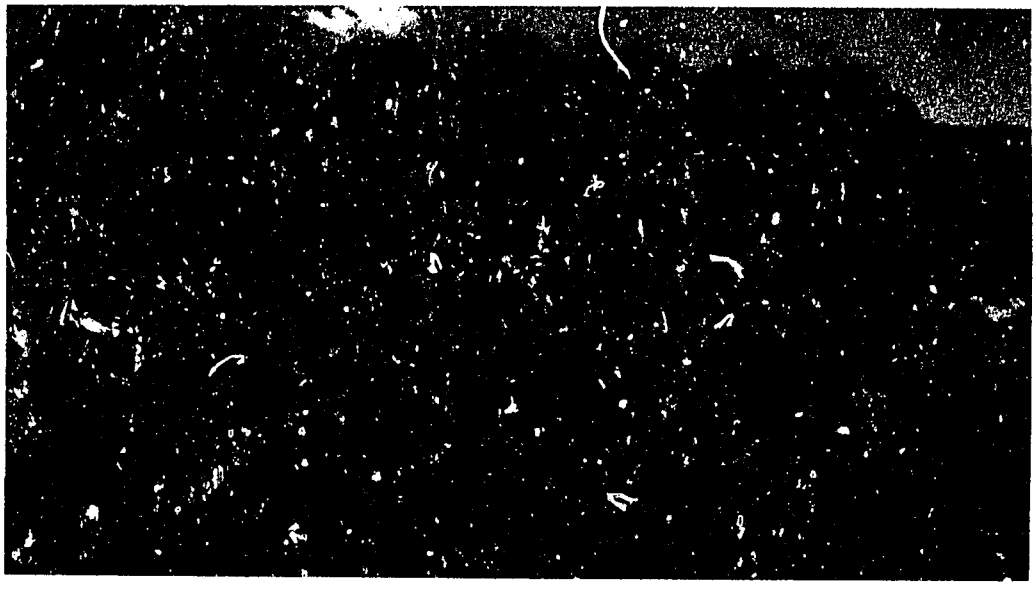
Aquaculture Research and Development in Rural Africa

Summary Report on the ICLARM-GTZ/Malaŵi Fisheries Department/University of Malaŵi Conference Zomba, Malaŵi 2-6 April 1990

EDITED BY
Barry A. Costa-Pierce
Clive Lightfoot
Kenneth Ruddle
Roger S.V. Pullin



DEUTSCHE GESELLSCHAFT FÜR TECHNISCHE ZUSAMMENARBEIT (GTZ), GmbH
Eschborn, Federal Republic of Germany

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
Manila, Philippines

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Cover: *A family fishpond on the lowlands below the Zomba plateau, southern Malaŵi.* Photo by B.A. Costa-Pierce.

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INTRODUCTION

Dr. Roger S.V. Pullin
Dr. Barry A. Costa-Pierce

Aquaculture development in Africa has lagged far behind that in other developing regions while human needs for additional protein sources are just as urgent. To date about one hundred million dollars has been consumed in over 500 aquaculture projects on the continent and aquaculture production in Africa is still insignificant. Even where aquaculture has shown initial signs of success, developments have not been sustainable without external subsidies. Aquaculture in Africa has unfortunate, checkered history.

This volume reports results from an international conference convened in Zomba, Malaŵi, that reviewed progress of the first three years of ICLARM collaborative research with the Malaŵi Department of Fisheries and the University of Malaŵi, financed by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), GmbH. Participants and working groups attempted to identify why the progress of aquaculture development in rural Africa has been slow, with Malaŵi as a case study, and suggested fresh approaches to aquaculture development for the consideration of policymakers. It was decided to publish extended abstracts so that as many presenters as possible could submit their results for full publication in the international peer-reviewed literature.

The conference found that African aquaculture is undergoing a revival in many countries, including Malaŵi, but is still a foreign practice to the vast majority of rural smallholder farmers who could benefit. Participants reported that aquaculture in Africa has developed largely using technologies and species from elsewhere, then by adapting these to African settings. This developmental scenario has been unfortunate, since governments and donors have largely followed recommendations of external consultants to use imported species or systems known to the consultants, rather than to devote more time and money towards investigations needed to evolve indigenous technologies based upon native species and the available resources of the African farmer. Exotic species and imported systems have met with little success, and have tended to suppress interest in native species of possibly equal or greater value.

Previous aquaculture conference have identified the lack of knowledge of sociocultural and household economic factors as major constraints to the sustainable development of aquaculture in rural Africa. While this conference recognized these constraints, it was also realized that the lack of indigenous aquaculture technologies appropriate to rural farmers and their farming ecosystems were also major problems. Extensionists must have viable, appropriate technologies to extend.

Participants identified the need for strong on-station biotechnical research programs linked to on-farm farming systems research and extension efforts. On-station research should focus on generation of appropriate technologies using native species and systems utilizing on-farm resources; on-farm extension efforts should investigate the resource base and household economic situation of the farmer, as well as the farmer's agenda before suggesting systems and species.

Africa is unique in having many of the world's most important fish genetic resources that are underappreciated and overexploited. Africa's farmers are remarkable survivors with important traditional farming knowledge that is rarely utilized. By designing aquaculture farming systems based upon local resources, we are hopeful that new indigenous aquaculture technologies for Africa will evolve. These will likely be based on native species, in polycultures

fed on local, on-farm and cheap off-farm resources. We cannot overemphasize that generation of indigenous aquaculture technologies for Africa using these principles is in its infancy. Strong financial support for aquaculture research and related farming systems research and extension are recommended to facilitate the evolution of African aquaculture and make it a widely known and attractive option for the rural farmer.

The complexity of the practical issues to be faced is indicated by the range of papers summarized here and in a companion volume published by ICLARM and GTZ.* The prize for addressing these issues is sustainable rural development, incorporating aquaculture. We trust that the information presented here will be of some assistance towards that end.

*ICLARM and GTZ. 1991. The context of small-scale integrated agriculture-aquaculture systems in Africa: a case study of Malaŵi. ICLARM Stud. Rev. 18, 302 p.

SESSION I
OPENING CEREMONIES

WELCOMING ADDRESS

Dr. Roger S.V. Pullin
Director
Aquaculture Program
International Center for Living Aquatic Resources Management

Honorable Minister of Local Government, distinguished Principal Secretary to the Ministry of Forestry and Natural Resources, distinguished Vice Chancellor of the University of Malaŵi, distinguished Principal of Chancellor College, Secretary of the National Research Council, Chief Fisheries Officer of the Fisheries Department, high officials of the municipality of Zomba and of regional and international organizations, distinguished guests from African, European and North American countries, fellow scientists and colleagues, ladies and gentlemen, friends:

On behalf of ICLARM and GTZ, welcome to this important and timely conference. It is my great pleasure and privilege to welcome you first on behalf of ICLARM. ICLARM's Acting Director General, Jay Maclean, has asked me to extend to all his good wishes for the success of this conference and his apologies that heavy duties in Manila have prevented his attendance. I must add a note of sadness here that last year, ICLARM's much-loved and respected Director General, Dr. Ian R. Smith, passed away. Ian's vision had helped the organization of much collaborative aquaculture research in Malaŵi and other countries. He would have been very proud to have participated in this conference and to have seen the results of well-focused research that will spur aquaculture development.

I also welcome you all on behalf of GTZ. Dr. Martin Bilio sends his sincere apologies for being unable to attend this conference. GTZ has long been a major supporter of aquaculture research and development activities targetted on the small farmers and disadvantaged peoples of Africa. GTZ is undertaking two major projects in Malaŵi and many others throughout the developing world. It is a pleasure to see here today several of Dr. Bilio's colleagues from Europe and representatives from GTZ projects in Africa.

This conference has a number of very important tasks: to hear about and discuss recent research results; to learn from each other's successes and failures; and to help chart the course for future aquaculture research and development both in Malaŵi and on a wider front in subSaharan Africa. I am confident that the conference will succeed in these tasks, because of the tremendous talents and goodwill that you, the participants, bring together.

I also wish to pay tribute to the leadership of His Excellency, the Life President, for furthering research for sustainable development and the stability that is vital for successful results.

Again, I welcome you all on behalf of ICLARM and GTZ. I thank Chancellor College for generously hosting the conference and our many friends in the University of Malaŵi and the Fisheries Department for their vision and hard work in making this conference a reality. I wish everyone a pleasant and productive stay in this beautiful setting. Thank you all for this opportunity to speak on behalf of ICLARM and GTZ.

OPENING SPEECH

Hon. E.C.I. Bwanali
Minister of Local Government
Lilongwe, Malaŵi

The Chairman for the Seminar, the District Malaŵi Congress Party Chairman, the Deputy Mayor of the Municipality of Zomba, the Vice Chancellor, the Principal of Chancellor College, the Assistant District Commissioner for Zomba, the Principal Secretary for Forestry and Natural Resources, Distinguished Delegates, Invited Guests, Ladies and Gentlemen:

First and foremost, I feel greatly honored by His Excellency The Life President, Ngwazi Dr. H. Kamuzu Banda, who has given me this privilege to perform this dual function of inaugurating the research facilities at Domasi and the opening of the fish farming seminar. It is indeed a great honor and privilege that this opportunity has been bestowed on me and I therefore wish to thank His Excellency the Life President very sincerely and wholeheartedly.

In behalf of the Government and the People of Malaŵi, and in my own behalf, I wish to welcome you all to Malaŵi and in particular to this seminar. I understand that some of you have travelled from as far afield as the Philippines, Japan, Europe, North America as well as West Africa. We are delighted to have you here as these meetings do not only serve to foster information exchange but more so to strengthen our bonds of friendship in our joint efforts to achieve a better future for mankind. You are all very welcome to Malaŵi, and I hope, in spite of your tight schedule, you will have an opportunity of seeing something of our beautiful country, "The Warm Heart of Africa".

