggs will pass through and be lost. To prevent the loss of eggs, materials such as fine mesh mosquito netting, a piece of plastic, a weighted board or anything with a flat surface that is not very heavy may be placed on the hapa floor to serve as a substrate for egg laying. If hapas are set up in concrete tanks or in ponds with a hard bottom the net floor may rest directly on the bottom. Water circulation will, however, be reduced.

Step 2: Determine how large the hapa system will be.

A farmer must be able to calculate how many brood fish are needed to produce a given number of fry. Assumptions must be made about the number of fry a female will produce. The assumptions presented in this manual are general and will not give the same results in all areas of the world. They are provided only as an example which can be adjusted according to local conditions.

The number of eggs and fry produced by a female depends largely on her weight. A 200g female will produce roughly twice as many fry as a female weighing 100g. Tilapia smaller than 50g are normally immature and are not satisfactory as brood fish.

Brood fish are stocked into hapas at rates of about 500g per m^2 (usually 3 to 7 fish depending on size) and in a ratio of 1 male to 3 females (or 1 out of 4 fish is a male). Under these conditions, 500g of brood fish on average may produce 250 to 300 fry every 5 weeks. This is about 2500 to 3000 fry per m^2 of hapa per year in countries where the average temperature is at least 25 degrees centigrade all year.

Breeding hapas with the following measurements are commonly used. One large hapa is less expensive to build than several small ones.

Hapa Dimensions	Surface Area	Weight of Brood Fish Held
a. 1m long x 1m wide x 1m deep	1m2	0.5kg
b. 2m long x 1m wide x 1m deep	2m2	1.0kg
c. 3m long x 3m wide x 2m deep	9m2	4.5kg

Example problem:

If a farmer in a tropical country needs 60,000 fry per year, how much broodstock and how many hapas are needed for this operation?

1) Surface area of hapas needed:

60,000 fry needed ÷ 2500 fry per m^2 of hapa = $24m^2$ of hapa needed.

2) If $2m^2$ hapas are used: $24m^2 \div 2$ = 12 hapas needed
   If $9m^2$ hapas are used: $24m^2 \div 9$ = 3 hapas needed

3) Total weight of brood fish needed:

$24m^2$ of hapas x 500g of brood stock per m^2 = 12,000g (or 12kg)

4) If 100g brood fish are used, the needed:

a) 12,000g of brood fish ÷ 100g per fish = 120 brood fish
b) 120 brood fish x 1 male per 4 fish = 30 males
c) 120 brood fish - 30 males = 90 females

Step 3: Managing the hapas to produce fry.

The following procedure for producing fry is followed after the number of broodstock and hapas needed have been calculated.

1) Place the hapa where it will be protected from strong currents. If hapas are placed in ponds, the pond should be prepared 2 weeks prior to stocking brood fish using standard fertilization practices. This allows phytoplankton to grow as food for the brood fish. Brood fish may be fed at 1% of their body weight daily with a good quality feed.

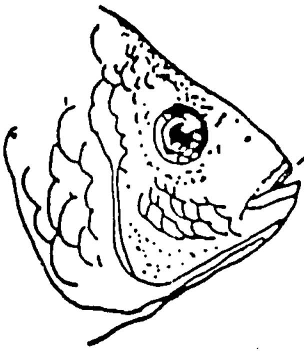
2) Examine the hapa for fry every 10 to 14 days after stocking brood fish. If the time period is shorter, females will still be incubating eggs. After more than 14 days, fry numbers will be reduced from cannibalism. Fry may be seen swimming in schools near the water surface. They can be scooped out with a fine mesh dip net, placed in pails and transferred to nursery ponds, tanks or hapas. This procedure for fry collection is described later. Great care is needed since fry are delicate at a young age.

3) Collected fry are graded to uniform size to reduce cannibalism and stocked into nursing facilities at rates of 1000 to $2000/m^2$ and grown for 1 month. Adequate natural and/or supplemental food must be provided during this time, and phytoplankton density in the rearing unit kept high. Visibility from the water surface should extend to a depth of only 25 to 30cm, and the water should be a rich green color. The number of fry should be reduced by half if no supplemental food is given. Survival may range from 50 to 75% during this first month.

