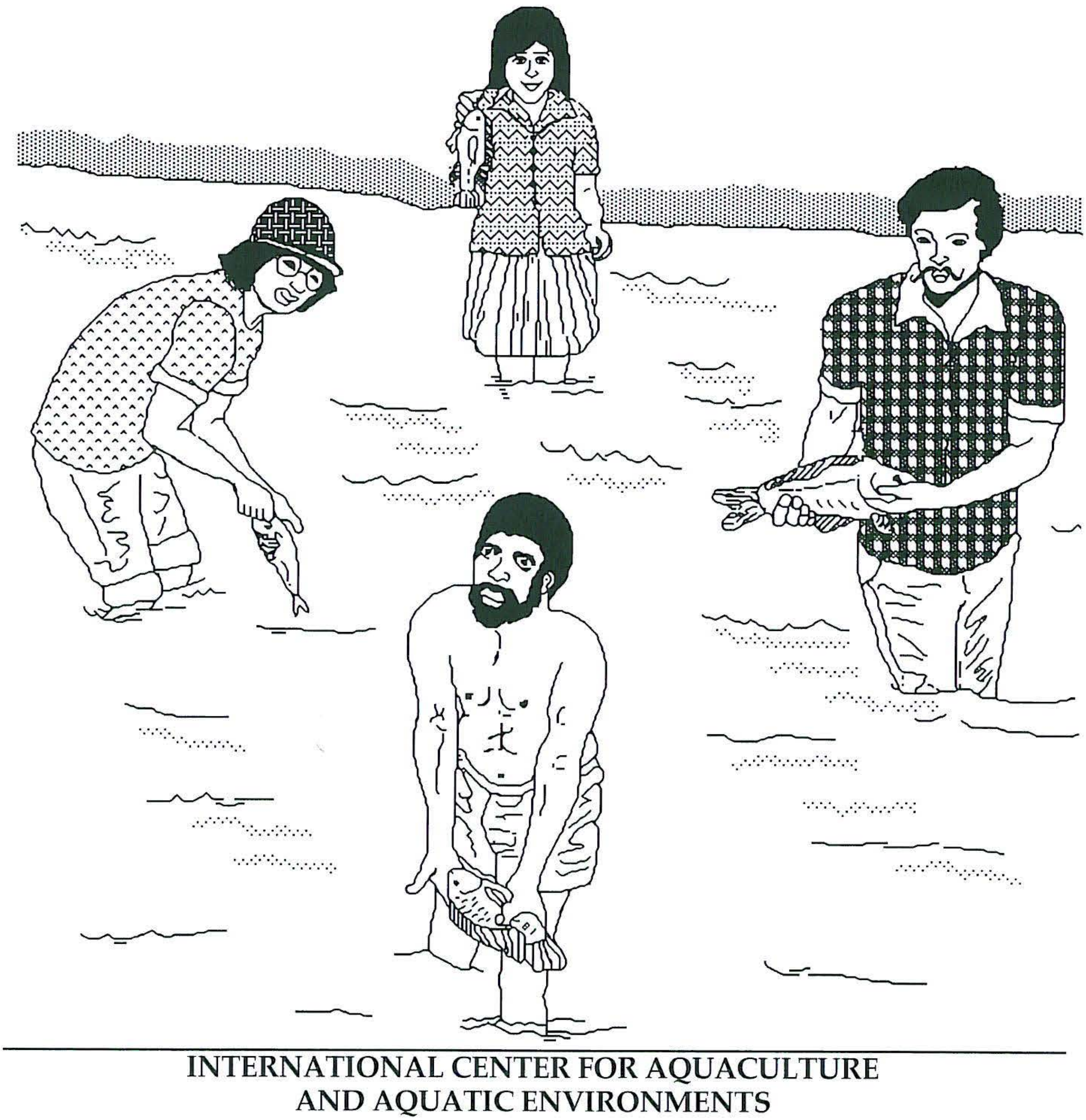
WATER HARVESTING AND AQUACULTURE
FOR RURAL DEVELOPMENT

INTRODUCTION TO AQUACULTURE



INTERNATIONAL CENTER FOR AQUACULTURE
AND AQUATIC ENVIRONMENTS
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.