Malaŵi wishes to thank the International Center for Living Aquatic Resources Management (ICLARM) for establishing a regional office for Africa in Malaŵi through which it has been possible to hold this important seminar.

Mr. Chairman, I recall that the International Center for Living Aquatic Resources Management held its first workshop in Malaŵi in 1987. That workshop was convened to create awareness amongst aquaculture scientists of this region of the work being done in Southeast Asia, their achievements and explore what developments could be adopted to our situation in Malaŵi and the African Region. I am informed that a lot of interest was generated from the deliberations which led to the formulation of a series of research projects aimed at testing how applicable some of the Southeast Asian concepts are to our African situation with particular focus to the needs of the small-scale rural farmer. Mr. Chairman, such studies, I am informed, have been going on for three years and this seminar will review and discuss the research results, their implications and their relevance to conditions prevailing in the African Region.

Let me state here Mr. Chairman that Malaŵi views this conference and its objectives with great interest. In Malaŵi, fish plays a very important role in the diet of the people. Over 70,000 tonnes of fish are landed from our natural fishing waters, mainly Lake Malaŵi, Lake Malombe, Lake Chilwa, Lake Chiuta, the Shire River and various water systems. At this level of production fish constitute an average consumption of about 10 kg/capita/year, contributing about 70% of the animal protein portion of the diet.

Fish production has grown tremendously after independence and, as at present, production is of the order of 70,000 tonnes per year. This is five times the production recorded during the pre-independence period. This growth reflects government's active role in developing fisheries. However, in recent years, production from our natural waters has been constant suggesting that catch is approaching the maximum sustainable yields of the resources. If these signals are indeed correct there is a dire need to look into alternative options of fish production growth. Already there is a declining trend in fish supply as a result of rapid population growth. Therefore, aquaculture development offers a possible option of addressing the situation.

Aquaculture development in this subregion of Africa is still in its infancy. Fish farming activities till now have been either at subsistence level or pilot stages. Past attempts to rationalize aquaculture developmental programs have mostly been in the nature of exploratory programs and feasibility studies. In general, the present contribution of aquaculture production in most countries of Africa is very limited. This is so despite the fact that surveys have shown that aquaculture in the subregion is technically and economically viable because of the favorable climate, soil conditions and water supply availability. However, in spite of this potential, the contribution of aquaculture to present production in Africa is only one per cent but this could be increased. In the light of our increasing populations, requiring more food, such a situation should not be allowed to continue. All regional resources must therefore be mobilized in order to overcome obstacles which are slowing down aquaculture development in our continent.

Mr. Chairman, I do not wish to pose as an expert in aquaculture, but let me share with your experts attending this seminar some problems slowing down aquaculture development. Some of these are:

(a) inadequate infrastructure and research facilities;
(b) lack of trained personnel;
(c) communication gap between research scientists and the public;
(d) lack of strong research base and institutional support for aquaculture; and
(e) concentration on biological factors of development with insufficient attention to economic, social and cultural factors.

This is by no means a complete list of the problems but I would urge you to consider these in your deliberations.

The focus of your deliberations on development of our aquaculture in rural settings is commendable. In most countries, a large proportion of population resides in rural areas, and it is every government's wish to strengthen rural economies in order to promote and increase self sufficiency. In Malaŵi about 90% of the population live in rural areas. Some of the available land is marginal and therefore unsuitable for intensive crop production. Some of this land has plenty of water which could thus be utilized for aquaculture. It is the policy of the government of Malaŵi that economic activities which rapidly transform the rural economies for the better should receive priority. The Ministry of Forestry and Natural Resources will therefore support recommendations from this workshop that will promote aquaculture technologies appropriate for our rural populations.

Mr. Chairman, earlier on today I had the privilege of cutting a ribbon at Domasi, heralding the completion of research facilities carried out through the collaboration of the Malaŵi Government, ICLARM and GTZ. These facilities include a new office, library and laboratory complex, 69 new research ponds and 114 new experimental tanks. These developments have upgraded the station to become one of the leading aquaculture research centers in the region. I wish to thank ICLARM for selecting Malaŵi for its regional activities.

Special thanks, Mr. Chairman, go to GTZ and the German Government for their support to ICLARM and to this country in general and in particular in the fisheries sector. Today Mr. Chairman, we are witnessing yet another of such gestures. Without their assistance, both the development of the research center at Domasi and this workshop would not have been possible. This is very commendable and we are indeed very grateful.

Finally, but not least, I wish to urge all participants to review seriously the concepts which will be put forward during this meeting. Too often research becomes too academic and therefore may fail to address the practical applications of its results to the target group - in this case the rural fish farmer. However, I have every hope that your recommendations and future research needs which will emerge from the meeting will be geared to solving present constraints at the village farmer level. I wish you all very successful deliberations.

Mr. Chairman, once again, I welcome you all, especially our visitors to Malaŵi. Although your program would appear to be very tight, it is my sincere hope that you will have an opportunity to see more of Malaŵi, her people and attractive natural resources.

With these few remarks, Mr. Chairman, The District Malaŵi Congress Party Chairman, The District Malaŵi Congress Party, Chairman of the Women's League, The District Malaŵi Congress Party Chairman of the Youth League, The German Ambassador, The Principal of Chancellor College, The District Commissioner, The GTZ Representative, Distinguished Delegates, Ladies and Gentlemen, I now declare the conference officially open.

Thank you.

SESSION II
BACKGROUND SOCIAL, CULTURAL, BIOECONOMIC AND TECHNICAL BASIS

Summary of Presentations
Dr. Kenneth Ruddle

Most papers in this session focused on the socioeconomic and cultural context in which small-scale fish farming is developing in the Central and Southern Regions of Malaŵi. The exceptions were on the history of fish farming in the Northern Region, and on small-scale fish farming in the west and northwest provinces of Cameroon.

The socioeconomic and cultural context within which fish farming is developing in Malaŵi, which was deemed representative of much of Africa, can be divided for convenience into factors external to the practising household - a) government issues, and b) those within the local community - and those within the household. Among the former, governmental issues include principally fish farming development policy, funding, extension (education and training) and physical infrastructure and equipment; and local community issues include mainly: social organization, kinship, access to resources and use rights, and access to information. The principal intra-household factors addressed were decisionmaking regarding the adoption of fish farming and its sustainment, household economics, the availability of suitable land, capital and labor, marketing and entrepreneurship.

External Issues

GOVERNMENTAL

Despite an official perception that small-scale fish farming could contribute significantly to improving both household budgets and nutritional status, and particularly if a policy was adopted to promote it via well-defined nutritional objectives as an integral part of agricultural development programs, it has been accorded low priority in policy in most countries. Hence, it is usually seriously underfunded and not well-supported by a comprehensive extension service. This has been a major constraint throughout Malaŵi, apart from the immediate vicinity of the Domasi Experimental Fish Farm. In particular, extension (including on-station research, farmer trials, education and training) requires improvement to explain better the potential household nutritional role of fish farming. The physical infrastructure in support of fish farming is scant at best, as is equipment, especially low-cost harvesting tools, which is a major constraint to the development of small-scale fish farming in Malaŵi.

LOCAL COMMUNITY

The social organization and accepted norms of behavior within the local rural community can be a major constraint on the development of fish farming. Kinship systems, which in large part govern the intimately related question of access to land and associated use rights, and which

can be especially complex in societies organized by matrilineal descent, can be a major constraint to the ability or willingness of households to adopt a major innovation that is recognized as a long-term investment, such as fish farming.

Intra-Household

Farm household decisionmaking regarding the adoption of fish farming as an innovation was a major consideration. The availability of suitable land, labor, capital and information are major considerations in decisionmaking regarding the adoption of fish farming and its sustainment. The social environment in the larger community is also a major consideration, since on one hand, other households could provide reciprocally supplementary resources, like labor or pond inputs, or on the other, act as a constraint, either by preventing directly innovative behavior or, indirectly, by being a source of burdensome obligations that make the opportunity costs of adoption unacceptably high.

For most households in Malaŵi, small-scale fish farming is a relatively low real and opportunity cost activity. In southern Malaŵi, total pond construction costs do not exceed MK150 (US$1 = MK2.60 as of February 1990), average investment in equipment does not exceed MK100 and annual working capital requirements are around MK25 or less.

Fish farmers in Malaŵi are by definition entrepreneurial. This important personality trait is also demonstrated by those small-scale, commercially-oriented fish farmers who are developing new markets, innovative marketing techniques and new products.

The Evolution of Fish Farming in Malaŵi

O.J.M. KALINGA, *Department of History, Chancellor College, University of Malaŵi, P.O. Box 280, Zomba, Malaŵi*
(Present address: National University of Lesotho, P.O. Box 180, Roma, Lesotho)

Abstract

Oral history field research, to interview former fish farmers and practising fish farmers, and documentary research in the National Archives at Zomba, were combined to trace the history of fish farming in northern Malaŵi until the early 1960s. Reliable and consistent records are not available for later years. Government policy toward the development of fish farming is also examined.

Although fish farming in Malaŵi began technically in 1908, when brown and rainbow trout were introduced into the Mulunguzi stream on the Zomba Plateau of the now Southern Region, this was only to cater to the recreational needs of the colonists. This activity in no way involved Malaŵians, except as general laborers.

Fish farming by small-scale farmers did not begin in Malaŵi until after the Second World War. However, its conceptual origins may be traced to the League of Nations' publication, the *Report on the Psychological Basis of Nutrition* (1935), which prompted the British Colonial Office to admonish all governors to improve the food supply and nutritional situation in their regions.