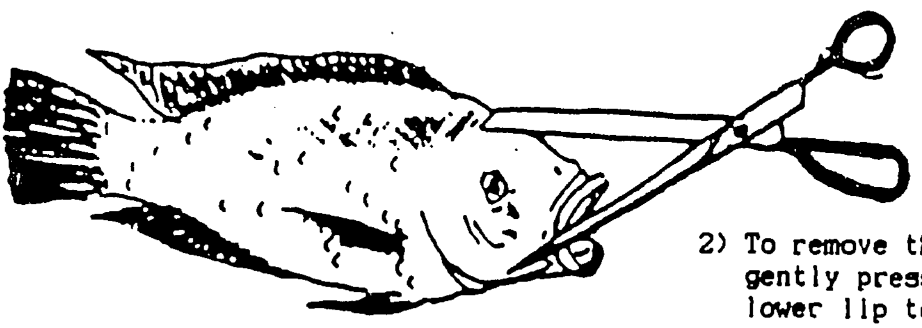
4) Fry are then thinned and stocked at rates of 10 to $20/m^2$ in secondary nursery units. Phytoplankton density is maintained as above. Supplemental feeds should also be provided or the number of fry stocked should be reduced by half.

5) Some scientists in Asia believe brood fish produce more fry when males and females are separated and allowed to "rest" about 2 weeks after each breeding. In this case, twice the number of brood fish are needed, but more fry would be produced. Replace broodstock at least once a year. Brood fish should be changed more frequently if good quality food is not available. This should be done when the number of fry collected drops constantly with each subsequent collection.

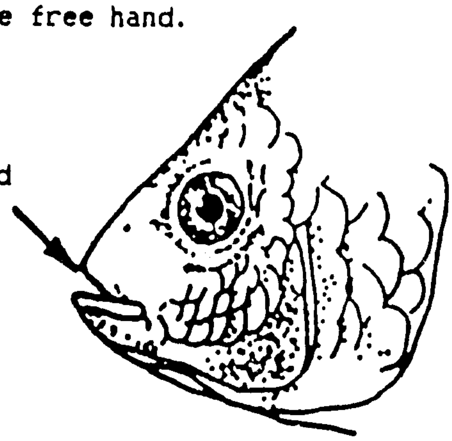
6) Male tilapia are aggressive and can injure unresponsive females while attempting to mate. Dense phytoplankton reduces visibility in water and reduces aggressive behavior. If fish are to be kept in clear water, the premaxillary or "upper lip" of the male can be removed with scissors or a sharp razor to provide protection for the female. The following illustrations show how this is done.



1) The premaxillary has small teeth. Aggressive male tilapia may injure females with these teeth during courtship. The lip can be removed with scissors to protect female brood fish.



2) To remove the premaxillary, gently press down the male's lower lip to open the mouth, and to extend the upper lip. This can be done with one hand. Then clip off the upper lip with the scissors held in the free hand.

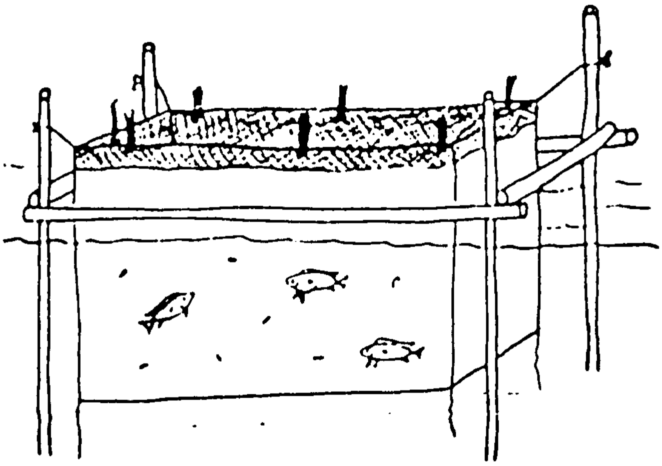


3) The cut will heal without harming the male. The lip may be retrimmed if it grows back.