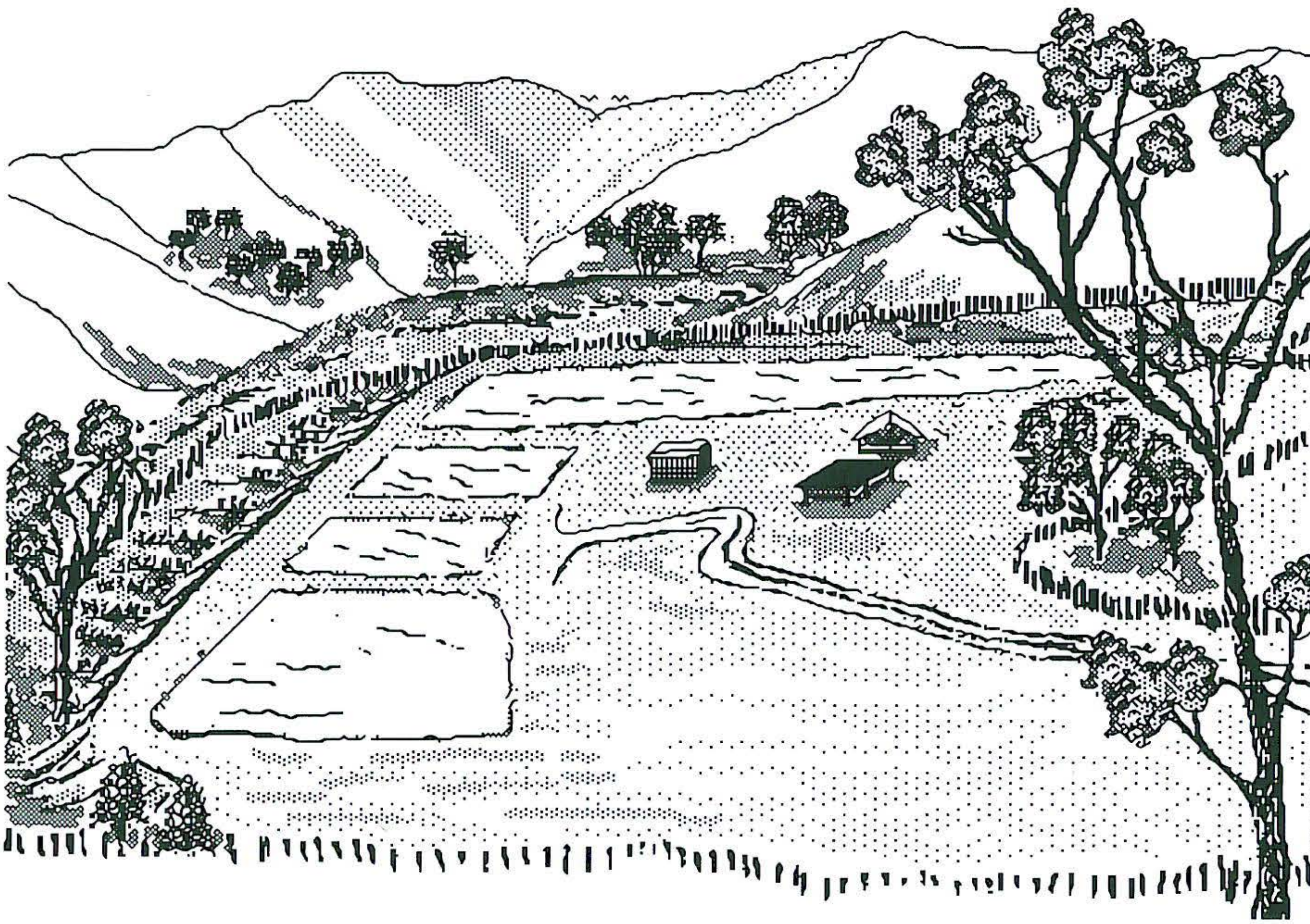


Figure 2: Small valleys often have excellent potential for pond construction.

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 2,500 kg 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 meats. 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 in Calories per 100 g of Edible Tissue
Channel Catfish	81	5	112
Beef	51	34	323
Pork	37	42	402
Chicken	65	3	84

5) 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.