As a result, in January 1939, a fisheries survey was commenced, in conjunction with the on-going survey of nutrition. This survey was undertaken by Dr. C.K. Ricardo Bertram (University of Cambridge), Dr. E. Trewavas (British Museum), and Mr. John H. Borley (Nyasaland Colonial Service). Regarding fish farming, the report of the Fisheries Survey *(Report on Fish and Fisheries of Lake Nyasa)* recommended that basic research be conducted on indigenous species from Lake Malaŵi, to ascertain those most suitable for large-scale fish farming. It was recommended that experiments be conducted on three species of tilapia (*Oreochromis shiranus, O. melanopleura* and *O. sparrmani*), *Barbus johnstoni, Labeo mesops* and *Clarias mellandi*. Should these fish prove unsuitable for farming, it was recommended that fast-growing carps be introduced from China, India and Southeast Asia.

Nothing was done to follow-up these recommendations until 1950, with the appointment of a Trout Warden in the fisheries section of the Nyasaland Department of Game, Fish and Tsetse Control. He was stationed at Nchenachena, in the Rumphi District of the Northern Region, and charged mainly with stocking trout in local waters, especially on the Nyika Plateau, which was being developed as a tourist destination. However, this also marked the beginning of serious attempts to extend fish farming to small-scale farmers, with trials using tilapia.

During the period 1954-59, small-scale fish farming developed in the Henga Valley and the adjoining region between Nchenachena and the Livingstonia Mission, in Chikwina-Kavuni, in Nhkata Bay District, and in the Tipwiri valley, close to the Nchenachena trout hatchery. By 1958, six fish farming training courses were held, attended by 42 students, and 74 farmers had constructed 52 ponds, with a combined area of 12.4 ha, of which 5.92 ha had been stocked. In 1958, these ponds yielded 1,000 kg of fish (excluding the Chikwina-Kavuni area). Although it was intended from 1959 onwards to focus on upgrading the operations of existing fish farmers, rather than recruiting new entrants, efforts ceased with the withdrawal of the Trout Warden as a consequence of political disturbances. The Nchenachena station was placed on a "care and maintenance basis" until 1961, and the Trout Warden relocated to Domasi, in the Southern Region, to develop activities there. Nevertheless, by the end of 1961, 141 ponds had been constructed in the Northern Region. In 1962-63 fish farming was extended to Misuku and Chisenga, in Chitipa District.

Despite the official perception that fish farming could contribute significantly to improved nutritional levels, there is no evidence that this was ever systematically acted on. Small-scale fish farming was accorded low priority, largely because it was viewed as an uneconomic undertaking in that it contributed no revenue to the central exchequer. Consequently, during the period under study, the activity was seriously underfunded, and starved of extension personnel, equipment and transportation.

The Status of Aquaculture Research and Development in Malaŵi

O.V. MSISKA, *Domasi Experimental Fish Farm, Malaŵi Fisheries Department, P.O. Box 44, Domasi, Zomba, Malaŵi (Present address: Department of Research and Environmental Affairs, P.O. Box 30745, Lilongwe, Malaŵi)*

Abstract

The origins of aquaculture in Malaŵi may be traced to the late 1940s and early 1950s following recommendations of the 1943 Nyasaland Nutrition Survey. However, interest in rearing trout for sport began as early as 1908. The Nutrition Survey was a landmark in fisheries development in general and specifically in aquaculture because it emphasized the role of fish in dietary intake, and clearly showed differences in fish consumption patterns which existed between lakeshore and more inland dwelling families. The practice by fishermen of Lake Chilwa of holding fish in enclosures called "galage" or "ngalanga" has been likened to pen culture. If this traditional practice is a rudimentary form of aquaculture, then the origins may be traced further back.

Until recently, abundant fish have been caught in lakes, swamps and rivers for Malaŵi's needs. As a result, the need to engage in large-scale fish farming has been nonexistent. The failure of fish production in natural water bodies to keep pace with the population increase and maintain high consumption patterns inherent in traditional diets has necessitated that serious consideration be given to fish farming in current and future fisheries development. Compared to livestock producers who have hundreds of years of experience to draw from and several generations of families in the business, fish farmers in Malaŵi may be considered to be inexperienced. The need for research to support the industry is great. Previous research has emphasized biological studies using experimental units of various sizes ranging from 5 m^2 to 1.0 ha, oftentimes without adequate replication. Many fish species have been tried. Although some of the most useful results are reviewed in this report, lack of appropriate institutional support, finance and staff have been the major constraints.

The Status of Fish Farming in Zomba District, Malaŵi

R.P. NOBLE, *Department of Biology, University of Malaŵi, P.O. Box 280, Zomba, Malaŵi*

S. CHIMATIRO, *ICLARM-GTZ Africa Aquaculture Project, P.O. Box 229, Zomba, Malaŵi*

Abstract

Smallholder aquaculture is expanding rapidly in the Zomba District of Malaŵi. In order to plan effectively to encourage and help those who have already embarked in this venture, it is necessary to know the growth and characteristics of the fish farming community.

A survey was carried out from July 1988 to January 1989 in the district: 229 ponds belonging to 131 farmers were measured and mapped. Information was collected on pond age, types of fish being reared, pond inputs, fingerling production, and crop and livestock holdings. Growth characteristics of fish populations in 12 ponds and harvests from 20 ponds were measured.

Fifty per cent of ponds were built between 1950 and 1983, the remainder between 1983 and 1989. Mean pond size was 366 m^2 (median = 196) and a mean area of 540 m^2 (median = 210) of land was used for ponds on each farm. Fourteen farms (mean size = 1.57 ha) had only 0.5% (0.07 ha) as pond area.

Ten per cent of farmers practised monoculture of *Oreochromis shiranus* and 15% *Tilapia rendalli*. The remainder had various combinations such as *O. shiranus/T. rendalli* (51%), *O. shiranus/T. rendalli/ Cyprinus carpio* (21%) and other types (3%). The Domasi Experimental Fish Farm provided 55% of the farmers with seed and 40% produced their own.

Weight-length relationships for *O. shiranus* always had a slope coefficient below 3.0, whereas *T. rendalli* and *Cyprinus carpio* were 3.0 or above, suggesting that *O. shiranus* may be food-limited. Both cichlid species demonstrated poor growth. Mean weights for the batch harvests were 14 g and 20 g, respectively, and for fish being sold, 20 g and 27 g, respectively. *C. carpio* achieved average weights of 224 g (for batch harvests) and 300 g (for fish sold). Harvests averaged 525 kg/ha/year *(O. shiranus)*, 1[illegible]0 kg/ha/year *(T. rendalli)* and 284 kg/ha/year *(C. carpio)*. The average harvest per farm was 18 kg, 6 kg and 11 kg, respectively. Mean total harvests from polyculture of three species was 974 kg/ha/year (range 241-3,637). The mean time between harvests was just over 330 days.

Harvest revenues varied from MK10 to 165 (mean = MK65) [MK (Malaŵi Kwacha) 2.6 = US$1 in 1990]. *O. shiranus, T. rendalli* and *C. carpio* had average sale prices of MK3.88, MK3.17 and MK3.36/kg, respectively.

In Zomba, aquaculture is clearly increasing rapidly and will stretch the current extension services. Farmers are unable to produce large crops of fish from their ponds because food and fertilizer inputs are too low. There is an urgent need for developing low-cost techniques for improving their harvests.

An Economic Analysis of Fish Farming in Malaŵi

B.F. KANDOOLE and M.M. MKWEZALAMBA, *Department of Economics, Chancellor College, University of Malaŵi, P.O. Box 280, Zomba, Malaŵi*

Abstract

A structured questionnaire was administered to 559 small-scale farm households in Zomba (387 households) and Mwanza (172 households) districts of the Southern Region, Malaŵi, to elucidate the household economics of fish farming.

Most fish farmers in the study areas are male, subsistence farmers, with little education, married, and between the ages of 20 and 50 years. They are poor, either with little or no access to credit. Since most ponds are small, they do not produce commercial quantities of fish. Some farmers sell fish, but no data were obtained on this aspect of the household economy.

Pond construction costs are modest, and generally do not exceed MK100 [MK (Malaŵi Kwacha) 2.6 = US$1 in 1990]. Hiring of labor for pond construction is uncommon, and generally does not cost more than MK50. Average expenditures on equipment are under MK100. Working capital devoted to fish farming is usually MK25 or less, and is spent on maize bran for feed, fingerlings, equipment and labor.

Farm Household Decisionmaking with Reference to Fish Farming in Zomba District, Malaŵi

G.A. BANDA, *Centre for Social Research, University of Malaŵi, P.O. Box 280, Zomba, Malaŵi*

Abstract

This study focused on the processes by which farm households in Zomba District, in the Southern Region of Malaŵi, decided to adopt the practice of fish farming, under the constraints of a matrilineal system of social organization. Data were collected through a questionnaire interview of 81 farm

households. These households consisted of 38 whose fishponds were in operation, 13 of former fish farmers who had ceased operations for various reasons, and 30 who had never attempted fish farming. These survey data were supplemented by participant-observation and open-ended discussions with 21 households, selected from those surveyed, and concentrated around the Chinseu Fish Farm Station, in Zomba West, Malosa, in the north and Chiphoola in the southeast.

The results demonstrate that farm household decisionmaking with respect to fish farming involved consideration of four sets of factors: (1) an assessment of resources - land, labor and water supply - and capital available to the household; (2) the evaluation of anticipated risks compared with the likely benefits of adopting a new farming activity; (3) evaluation of the social environment as a source of additional resources, as a constraint on adopting an innovation, and as a source of obligations resulting from adoption; and (4) information about fish farming and other innovations available to the household, to permit an assessment of the opportunity costs involved in adopting an activity.

In all households, whether or not engaged in fish farming, decisions were made by the household members alone. However, decisions were arrived at after considerable deliberation within the household, and after much consultation with neighboring farmers and with the extension workers.

Wives had an important role in the decisionmaking process that was not a result of the matrilineal social organization. Women often initiated and continued to shape ideas, which usually formed the basis for household decisionmaking. Socially, however, the final decision was often attributed to the male as head of the household. But where the activity involved generated income, the male tended to have a stronger say on decisionmaking mainly in relation to the expenditure of funds.