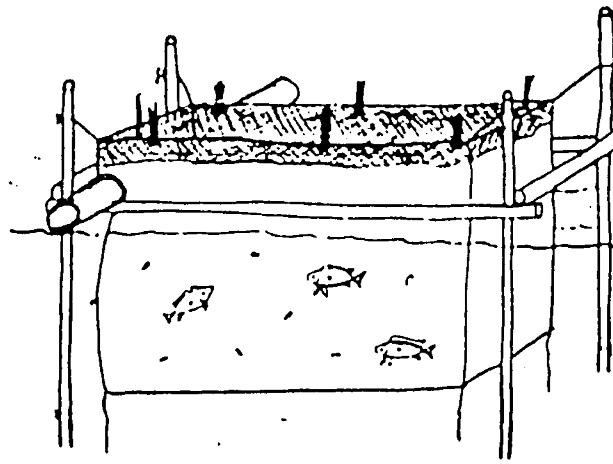
Figure 5: Removing the male's premaxillary.

INSPECTING A HAPA FOR FRY

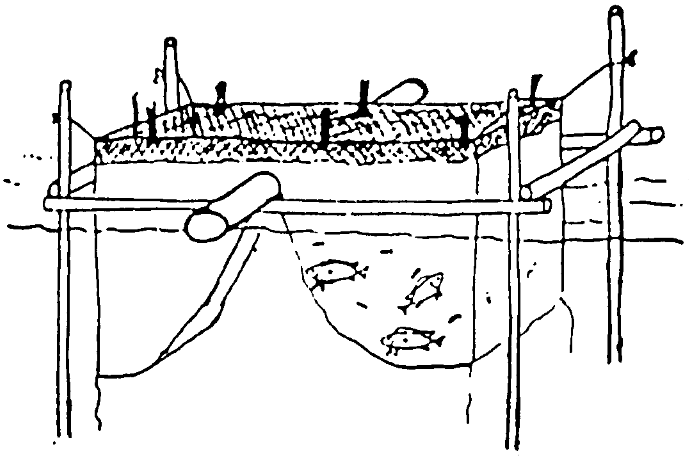
Small breeding hapas are easily inspected for fry. The bottom support strings are untied and a piece of bamboo, wood or plastic pipe (crowding bar) is pulled under the net from one end to the other to crowd the fish into one end of the hapa. Objects inside the hapa should be removed to avoid injuring fish. Floating crowding bars (3-inch diameter bamboo or sealed 3-inch diameter plastic pipe) are easier to use and require only two people to handle the inspection and fry removal procedure. Non-floating crowding bars require two people to move the bar and may require an additional person to remove fry with a dip net. The following figure illustrates the inspection procedure using a non-floating crowding bar which slides over the hapa support frame.



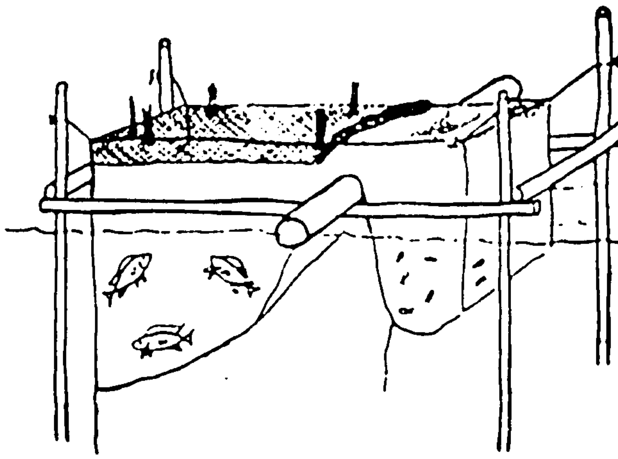
a) Untie bottom support strings.



b) Insert crowding bar at one end of the hapa.



c) Push crowding bar towards the opposite end of the hapa.



d) Transfer brood fish to the empty end of the hapa and remove fry with a net.