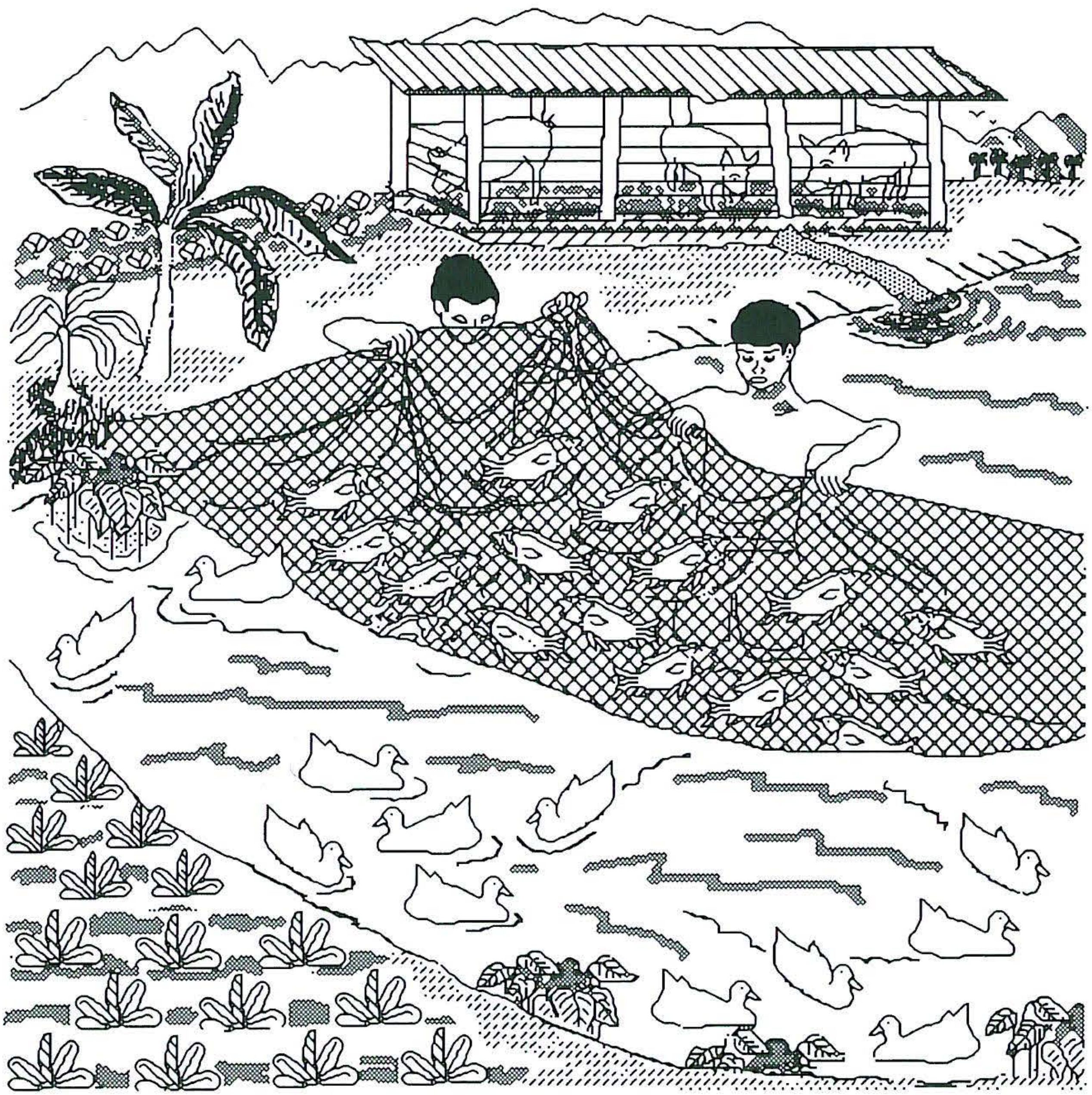


Figure 3: Aquaculture can be integrated with the production of livestock, fruits, vegetables and other water uses.

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.