Entrepreneurship in Integrated Small-Scale Fish Farming

G.G. Mills, *Department of Sociology, Chancellor College, University of Malaŵi, P.O. Box 280, Zomba, Malaŵi*

Abstract

A field survey to investigate entrepreneurship in fish culture was conducted among 41 established and 18 potential small-scale farmers in Zomba District, Malaŵi, in 1988. Of the 41 farms with ponds, 25 were commercially oriented, but with a subsistence component, whereas the remainder were basically subsistence operations complemented by exchange of products.

Among both fish farmers and potential fish farmers, the prime motive for operating a fishpond was to generate cash income (and where not prime, it ranked second); social status ranked second, and exchange third. Enhanced household nutrition had consistently low priority, ranking mostly fourth.

Entrepreneurship in fish farming in Zomba District was demonstrated by the decision to construct and operate a pond, and by marketing practices.

In addition to the constraints of land, labor and capital, increased entrepreneurship in fish farming was constrained by farmer perceptions, since the knowledge and skills required to construct and manage a fishpond were viewed as complex, risky and involving unwanted dealings with "the Government", that might result in an increased tax liability. Household resource allocation decisions may also be a constraint, since 31% of fish farmers reported disagreements with their wives over the allocation of *madeya* (maize bran) between household subsistence needs and pond inputs, and 5% reported that their wives had refused to permit the use of *madeya* as a pond input.

Another aspect of entrepreneurship was that knowledge about pond construction and management was not given freely, except to family and close friends. Rather, it was perceived as being difficult to acquire, and thus an extremely valuable asset that enhanced social status within the community. As such it was a commodity, the giving of which required some form of recompense.

Approximately 24% of commercially-oriented fish farmers have attempted to develop markets and marketing techniques other than the conventional pondside/house fresh fish sales, selling at bus stations, schools and hospitals.

Aquaculture Innovation: Its Diffusion and Adoption in Central Malaŵi

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Abstract

A survey of 180 smallholder farmers was undertaken to study mechanisms of diffusion and adoption of aquaculture innovations in Central Malaŵi.

Pond ownership was used in this study as a manifestation of the adoption of aquaculture. The study clearly showed slow rates of diffusion between 1960 and 1986 and a rapid diffusion between 1987 and 1988. Rapid diffusion of aquaculture innovations was almost exclusively attributed to the work of field extension services of the Ministry of Agriculture. Aquaculture training of field extension staff was the catalyst. Farmers also contributed significantly through informal diffusion using normal interpersonal channels of communication. Positive correlations were found between several aquaculture skills that farmers acquired informally from neighbors. Extension contact correlated negatively with the farmers' acquisition of aquaculture skills by informal methods. Rates of adoption of aquaculture were slower than the rate at which farmers became aware of the innovation. Several socioeconomic, physical, traditional and psychological factors were identified as reasons for non-adoption of aquaculture.

Total substitution between informal and formal extension approaches is unrealistic for future aquaculture development. Both informal and formal aquaculture extension services should be used concurrently to stimulate further development in rural areas.

Land Rights, Security of Tenure and Fish Farming Development: The Cases of Zomba and Mwanza Districts, Southern Malaŵi

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Abstract

Despite the establishment of the Domasi Experimental Fish Farm in 1959, and the involvement of neighboring smallholders in fish farming since 1962, the "demonstration effect" has been limited since only few farmers in the surrounding area have included a fishpond in their farm. The adoption of fish farming is constrained in southern Malaŵi by availability of secure access to land with adequate water, suitable for constructing a fishpond. In this region, security of land tenure, and thus motivation to develop a long-term investment such as fish farming, depend ultimately on a person's social status with a village community.

Typically, villages in southern Malaŵi are composed of three broad categories of people: *mbadwa*, *akamwini* or *akamwana* and *akudza*. The security of land tenure enjoyed varies considerably among these three categories.

Mbadwa are the original inhabitants of a community, and they enjoy lifelong security of tenure to lineage land. This category of persons is that most likely to establish fishponds. In Zomba District, some 65% of fish farmers sampled were in this category, having established ponds in land acquired from their relatives. Only 7.4% had built ponds in land to which their wives held tenure. This is an expression of the matrilineal system, and the associated virilocal residence pattern in Zomba, such that men made ponds in their own villages where they are *mbadwa*, rather than in their wife's village, where they are *akamwini*.

In Mwanza District, in contrast, where elements of matriliny and patriliny coexist, owing to a century of intermarriage between Ngoni people (a patrilineal society) and Chewa (a matrilineal society), and where economic investments are regarded as benefiting primarily the children rather than adults, some 28% of fish farmers had built ponds in the land of their respective wives. However, these reflected longer marriages (average length 11.6 years), owing to the need for an outsider (*akamwini*) to gain acceptance by his in-laws.

Akamwini (male) and *akamwana* (female) are those who have married into a village, and, therefore, do not form part of the local social structure. They have usufruct rights only through their respective spouses and lose them in the event of the spouse's death or divorce. Security of tenure therefore derives from the longevity of a marriage. Thus, the bulk of farmers in this category make long-term investments in their natal village and in which, therefore, they have the status of *mbadwa*.

Akudza are immigrants from other villages and are totally outside the local social structure. They generally have no resource rights and their position in a village is precarious, since they may be forced to leave for minor infractions of locally acceptable behavior. Generally, however, after about one generation, *akudza* are accepted as established residents and their children obtain tenure rights. People in this category tend not to establish fishponds, lest their success arouse jealousy and cause their eviction. Thus they tend to limit their economically productive activities to subsistence crops and less lucrative ventures.

As a result of such complex patterns of resource rights, land tenure is a major consideration in the decision to adopt an innovation like fish farming, that requires a relatively long-term investment. Land tenure is therefore a principal initial consideration in feasibility studies for fish farming development.

Socioeconomic Constraints to Fish Farming Integration and Impediments to the Acceptability of Fish Cultured in Manured Ponds in Malaŵi: The Cases of Dedza Hills and Lilongwe Northeast Rural Development Projects

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Abstract

A survey of 112 randomly selected smallholder farmers, comprising 56 operating fishponds and an equal number not operating them, was conducted during the period October 1988-January 1989 in the Dedza Hills and Lilongwe Northeast areas of the Central Region of Malaŵi. Primary data were obtained from heads-of-household, using a pretested questionnaire. The objectives of this survey were to identify: (1) the main socioeconomic constraints on the integration of fish farming within existing farming systems, and (2) the principal impediments to the acceptability of fish cultured in manured ponds.

It was postulated that land tenure, lack of productive resources (suitable land and labor), off-farm employment, education and deficiencies in the extension service were the main constraints on integration.

Under the matrilineal system of social organization predominant in the study area, land tenure was found to be a major constraint on the decision to practise fish farming, since 83.7% ($P<0.05$) of fish farmers had acquired their land from parents or relatives (rather than working land to which their wife had the usufruct), compared with only 55.9% of non-fish farmers.

Lack of suitable land (perennially moist *dimba* areas) with year-round water availability is a major constraint to adopting fish farming, particularly in Lilongwe Northeast. There, a significantly ($P<0.05$) higher percentage of non-fish farmers (37.5%) than fish farmers (6.3%) lacked access to *dimba* land.

Lack of extension advice was found to be a principal constraint. Proportionately more non-fish farmers (50.%) than fish farmers (30.4%) did not receive extension advice on fish farming, and the difference was significant ($P<0.05$).

Labor supply and the opportunity cost of having to forego income from off-farm work were not principal constraints on the adoption of fish farming. Education, in terms of literacy, is a constraint only in Lilongwe Northeast.

Beliefs and attitudes associated with religion and disease were postulated as affecting the acceptability of fish cultured in waste-fed ponds. Fish cultured in ponds manured with cattle and/or chicken waste would be accepted for consumption by 90% of respondents, whereas, for religious reasons, only 65.8% would accept those from ponds manured with pig waste. Perceptions that fish raised in manured ponds would cause disease were widespread. Although the possibility of using human waste as a pond input was not known to 98.2% of the respondents, only 9.2% of respondents would accept fish cultured in ponds receiving it.

The Role of Aquaculture in Household Food Security, Nutrition and Health Status in Central Malaŵi

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Abstract

An examination of the influence of small-scale pond aquaculture on household food security, food consumption patterns and the nutritional status of children, together with the incidence of waterborne diseases, was conducted in the Bembeke and Chinyama areas of Dedza District, and in the Tsangano area of Ntcheu District, both in the Central Region of Malaŵi. A sample of 108 families was studied, 55 of which operated fishponds and 53 did not. Most households were engaged principally in subsistence agriculture.

Data on household characteristics, food-type consumption frequencies, beliefs and knowledge related to fish consumption, aquaculture practices and incidence of waterborne disease were collected using a scheduled and pretested questionnaire. Data were collected during a 4-week period by trained enumerators working in interviewer-recorder pairs. These same pairs then made anthropometric measurements.

Anthropometric measurements of weight and height were taken from 133 children whose ages ranged from 0.5 to 6 years. The children sampled were from 63 households with fishponds and 70 without. Ages were estimated by parents where official records were missing.

Results were obtained from frequency analysis of the data, using the SPSS (Statistical Package for the Social Sciences Program). They indicated no significant difference in levels of wasting (low weight-for-height) and underweight (low weight-for-age) among the children from household without ponds compared with those from pond-operating households. Stunting rates tended to be somewhat lower among children of pond-operating households (25% with height-for-age <90%) than those from families without ponds (29% with height-for-age <90%). Undernutrition is about 33% in children of both types of households.

Both daily and weekly food consumption patterns were similar in both types of households; in most households, beans are the main protein source consumed daily, and dried fish consumed once per week. Of the pond-operating households, only 5% claimed to consume pond-raised fish once a month; the remainder either consumed them occasionally or not at all. This low consumption rate of pond fish is attributed to inability to harvest and deficient nutritional knowledge on the value of fish.

The presence of a fishpond was found to have no influence on the incidence of waterborne diseases.