Figure 6: Inspecting a hapa for fry.

ADVANTAGES OF THE HAPA SYSTEM

1. Maximum recovery of fry is possible because broodstock are enclosed in nets.
2. Hapas may be set up in many different areas where it might normally be impossible to stock brood fish or nurse fry.
3. Separation of brood fish and fry is easy.
4. Fry may be produced continuously under favorable temperatures without having to drain reproduction ponds.

DISADVANTAGES OF THE HAPA SYSTEM

1. Netting for hapa construction may not be available or may be expensive.
2. Netting material may degrade in sunlight and need replacing annually. To avoid this do not dry nylon nets in direct sunlight. Properly cared for nets may last 5 years.
3. Fish may easily escape if the netting is torn.
4. Organisms in the water and uneaten food may clog the mesh. This limits water circulation in the hapa and may cause low oxygen problems. The net may need periodic scrubbing to remove fouling organisms from the mesh.
5. Fish may be easily stolen from hapas.
6. Females incubating eggs may spit them out when hapas are inspected for fry. These eggs will be abandoned.
7. Aggressive males may kill females while attempting to mate.
8. If brood fish are used for an extended time, a better quality food is needed than in an open pond where much natural food is available. This disadvantage can be overcome by changing brood fish more frequently.

GLOSSARY OF TERMS

brood fish - sexually mature fish selected for reproduction.

fertilizer - a substance added to water to increase the production of natural fish food organisms.

fingerling - a fish ranging in weight from 1g to 25g or greater than 2.5cm in total length.

food fish - fish cultured and marketed for human consumption.

fouling organisms - organisms that attach to nets and retard water circulation through the mesh.

fry - recently hatched fish less than 2.5cm in total length.

grow-out pond/facility - a pond or other facility used to grow aquatic animals to marketable size.

hapa - an enclosure of fine mesh net used for breeding fish and nursing fry.

natural fish food organisms - plankton, insects and other aquatic organisms that fish eat.

nursery pond/facility - a pond or other facility used to culture recently hatched aquatic animals to a size suitable for stocking into a grow-out facility.

oxygen depletion/low oxygen - a condition, normally occurring at night, in which dissolved oxygen in pond water has been depleted mainly because of the decomposition of organic matter and respiration of organisms in the pond.

phytoplankton - the plant component of plankton.

plankton - the mostly microscopic aquatic organisms (plants and animals) that serve as food for larger aquatic animals.

premaxillary - a mouth bone on the upper lip containing teeth.