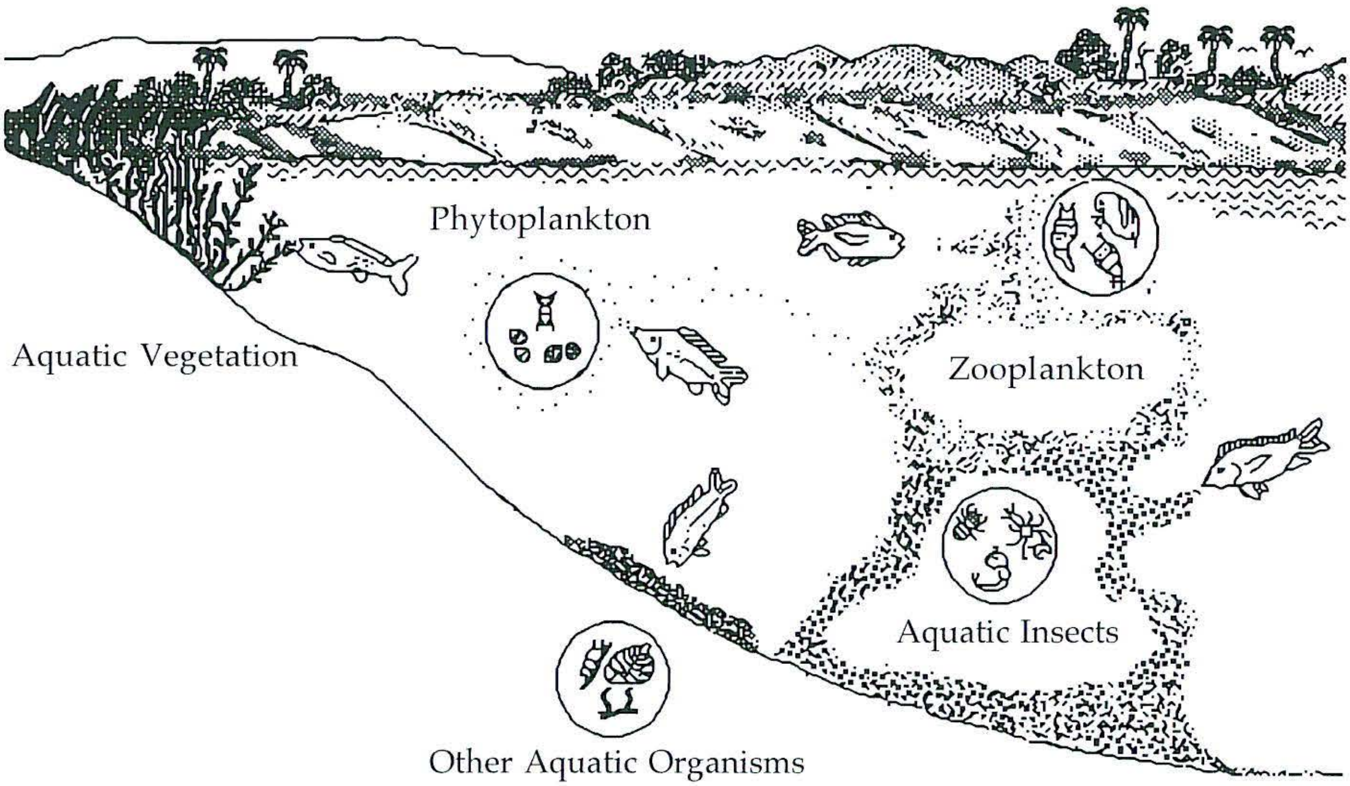


Figure 4: Polyculture utilizes more of the available food and produces a variety of fish for market.

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

<u>aquaculture</u> - raising of animals or plants in aquatic environments under controlled conditions.

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

extensive aquaculture - raising aquatic animals or plants under conditions 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.

Funding for this series was provided by the United States Agency for International Development. Communications regarding this and other technical brochures on water harvesting and aquaculture should be sent to:

Alex Bocek, Editor
International Center for Aquaculture and Aquatic Environments
Swingle Hall
Auburn University, Alabama 36849-5419 USA

Suzanne Gray, Illustrator