It is argued that fish farming could play a major role in enhancing household food security and nutritional status, if properly promoted via well-defined nutritional objectives within agriculture development programs. Better education and extension on both fish farming and its potential role in nutrition, together with the provision of low-cost harvesting tools, are essential if small-scale fish farming is to be both sustained and expanded in the region studied.

Sociodemographic and Socioeconomic Profiles of Fish Farmers in the West and Northwest Provinces of the Republic of Cameroon

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Abstract

In the west and northwest provinces of Cameroon, 959 fish farmers (903 males and 56 females) were identified by an extensive socioeconomic and demographic survey, conducted during July-September 1987. Data were obtained from all fish farmers in the area through recall questionnaire, personal interview and record sheet. The data obtained were processed by 24 third-year social science students of the University of Yaounde, and then analyzed using the microcomputer version of the Statistical Package for the Social Sciences (SPSS).

The principal demographic characteristics of the fish farmers were: (1) an average age of 48 and an average of 15 years experience in fish farming; (2) all females and 98% of the males were married and 48% of the marriages were monogamous; (3) an average of 6 children per household and average of 12 persons per household; (4) a religious affiliation that was 70% Christian, 20% Muslim, and 10% either of customary religions or no affiliation; and (5) that 70% received neither formal education nor training in a trade. Socially, the fish farmers are characterized by a strong attachment to the extended family and high affinity to fish farmers' associations.

Lack of education and training limits occupational mobility as well as opportunity costs to these farmers, and limits their range of economic activities to traditional agro-pastoralism, of which fish farming is but a minor component. Total average annual incomes of such farmers are approximately 490,000 FCFA (425 FCFA=US$1.0); of which 57% is derived from agriculture, 36% from livestock production, and only 7% from fish farming.

Although the contribution of fish farming to household incomes is low, owing to the small average pond size of 307 m^2 as well as the low average production level of 1.1 t/ha/year, nevertheless farmers aim to produce for commercial sale as well as for household subsistence. There is a total of 1,269 ponds in the region, of which 75% are diversion ponds. Ninety-five per cent of the fish farmers are owner-operators. The principal species cultured are *Oreochromis* sp., *Cyprinus carpio*, and *Clarias gariepinus*, in either mono- or polyculture. Eight farmers operate integrated livestock-fish systems.

In order to overcome the principal problems of fish farming, both to accelerate the development of fish farming and to improve socioeconomic conditions in the region, (1) aquaculture training should be provided to youths; (2) the extension service should be enhanced; (3) on-station, on-farm and extension pilot projects should be initiated to examine the economics of fish farming and the feasibility of integrated farming; and (4) land and water rights should be apportioned to fish farmers.

SESSION III
ECOLOGY OF SMALLHOLDER FARMS

Summary of Presentations
Dr. Clive Lightfoot

Extension trials in small ponds at Chinseu, southern Malaŵi, reported by Otte, demonstrated that *Tilapia rendalli* and *Oreochromis shiranus* could be grown economically to over 60 g in four months. However, smallholders with 1.57 ha holdings of which 1.30 ha are cultivated, 0.2 ha are fallow, face a problem of obtaining the recommended inputs. The 296 kg of *madeya* produced each year on the farm is far below the recommended level. Other potential pond inputs like the 2.5 t of maize stover and 0.9 t of rice straw produced on the farm each year are returned to the fields. Similarly, the 50 kg of manure produced every month by chickens are applied to the vegetables. The only on-farm resources determined by Noble and Chimatiro not to be fully utilized are ash from cooking fires and the nearly 1 t of weeds growing in the fallow areas. Integrating chicken with fish culture as tested by Kali-Tchikati in the Congo can overcome pond input shortages. Ten chickens raised the productivity of 100-m^2ponds from 72 to 2,972 kg/ha and produced nearly 1 t of broilers. The system as a whole, unfortunately, was not economically viable. Economic viability of aquaculture for prospective small-scale fish farmers in Malaŵi rests on finding cheap pond inputs and cheap harvesting techniques.

For aquaculture to attract many new entrants, not only must alternative pond inputs be found but also farmers must participate in the search. Participatory methods employing farmers to draw experimental layouts, calendars of activities and models of bioresource flows on the ground using whatever materials are on hand as presented by Lightfoot, demonstrate that farmers can be involved in a search for pond inputs. Vietnamese farmers drew how their agricultural enterprises provide many inputs to their aquaculture enterprise in a highly integrated rice-fish system. Farmers' bioresource flow models also provide the conceptual frame for formal systems dynamic modelling. Zweig showed how STELLA™ software used Chinese integrated pond-dike farming data to develop a bioeconomic simulation model. Simulation models not only provide information for optimizing productivity and economic performance through exploring the effects of variations in feeding, stocking and harvesting regimes, but also identify areas that require further research.

Alternatives to seine nets and draining must also be found. Kaunda's assessments of encircling fish fences, hook and line, fish traps and plunge baskets found that while all worked well, the last mentioned had the highest catchability in 30-cm deep 200-m^2 ponds at Domasi's experimental farm. Another traditional way to harvest fish is through poisons. Farmers in southern Malaŵi, according to Seyani and Chiotha, extract fish poison from 53 plant species. Ground bark, leaves, roots, tubers, bulbs or fruits applied in a fresh state kill or stun the fish. *Swartzia madagascariensis* and *Tephrosia vogelli* do the job in 3 to 5 minutes. Poisoning, while being a cheap way to harvest fish, also affects frogs, snails and snakes. In a more detailed study with Fabiano they found that 14 plant (*Tephrosia vogelli, Swartzia madagascariensis, Bridelia micrantha, Aloe swynnertonii, Agave sisalana, Breonadia microcephala, Ensete livingstonianum, Chikhawo, Neorautanenia mitis, Opuntia vulgaris, Xeromphis obovata, Erythrophleum suaveolens Sesbania macrantha* and *Phytolacca dodecandra*) extracts at concentrations of 100 mg/l killed 95-100% of the *Tilapia rendalli* and *Oreochromis shiranus* tested. Only three of these

(*Xeromphis obovata*, *Erythrophleum suaveolens* and *Phytolacca dodecandra*) at the same concentrations killed 100% of the *Bulinus globus* snail. The fact that plant extracts can kill *Bulinus globus* is important because it is one vector of schistosomiasis. The naphthoquinone from *Diospyros usambarensis* isolated by Msonthi is toxic to *Bulinus* at 5 ppm and its isomer (plumbagin) can kill at 2 ppm. Water extracts of the saponin oleanoate from *Talinum tenuissimum* are less toxic as they require concentrations of 25 ppm. Molluscicides along with the removal of weeds from ponds as recommended by Chiotha and Jenya are good precautionary measures against schistosomiasis. Though their survey of 25 ponds in Zomba found only one snail with cercaria, an insignificant level of infection, *Bulinus globus* was found in 70% of the ponds.

Principles and Methodology of Ecological-Economic Modelling of Integrated Agriculture-Aquaculture Farming Systems

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Abstract

Ecological-economic modelling can provide the basis for a systems approach to the design and development of integrated agriculture-aquaculture farming systems. Inherent in a systems approach is the need to consider environmental and socioeconomic conditions and to evaluate the availability of required resources and inputs to achieve production targets. It also requires decisions over the selection of the components to be included or added to existing farms and the relative size each activity should be. The modelling process itself can help identify a number of the critical factors required in a design and organize a methodology for consideration of design options. Many of these factors can be simulated and evaluated through the use of ecological computer models. One application where simulation modelling has proven significant is in decisions over the incorporation of pond fish culture in the development of an integrated agricultural scheme.

The baseline criteria for mathematical modelling of aquaculture ecosystems include feedback, interconnectedness, nonlinearities, relationships described by plateaux, break-points and sigmoidal curves, delays and accumulations, and non-equilibrium or transient dynamics.

To meet these criteria, an explicit modelling methodology, System Dynamics, was used to fulfill the requirements for model development. The conventions of the methodology emphasize important structural distinctions, such as levels versus rates, endogenous versus exogenous variables and feedback versus one-way causality.

Computer simulation models of aquatic ecosystems used for fish culture should include climatic and water quality factors and their effect on fish growth and provide information toward optimizing productivity and economic performance. The Chinese system of integrated fish farming has been used as a reference to develop two models: "EcoLogic 2.1©, A Computer Simulation Model of a Carp Polyculture Production Pond" and "EcoLogic 2.2©, A Computer Simulation Model of a Nursery Pond". These can explore the effects of variations in feeding, stocking density, harvesting and water exchange on fish growth and production. They track nitrogen flows and accumulations within the fish and pond environment. These were formulated and assembled using STELLA™ 2.1 software, a powerful programming medium that simplifies structural diagramming, development of interlinked relationships and formulation of differential equations that define the simulation model. EcoLogic 2.1 has been further modified into a strategic gaming format - "EcoLogic 3.0©, The Integrated Fish Farm Game" - to be used as a training environment in integrated fish farm management. It provides students the opportunity to experience the impact of management decisions on production and performance of an integrated fish farm through simulation.

It is postulated that by combining a number of the parameters from both EcoLogic 2.1© and 2.2© and a new factor for spawning in ponds, a practical model for small-scale tilapia farming in Africa could be developed. This model could include critical socioeconomic factors.

On Farm Biotic Resources for Small-Scale Fish Farming in Malaŵi

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Abstract

In Malaŵi, smallholders engaged in aquaculture are faced with the problem of the availability of low-cost inputs to feed their fish and fertilize their ponds. Rural incomes are low and farmers have to struggle to afford fertilizer for their main staple crops, let alone their ponds. It is essential therefore to find cheap inputs which can be used to increase rural fish production.

Twenty farmers were chosen from a group of 131 cooperators. They were stratified into groups on the basis of livestock and crop differences, and also on geographical location. Choice was also affected by access in the wet season and distance, the latter due to time and manpower limitations. The main resources chosen for measurement were maize and rice residues, weed production on cultivated and fallow land, and livestock manure. The Fisheries Department recommends *madeya* (coarse maize bran) and rice bran as direct fish feeds, hence these residues were given particular attention.