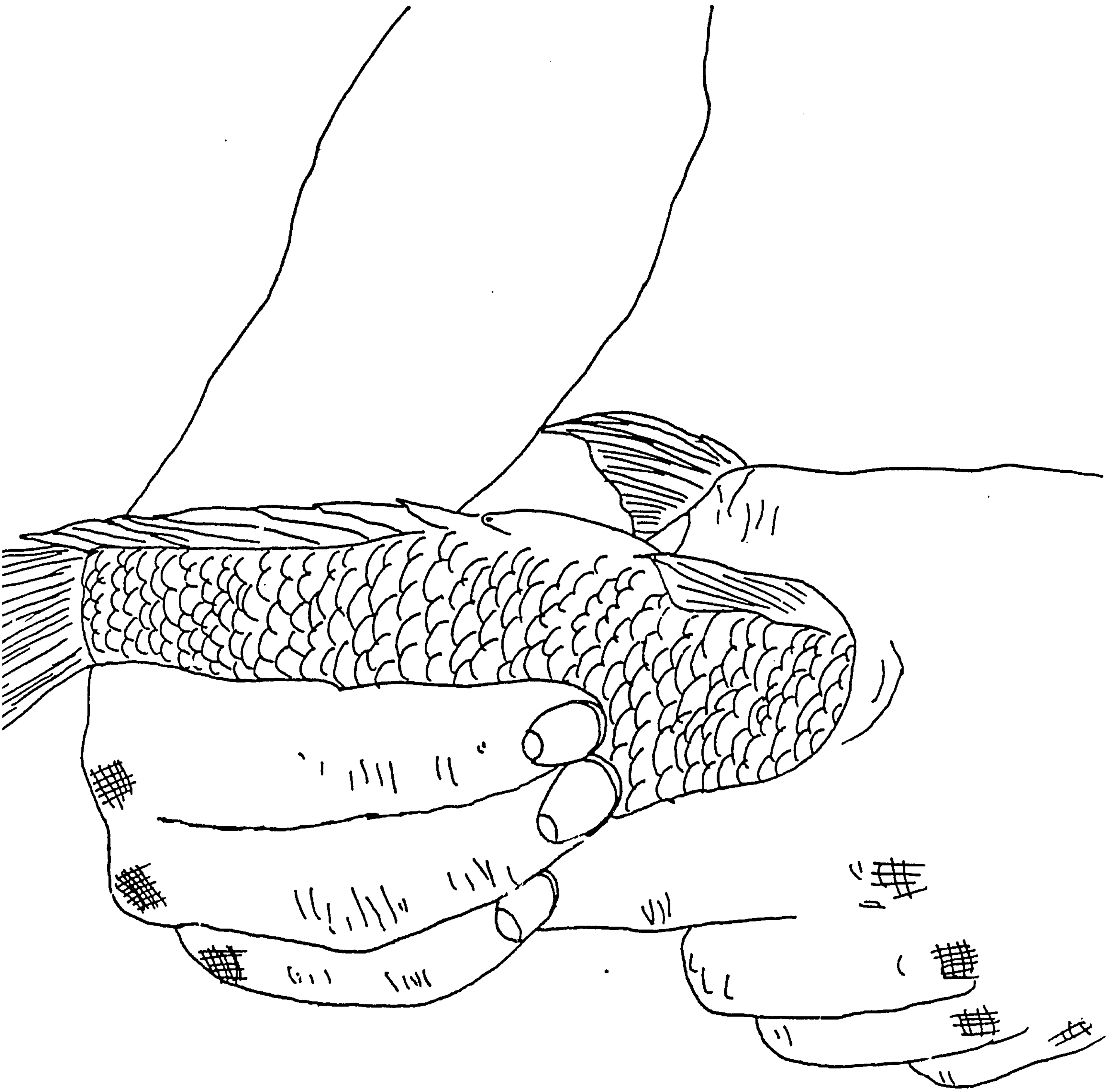
school - a group of fish swimming together.

supplemental food - a food that does not contain all the vitamins and nutrients essential for growth.

Communications regarding this and other technical brochures on water harvesting and aquaculture should be addressed to:
Water Harvesting/Aquaculture Project
Swingle Hall
Auburn University, Alabama 36849

WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

MONOSEX TILAPIA CULTURE



WATER HARVESTING/AQUACULTURE PROJECT
INTERNATIONAL CENTER FOR AQUACULTURE
AUBURN UNIVERSITY

INTRODUCTION

A major problem of pond-cultured tilapia is excessive reproduction, and subsequent stunting of fish due to overcrowding. To combat this problem a pond may be stocked with all-male fish. This technique is called monosex culture and is used when large fish are required by the market. Males are preferred because they grow almost twice as fast as females. The result is more protein and profit for the farmer.

PROCEDURE FOR MANUAL SEPARATION OF SEXES

A farmer can readily distinguish male from female tilapia with practice. When tilapia reach about 10cm in length (about 20g) the sexes can be distinguished by inspecting the genital papillae on the fish's underside. See the figure below.

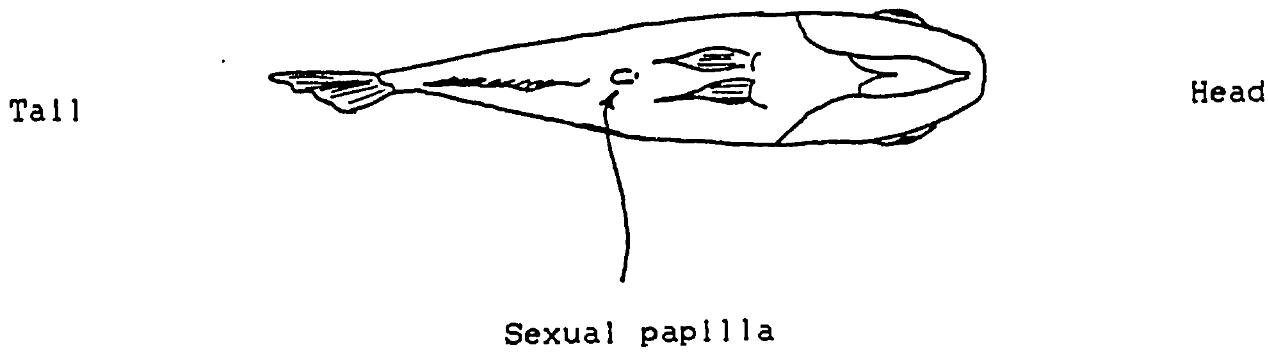


Figure 1: Ventral view of a tilapia.

Experienced workers can manually separate by sex about 2000 fish per day with an accuracy of 80 to 90%. Therefore, some reproduction will always occur. The method is tedious, stresses fish and is not 100% effective. However, production of manually selected tilapia fingerlings for grow-out to market size can be accomplished by farmers with few financial resources and little fish culture experience. The procedure is illustrated by the following figures.

Figure 2: A farmer examining and sorting tilapia by sex.

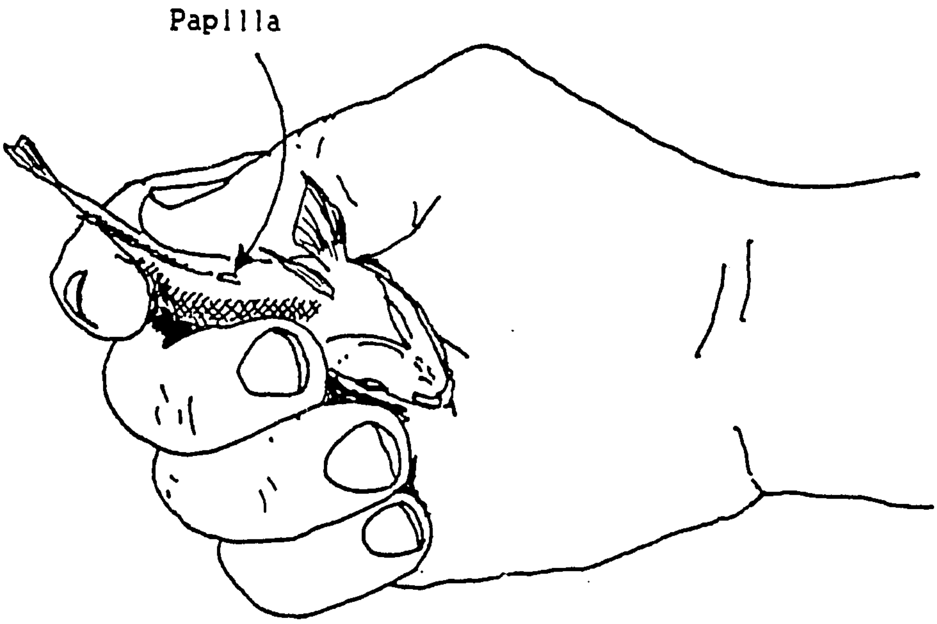


Figure 3: Small fish may be held in one hand and examined. Large fish, like that on the cover page, are held with two hands.