Land use patterns on the farms were described. Mean farm size was 1.57 ha with 1.30 ha under cultivation, 0.2 ha fallow and 0.07 ha as ponds. The farmers all practised mixed cropping, growing local maize interplanted with ground nuts, pulses and pumpkins. Three farmers grew hybrid maize. Fifty per cent of the farmers had rice gardens, often adjacent to their ponds.

The mean production of *madeya* from local maize was 296 kg/farm/year, and from hybrid maize, 363 kg/farm/year. This was generated from a total seed production of 1,467 (local) and 2,311 (hybrid) kg/farm/year. All maize stover (local = 2,513; hybrid = 2,311 kg/farm/year) is composted in the fields together with weeds (1,595 kg/farm/year). Rice generates only 54 kg/farm/year of bran from a total grain production of 418 kg/farm/year. All rice straw (888 kg/farm/year) is composted in the ricefields. Weed production on fallow land (922 kg/farm/year) is not utilized.

Livestock manure is very difficult to assess and was measured for only five farms. Chickens produce 50 kg/month (range: 15-107), the majority of which is used on vegetables and crops. Farmers also add wastes from pumpkins, fruits, pulses and leafy vegetables to their ponds, but as yet there are no estimates for these residues.

These data show that *madeya* production per farm is far below the input levels recommended for feeding fish by extension services. Many farmers have to buy *madeya* to make up for the shortfall, and often have none for several months. All other wastes on cultivated land are used for direct composting on the fields to preserve the soil and reduce the need for fertilizer use. Other maize wastes such as cobs (local = 292; hybrid = 256 kg/farm/year) are important as fuel for cooking. Hence, they are unavailable for composting for ponds. The only on-farm resources which are not fully utilized at present are ash from fires (438 kg/farm/year) and weeds on fallow land.

Participatory Methods for Integrating Agriculture and Aquaculture: Examples of Farmers' Experiments in Rice-Fish Integrated Farming

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Abstract

Integrating aquaculture into crop-based farming systems can play an important role in reversing environmental degradation, improving human nutrition and increasing farmers' purchasing power in Africa. Many farmers, however, must participate in the generation of these integrated farming systems for any measurable impact on households and the environment to be felt in the near or medium term.

Participatory methods in experimental design that build on farmers' skills in visualizing their complex systems are described. The participatory method has groups of farmers drawing their experimental plot layouts, calendars of activities and models of bioresource flows between aquaculture and agricultural enterprises of the farm system. Drawings are made on sheets of paper or on the ground with whatever materials are on hand. Farmers' diagrams of their experimental layouts and activities in integrated rice-fish experiments from India showed how system performance could be enhanced. Changing field layout from deep lateral trenches to a shallow central sump and harvesting the fish with the rice crop permitted the reduction of water requirements, the planting of a wheat crop and the utilization of manured sump soil by wheat. That farmers can visualize complex material flows between aquaculture and agricultural enterprises is demonstrated in a case study from Vietnam. A group of Vietnamese farmers drew how fish and prawns raised in a rice paddy are fed with animal manure, oil cakes, cassava flour, rice bran and tree leaves. The paddy provides water for vegetables growing on dikes constructed from trench mud. Rice straw provides a mulch for the vegetables. These farmers also drew how fish and prawns graze on rice crop weeds and how their feces improve soil fertility.

The lesson for Malaŵi is to recognize the value of farmer participation and its role in accelerating recruitment of new entrants into integrated aquaculture-agriculture farming systems.

A Proposed Pond Management System for Small-Scale Fish Farmers in Southern Malaŵi

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Abstract

During the pilot phase of the Malaŵi-German Fisheries and Aquaculture Development Project, the objective of the aquaculture component was to develop a simple fish farming model for small-scale farmers in southern Malaŵi which would allow them to manage their ponds economically and independently from any institutional support.

Simple trials were carried out under local conditions in the earthen demonstration ponds at the project's extension station in Chinseu (Chingale area) to develop and test fish farming technologies suitable for the small-scale farmers.

These trials showed that raising local tilapia species (*Tilapia rendalli* and *Oreochromis shiranus shiranus*) within a period of about 4 months, from fingerling to a market size of 60 to over 100 g per fish, depending on the available inputs, was economical. At the same time, the fish produced enough fry for

the next rearing cycle. Ponds were drained for harvesting. This eliminated predator fish, controlled snail population and increased the natural fertility of the mud. The fish were caught at the outlet with a locally produced basket which removed the need for farmers to invest in a net.

Tests under the conditions of private small-scale farms in the pilot areas demonstrated that this system can be managed and can be readily accepted by the target group. It can contribute considerably to farm cash incomes.

Relative Performance of Alternative Fishpond Harvesting Techniques in Malaŵi*

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Abstract

The high cost of seine nets and difficulties with draining ponds are root causes of lack of cheap and efficient pond harvesting techniques in Malaŵi. This investigation used the Leslie method to investigate the relative efficiencies of: a) encircling fish fences, b) hook and line, c) plunge baskets and d) fish traps as alternative gears for small-scale farmers.

The Leslie method involved plots of catch per effort (1 hour of gear use, in all cases) against cumulative catch. Given suitable statistics (a significant negative regression), these plots yield gear-specific catchability coefficients as slope and the total (initial) stock in the pond as intercepts. The Leslie method was used here in conjunction with *Tilapia rendalli* kept in 200-m^2 ponds at Domasi, Malaŵi. All nine experimental sets were significantly different from each other, and the plunge basket, operated at a depth of 30 cm, had the highest catchability.

Sources of variability included different persons operating the gears, the depth of gear operation, and for at least one gear, the experimental date. Overall, these results suggest the Leslie method to be highly appropriate for pond application. Results point out, however, the need for more studies of this kind.

*The full paper is published in Aquabyte 4(1):4-5.

Preliminary Results of Integrated Chicken-Fish Culture in the Rural Areas of Congo

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Abstract

Integrated broiler chicken-fish culture trials were conducted simultaneously at the D'joumona National Fish Farm and rural areas in Congo. The principal objectives were estimation of the optimal number of chickens for pond fertilization and the economic aspects of such integrated systems. Five hundred and fifty-six kg of Nile tilapia (*Oreochromis niloticus*) were harvested from six ponds (total 0.44 ha) after 165 days. The fish stocking density was 2.2 fingerlings/m^2. Extrapolated net fish production ranged from 72 kg/ha/year (control ponds with no chicken manure) to 2,971 kg/ha with 10 chickens/100 m^2 of pond. There were five chicken production cycles/year of 66 days each. Some 924 kg of broilers were produced. These trials, highly preliminary and the first of their kind in Congo, indicated that integrated broiler chicken-fish culture was not yet economically viable, but recommendations are made to improve this.

The Potential of Fishponds in Bilharzia (Schistosomiasis) Transmission

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Abstract

Present enthusiasm for fish farming in southern Malaŵi demands that an assessment be made of the significance of fishponds in the transmission of bilharzia. A survey of twenty-five fishponds in Zomba District, southern Malaŵi, for bilharzia snails was undertaken. About 70% of these ponds had *Bulinus globosus*, the vector snail for urinary bilharzia. Some other types of snails such as *Lymnaea natalensis*, the vector of liver fluke, and *Bulinus tropicus*, were also encountered in the ponds. The vector snail for the bowel bilharzia, *Biomphalaria pfeifferi*, was not found in any pond. Only one of the vector snails shed cercaria and crushing failed to reveal immature stages of schistosomes in the rest of the snails. Population density of vector snails varied dramatically between ponds, but ponds with weedy edges tended to be the most dense.

This survey suggests that infection rates among snails in fishponds are probably low. However, since more snails were found in fishponds than in streams or canals feeding water to them, ponds may increase the risk of infection. Precautionary measures like the removal of weeds from ponds should be encouraged.

A Survey of Fish-Poison Plants in Malaŵi: Their Traditional Uses and Potential Roles in Integrated Fish Farming

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Abstract

Three-hundred-and-fifty people from eight districts in the Southern Region of Malaŵi were interviewed about plants poisonous to fish and their use. The survey found that people used about 53 plant species, belonging to 23 families and 42 genera, to catch fish by poisoning them. Collection, processing and application of fish-poisons from plants are associated with many ceremonies, prayers and taboos. Men, both old and young, do these activities. Plants are usually processed and applied in a fresh state - the bark, leaves, roots, tubers, bulbs or fruits being crushed or ground. Most respondents said that these

plants affect a wide range of fish species, particularly small- and medium-sized fish. Plants poisonous to fish also affect other water-living organisms, such as snails, snakes and frogs. *Swartzia madagascariensis* and *Tephrosia vogelii* were reported to kill or stun fish within 3 to 5 minutes. *Sesbania* spp. may take up to a day to kill the fish. People prefer fishing with plant poisons because they are effective, cheap and easily obtainable. Moreover, some fish-poison plants have alternative uses like medicine, fuelwood, fodder or construction.

Molluscicidal and Piscicidal Properties of Indigenous Plants

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Abstract

Over fifty local plants collected from southern Malawi were screened for toxicity against fish and snails. The species of fish tested were *Tilapia rendalli* and *Oreochromis shiranus*. *Bulinus globosus*, a schistosome intermediate host, was the snail species tested. Plant material was extracted in water at room temperature with initial exposure of fish and snails at 100 mg/l for 24 hours followed by 24-hour recovery period in clean water. Results showed that 14 plants (*Tephrosia vogelii, Swartzia madagascariensis, Bridelia micrantha, Aloe swynnertonii, Agave sisalana, Breonadia microcephala, Ensete livingstonianum, Chikhawo, Neorautanenia mitis, Opuntia vulgaris, Xeromphis obovata, Erythrophleum suaveolens, Sesbania macrantha* and *Phytolacca dodecandra* [leaves and fruits]) were very toxic to fish, causing 95-100% kill, while the rest of the plants were observed to be moderately toxic (28-45% kill), slightly toxic (2.5-15% kill), or not toxic (0% kill). Extracts from five plants (*Sesbania goetzei, Synadenium molle, Aloe swynnertonii, Acacia albida* and *Syzygium cordatum*) acted very slightly as stupefacients. At lower concentrations, one of the plants, *Tephrosia vogelii*, acted as a stupefacient. Three of the plants (*Xeromphis obovata, Erythrophleum suaveolens* and *Phytolacca dodecandra*) tested killed 100% of the snails at 100 mg/l; the lethal effects ranged mostly from 0 to 70%, although six plant extracts caused 71-99% kill. For the very toxic substances, toxicity decreased with decreasing concentration, but the decrease in toxicity for different extracts did not follow a common pattern. Possible use of the plants to control schistosomiasis and in solving some aquaculture management problems is discussed.

Molluscicidal Components of Plant Origin*

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Abstract

Phytochemists' interest in plant molluscicides stems from their lethality to bilharzia-carrying snails. These plants are also cheap to isolate, specific to target animals, easily biodegradable and snails do not develop resistance to schistosomiasis.

In Malaŵi, the roots and bark of *Diospyros usambarensis* (Ebenaceae) provide a traditional cure for bilharzia. One compound (7-methyljuglone) isolated from this plant showed strong molluscicidal activity. This naphthoquinone was toxic to *Biomphlaria glabrata* snails at concentrations as low as 5 ppm. Its isomer (plumbagin) was even more active and killed snails at concentrations of 2 ppm. Fungicidal activity by TLC assay using *Cladosporium cucumerium* was detected at 0.0025 μg of 7-methyljuglone. Plants which biosynthesize naphthoquinones are worth investigating for their molluscicidal activity.

An infusion of the roots of *Clerodendrum uncinatum* (Verbenaceae) is reputed among traditional healers in Malaŵi to cure schistosomiasis. Screening for biologically active compounds showed that its lipophilic extract, uncinatone, has antifungal activity against *Cladosporium cucumerium* at concentrations of 0.5 ppm. Tests are underway to evaluate the possible *in vitro* and *in vivo* effects against schistosomes.

Talinum tenuissimum (Portulacaceae) tubers are another traditional treatment for schistosomiasis. The water extract containing traces of saponin oleanoate kill *Biomphlaria glabrata* snails at concentrations as low as 25 ppm within 24 hours. A 3-0-(0-β-D-xylopyranosyl)-(1->3)-0-(β-D-glucopyranosylcuronic acid) oleanolic acid extracted from tubers killed *Biomphlaria glabrata* snails at concentrations of 1.5 ppm within 24 hours. Potency of the molluscicidal activity in saponin-containing plants depends on the extraction processes since the genuine inactive bidesmosidic saponins are easily base hydrolyzed to very active monodesmosidic saponins in the course of the water extraction.

Another potential molluscicide is the fish stupefacient contained in the leaves and seeds of *Tephrosia vogelii* (Leguminosae). The petroleum ether extract of its leaves was active against *Biomphlaria glabrata* snails at 400 ppm. Dequelin and tephrosin, due to their insolubility in water, were both inactive as molluscicides.

*The full paper is published in Aquabyte 4(1):6-7.

SESSION IV
RESULTS OF BIOLOGICAL RESEARCH

Summary of Presentations

Dr. Barry A. Costa-Pierce

Papers presented research results of using agricultural by-products available on most rural farms in Malaŵi as low-cost inputs for increasing fish production in smallholder aquaculture. The need to increase fish production from rural aquaculture in Malaŵi is obvious; 229 smallholder fishponds in Zomba, Malaŵi, are reported to produce average yields of only 400-600 kg/ha/year. Low fish production is mainly due to farmers' lack of cost-effective inputs and management strategies. Agricultural by-products used in the research (maize bran [*madeya*], napier grass, ashes, plantain and yam peelings), dried fish wastes and a simple management strategy (pond stirring), were found to be within the means of the majority of farmers in rural Africa. Research results were also presented on fry production in *hapas* and new ways of analyzing data gathered from applied aquaculture research.

Experiments by Maluwa testing different broodstock densities in small *hapas* (net cages) found that total seed production of *Oreochromis shiranus* per area of *hapa* was not significantly reduced by the highest broodstock density ($1.7/m^2$) used, but was directly related to temperature. Below 18°C, all breeding ceased.

The use of wood ash from household cooking fires was found to be an effective alternative liming agent for smallholder fishponds. Wood ash significantly raised the pH and alkalinity values of Domasi ditch water and had a neutralizing value of $79.8 \pm 1.4\%$ when compared with agricultural limestone ($118.2 \pm 2.1\%$).

Digestibility studies of fish waste, plantain and yam peelings with African catfish (*Clarias gariepinus*) by Mgbenka et al. indicated that all these materials can be used as feed ingredients; 60 mg of vitamin C/kg diet produced a maximum fish growth rate.

Maize bran is the most commonly used feed input to smallholder fishponds in rural Malaŵi. Experiments to select an optimal feeding rate were reported. Satiation consumption rates of 4.1% (*Tilapia rendalli*) and 3.1% (*Oreochromis shiranus*) of fish body weight per day (BWD) were found. A 2.5% BWD rate was recommended based upon findings that specific growth rates for both species were not simply related to feeding rates. At this rate, the overall food conversion ratio (FCR) was improved to 5.3.

Use of napier grass, maize bran and combinations of a diverse array of inputs were reported by Chikafumbwa et al. and Balarin et al. *Madeya* is the most important fishpond input but is used as human food during the rainy season in rural Malaŵi. As a result, fish in ponds often go unfed during this period. Napier grass, however, is abundant during this time, so it could be a valuable pond input. Chopped napier grass added once a day at 100 kg (dry matter)/ha gave comparable fish growth and production to *madeya* over a 126-day culture period. Combinations of napier grass, *madeya*, wood ash and urea with pond stirring did not produce expected increases in fish growth or production. *T. rendalli* grew best in the napier grass only treatments and *O. shiranus* in the *madeya* only treatments. In both experiments, newly spawned fry and fingerlings (recruits) contributed 63-76% (napier grass and *madeya*) and 53-80% (combination) to total fish production. In the combination experiments, pond stirring had positive impacts on water hardness, conductivity and alkalinity; however, total production of stocked fish decreased. Stirring significantly increased production of recruits.

Two papers addressed data analysis. A. van Dam clearly demonstrated that parametric ANOVA tests would likely fail to detect significant differences in poorly-replicated aquaculture pond experiments. Kapeleta et al. performed multivariate regression analyses on experimental data from ponds receiving a variety of on-farm inputs. A significant portion of the variability in fish growth rates (*T. rendalli*) was explained by pond stirring, napier grass, *madeya* inputs and fish initial weights. Growth rates of *O. shiranus* were predicted by fish initial weights, napier grass and *madeya* inputs.

Fry Production of *Oreochromis shiranus* in *Hapas*

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Abstract

Results are presented on fry production from *Oreochromis shiranus* in 3 x 3 x 1 m *hapas* installed in a 200-m^2 pond at the Domasi Experimental Fish Farm. Three broodstock densities of 1.7, 1.0 and 0.7/m^2 were used at a sex ratio of 1:2 (males:females). First sampling was done 14 days after stocking and every 21 days thereafter. Free-swimming fry first appeared 56 days after broodstock (38-48 g and 43-50 g body weight for males and females, respectively) were stocked in *hapas*. Total seed (free-swimming fry, sac fry, eggs) were counted every 21 days from experimental day 224.

There were no significant production differences in free-swimming fry and total seed per spawner and per area among the three broodstock densities ($P > 0.05$; Kruskal-Wallis ANOVA). There was a direct relationship between fry and seed/m^2/day production and broodstock density ($P < 0.05$; $r = 0.95$) and an inverse relationship between seed/female/day and broodstock density ($P < 0.05$; $r = -0.96$). Water temperature contributed significantly to total variation in fry production ($P < 0.05$). Dissolved oxygen and pH contributed less than 2% to the total variation in fry yields. Minimum temperatures below 19°C delayed reproduction within a 21-day cycle by slowing gonadal ripening. Breeding ceased when minimum temperatures fell below 17°C. The contribution of all water quality parameters to total variation in fry yield was not significant ($P > 0.05$; multiple $r^2 = 0.34$).

Results showed that *O. shiranus* breed successfully in *hapas*. More fry would be harvested with higher broodstock densities (1.7/m^2) in *hapas* provided temperatures do not go below 18°C.

Ash as a Liming Agent in Fishponds

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Abstract

The chemical and liming properties of ash from a number of plant residues generally available as on-farm resources in Malaŵi were evaluated. Ashes were: maize stover (*Zea mays* L. Gran), rice straw (*Oryza sativa* L. Gran), grass (*Rottboelia exaltata* L.f.) and fuelwood (*Sterculia quenquiloba* [Garkel] K. Schum). Control was agricultural limestone, a routinely used liming agent in fishponds.

The pH and total alkalinity (mg/l as $CaCO_3$) were measured at 0, 0.5, 1.0, 2.0 and 3.0 t/ha equivalent applications in duplicate 4-l jars over 20 days in the laboratory. Application of wood ash at 3.0 t/ha gave the highest increase in pH from 7.45 ± 0.31 to 9.57 ± 0.26 (all values mean ± 1 S.D.) and total alkalinity from 14.6 ± 2.5 to 34.5 ± 2.2. The order of increase in pH was significantly different (one-way ANOVA; $P < 0.05$): agricultural limestone (AL) > wood ash (WA) = grass ash (REA) > maize stover ash (MSA) = rice straw ash (RSA). Neutralizing values from laboratory analyses (relative % over $CaCO_3$) were 118.18 ± 2.06, 79.77 ± 1.38, 53.30 ± 6.87, 44.00 ± 8.25 and 29.18 ± 4.21 for agricultural limestone wood ash, grass ash, maize stover and rice straw ash, respectively. Effects of pond water activity on pH showed that 100% pond water significantly reduced pH after 10 days where grass ash, maize stover ash and rice straw were applied, but did not reduce pH in jars where ash was applied (paired t-tests, $P < 0.05$).