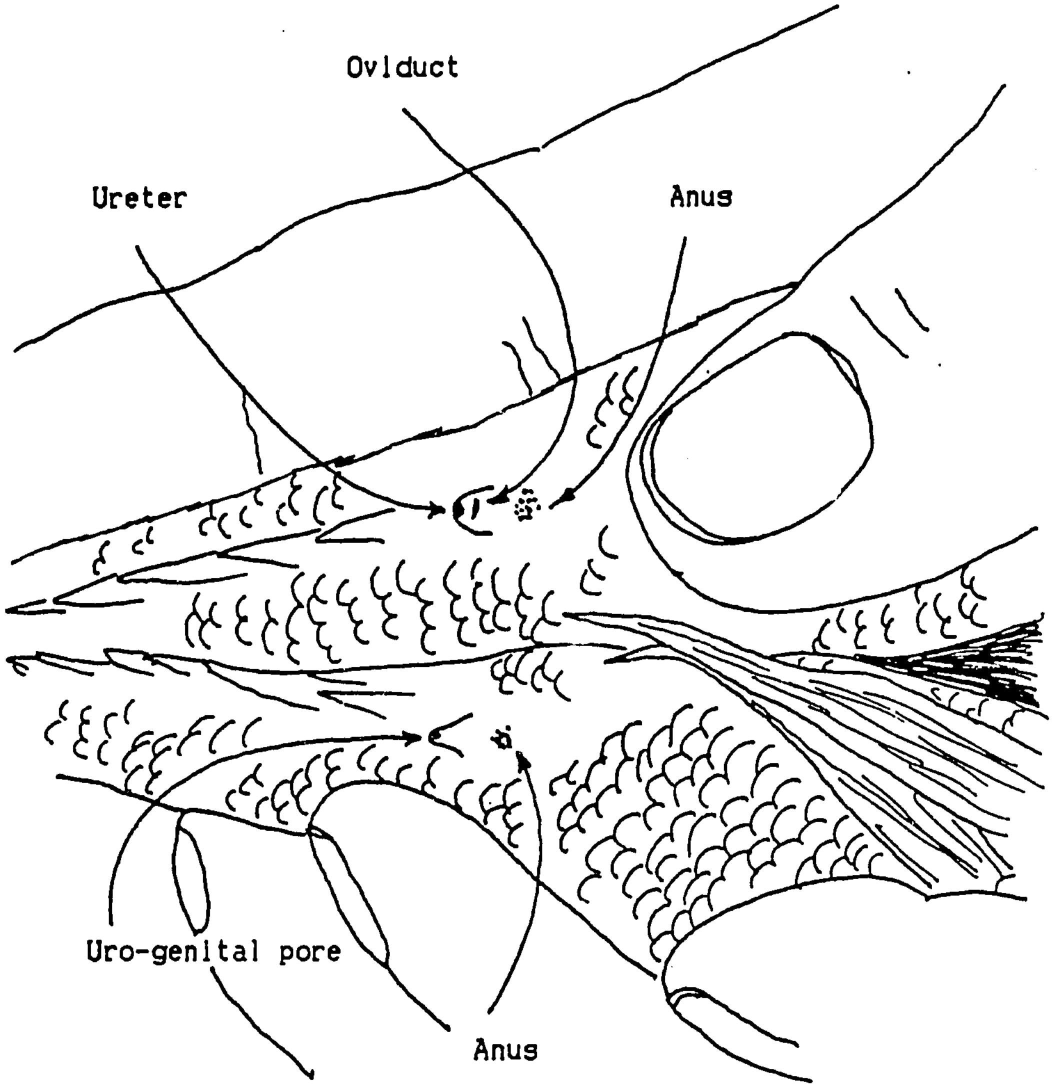


Figure 4: This close-up shows a female (top) and male (bottom) tilapia together. Note that the female has two openings in the papilla for passage of urine and eggs, while the male has only one opening for urine and sperm passage.

PROCEDURE FOR CULTURE OF MALE TILAPIA IN PONDS

1. Stock 4 to 5g tilapia fingerlings in a prepared nursery pond at a density of 10 fish per square meter of pond surface area.

2. Culture the fingerlings for about 60 days with high rates of fertilization and/or supplemental feeding until they reach 20 to 40g.

3. Slowly drain the nursery pond and partial harvest the tilapia fingerlings as the water level recedes. Separation of males and females can be made easier by applying dye (India ink, indigo, camwood, etc.) to the papilla with a soft brush or cotton swab to outline the male and female openings. Place males and females in separate containers. Do not stress the fish by overstocking the containers.

4. Manual sexing should be done early in the morning so fish will not be stressed by high water temperatures. A supply of freshwater to renew water in the holding containers will assist in keeping fish alive. Do not feed the fish 48 hours prior to sexing to reduce stress. Stop fertilizing the nursery pond one week prior to draining it.

5. Stock males in prepared growout ponds at densities of 1 to 2 fish per square meter. Culture these fish for 2 to 4 months using fertilizers and feeds. Fish whose sex can not be determined should not be stocked. Reproduction by females stocked inadvertantly can be controlled by stocking a few carnivorous fish to eat the tilapia off-spring.

6. Females may be used as brood stock, eaten, sold, fed to livestock or preserved by drying, salting or smoking.

NOTE: Male tilapia can also be stocked into cages and rice paddies.

GLOSSARY OF TERMS

monosex culture - culture of all-male fish for market.

oviduct - a tube serving as the passage for eggs from the ovary.

papilla - a small fleshy appendage which projects from the underside of a fish and through which a female passes eggs and urine and a male passes sperm and urine.

uro-genital pore - an opening for passage of urine and sperm outside the body.

Communications regarding this and other technical brochures on water harvesting and aquaculture should be addressed to:
Water Harvesting/Aquaculture Project
Swingle Hall
Auburn University, Alabama USA 36849

ATTACHMENT D. Development Stages

WHAP FIELD PROJECT DEVELOPMENT STAGES

Stage 1: Awareness of WHAP technology among PVO country missions staff and selected headquarters staff.

WHAP role: 5-day training courses at Auburn and abroad.

Short presentations at PVO international headquarters and at meetings of PVO staff.

Brief country visits and discussions with PVO mission staff.

Hosting PVO staff visits to ICA of one or more days.

PVO role: Requesting training courses, and identifying and sponsoring participants.

Informing country missions of WHAP and available technical assistance and training.

Requesting visits by WHAP technicians to country missions.

Inviting WHAP technicians to speak at headquarters and meetings of PVO staff.

Stage 2: Interest in including WHAP initiatives in country programs.

WHAP role: Visiting country programs and potential sites to: 1) assess feasibility and benefits of WHAP activities, 2) make recommendations leading to initiation of WHAP activities, 3) assist in preparation of project documentation, and 4) submit report of visit to PVO mission and internatinal headquarters.

PVO role: Inviting WHAP technician and providing scope-of-work.

Providing in-country administrative and technical support, including local travel and logistics.

Stage 3: Trial of water harvesting and aquaculture technology.

WHAP role: If WHAP activities already undertaken, assess and suggest improvements.

Assistance in designing pilot projects, trials, demonstrations, etc.

Technical backstopping for pilot project, etc., including, 1) provision of technical information, 2) technical assistance visits to monitor pilot project performance and make recommendations for improvement.

Helping PVO identify technical persons for staffing needs, and provide orientation and training, or identification of training opportunities as needed.

Identification of in-country linkages for potential technical support of PVO.

PVO role: Management of pilot project, etc. and provision of necessary resources for its conduct, with the exception of technical assistance and training.

Designation of existing or new staff member to have technical responsibility for water harvesting and aquaculture activities, and allocation of resources for training this person as needed.

Administration and logistical support for WHAP technician during visit.

Evaluation of pilot project performance.

Stage 4: Extension of Water Harvesting/Aquaculture technology to intended beneficiaries of PVO field projects.

WHAP role: Brief visits to projects as requested to review progress, provide technical assistance for special problems and provide brief, special-purpose training.

Technical information backstopping by correspondence.

PVO role: Program direction and support provided by fully capable PVO staff for outreach to intended beneficiaries in water harvesting and aquaculture.

PVO staff providing routine technical assistance and training for farmers and new staff in water harvesting and aquaculture.

New water harvesting/aquaculture field projects initiated by PVO staff with no external technical assistance except for special purposes.

Evaluation of field project performance.