Results indicate that firewood ash from household cooking fires could be used as a cheap alternative liming agent in fishponds for smallholder fish farmers in Malaŵi.

Effects of Different Feeding Rates of Maize Bran (*Madeya*) on *Oreochromis shiranus* and *Tilapia rendalli* Juveniles in Polyculture

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Abstract

Satiation feeding was done to find the maximum amount of maize bran *(madeya)* that two native Malaŵian tilapias *(Tilapia rendalli* and *Oreochromis shiranus)* can consume when fed *ad libitum*. A quantity of 4.1% (*T. rendalli*) and 3.1% (*O. shiranus*) of fish body weight per day [BWD] was found. *Madeya* at five different feeding rates (0; 2.5; 5.0; 7.5; 10.0% BWD) was fed to a 50:50 combination (2 fish/m^2) of *T. rendalli* (mean body weight [MBW ± SD] = 10.5 ± 1.60 g) and *O. shiranus* (10.7 ± 0.48 g) in two equal portions daily, six days a week, for 126 days, in 5-m^3 concrete tanks. Mean daily water maximum and minimum temperatures ranged from 23.4 ± 3.0 to 26.5 ± 3.3°C.

Results showed a significant growth-promoting effect of *madeya* for both species (one-way ANOVA; $P < 0.05$). Specific growth rate (SGR) for *T. rendalli* was highest at 5.0% BWD (0.86 ± 0.08%/day); this was significantly higher than all other treatments except at 7.5% BWD (one-way ANOVA; $P < 0.05$). For *O. shiranus*, the SGR was significantly higher at 7.5% BWD over the control (one-way ANOVA; $P < 0.05$). SGRs for both *T. rendalli* and *O. shiranus* were not related to feeding rates ($P > 0.05$). Overall feed conversion ratios (FCRs) were lowest at the 2.5% BWD at a FCR of 5.3 and were significantly different from FCRs at 7.5 and 10.0% BWD (one-way ANOVA; $P < 0.05$). One-way ANOVAs employed on the final MBWs showed that results were significantly lower between the control and 2.5% BWD and higher feeding rates (7.5% and 10.0% BWD) ($P < 0.05$).

Dissolved oxygen (DO) decreased with time for all treatments except the control. Increasing feeding rates resulted in lowering of DOs which fell to 0.7 mg/l at dawn in the 10% BWD. Low DOs could have adversely affected fish growth at higher feeding rates. Despite working with high initial pHs (10.2 ± 0.3 in the experimental units) the higher feeding rates of *madeya* caused large pH decreases with time (e.g., 10% BWD = pH 7.8; 2.5% BWD = pH 9.9 at harvest). The pH at harvest was significantly different (one-way ANOVA; $P < 0.05$) between 2.5% and 5.0% BWD, but was not significantly different among other treatments. Alkalinities rose from 40.0 mg/l (as $CaCO_3$) to 82.33 ± 9.8 mg/l in the 10.0% BWD while the control was 46.3 mg/l. Final alkalinities were significantly lower between the lower feeding rates (control and 2.5% BWD) and all other treatments. Significant differences also occurred between the control and 5.0% BWD treatment, and between the 5.0% and 10.0% BWD treatments (one-way ANOVA; $P < 0.05$).

Use of Napier Grass (*Pennisetum purpureum*) and Maize Bran (*Madeya*) for Small-Scale Aquaculture in Malaŵi

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Abstract

Napier grass (grass), grass/*madeya*, and *madeya* were given once per day at 100 kg dry matter (DM)/ha/day (grass) and at 3% of mean fish body weight (MBW) *(madeya)* to *Tilapia rendalli* (21.6 ± 1.0 g =

MBW ± 1 S.D.) and *Oreochromis shiranus* (20.9 ± 2.6 g) in monoculture and a 1:1 polyculture stocked at 2 fish/m^2 earthen ponds for 126 days. A no input control stocked with the 1:1 polyculture was included.

. Highest MBWs and specific growth rates (SGRs) for *T. rendalli* (43.0 ± 4.3 g; 0.59 ± 0.04%/day) and *O. shiranus* (41.3 ± g; 0.42 ± 0.12%/day) in monoculture at harvest were obtained in the grass/*madeya* treatment, but these were not significantly different (P > 0.05) from individual grass and *madeya* treatments. Similar results in a polyculture of *T. rendalli* (46.9 ± 1.7 g; 0.67 ± 0.18%/day) and *O. shiranus* (41.8 ± 4.8 g; 0.69 ± 0.06%/day) were obtained for the grass/*madeya* treatments. SGRs for *T. rendalli* in polyculture were not significantly different (P < 0.05) between individual grass and *madeya* treatments, but were significantly different for *O. shiranus* in all treatments. MBWs and SGRs in the no input controls were significantly lower (P < 0.05) than all other treatments (one-way ANOVA). Survival rates were above 80% except the control which had 73% survival. Fish bred in all treatments with the number of fry ranging from 1,882 ± 1,164 to 3,217 ± 2,112 per pond. Recruits contributed 63-76% to total net yield.

Minimum water temperature averaged 23 ± 1.7°C. DOs at 0500 hours were less than 1 mg/l in grass and grass/*madeya* treatments for 56 out of 126 days (44%), but never went below 3 mg/l in *madeya* and control. Diurnal DOs measured on day 96 were below 1 mg/l for 6 hours in grass and grass/*madeya* treatments. The pH ranged from 6.5 to 8.0 in all treatments, and alkalinities from 11 to 30 mg/l (as $CaCO_3$). Conductivities ranged from 32 to 70 µmhos/cm in grass and grass/*madeya* treatments, and were lower in *madeya* and the control. Ammonia concentrations ranged from 0.05 to 0.80 mg/l in all treatments.

Results suggest that similar fish growth and production could be realized by feeding chopped grass or *madeya* alone in monoculture and polyculture.

Combinations of On-Farm Resources (Napier Grass, Maize Bran and Wood Ash), Urea and Stirring for Small-Scale Aquaculture

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Abstract

Single inputs and isonitrogenous combinations (0.7 kg N/ha/day) of napier grass, maize bran *(madeya)* and urea were applied once a day for 112 days to 200-m^2 ponds at the Domasi Experimental Fish Farm, Malaŵi. Wood ash at 1 t/ha/month was used for pond liming in the combination treatments. Treatments included stirring of pond sediments using a 1-m wide pond rake twice weekly at 1400 hours. A zero input control was used. A 1:1 polyculture of *Tilapia rendalli* (mean body weight or MBW, 41.3-52.6 g) and *Oreochromis shiranus* (MBW, 49.1-53.5 g) was stocked in triplicate ponds at 1/m^2.

The highest final MBW (94.6 g) and specific growth rate (SGR, 0.55%/day) was attained in the *madeya* only treatment for *O. shiranus*. *T. rendalli* grew best in the grass only treatment (MBW, 85.8 g; SGR, 0.62%/day). Despite a 8:1 male:female ratio at stocking, 55 to 65% of harvest biomass was due to fry and fingerlings, with one exception. *Madeya* showed a similar trend. Except for stirring (53%) and urea (71%), *T. rendalli* fingerlings contributed over 80% of fingerling production, due to a 2.5 times higher female ratio than *O. shiranus* at stocking. *T. rendalli* contributed over 75% to final production in all but zero (64%), urea (62%) and *madeya*/grass/wood ash (60%) treatments.

The addition of small amounts of urea to *madeya*, grass and wood ash combinations and stirring gave equivalent net production levels of over 2,000 kg/ha/year, and reduced the amounts of grass and *madeya* needed. A dry matter input conversion ratio of 12 and protein conversion ratios of 4.5-5.4:1 were achieved in these treatments.

Some Impacts of Manual Pond Stirring on Aquaculture Ponds in Malaŵi

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Abstract

Impacts of manual pond stirring on water quality and fish yield characteristics are reviewed. Stirring was accomplished in small 200-m^2 earthen ponds with five pulls of a 1-m wide rake, twice a week at 1400 hours. Stirring had significant positive impacts on total alkalinity, conductivity and total hardness concentrations (r^2 = 0.49-0.72; P<0.01; N = 72) over a 112-day period. A significant negative impact on dissolved oxygen (DO) was found (r = -0.31; P<0.01; N = 72).

Stirring had a negative impact on total production of stocked fish in a multiple regression model with maize bran, napier grass and wood ash inputs as independent variables (b= -0.948; r^2 = 0.989; P<0.001; N = 28), but had significant positive effects on total and individual fry numbers and weights for *Oreochromis niloticus* and *Tilapia rendalli* in polyculture (range of models; r^2 = 0.474-0.632; P<0.05; N = 28). Stirring treatments had net yields of 1,874-2,249 kg/ha/year, higher than nonstirred ponds (684-1,924 kg/ha/year), but this was likely due to enhancement of recruitment and fry survival (28-83% of net yield vs. 76-93% for stirred ponds). The largest percentage of increased fry production was contributed by *T. rendalli*.

This preliminary research on simple pond stirring has allowed a number of testable hypotheses to be formulated. These and others put forward by Costa-Pierce and Pullin (1989)* are discussed in light of preliminary data.

*Costa-Pierce, B.A. and R.S.V. Pullin. 1989. Stirring ponds as a possible means of increasing aquaculture production. Aquabyte 2(3):5-7.

Multivariate Analysis of *Tilapia rendalli* Growth as Affected by Water Quality Changes and Inputs (Napier Grass, Wood Ash, Maize Bran) in Aquaculture Ponds in Malaŵi*

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Abstract

Multiple regression analyses were performed on growth data for *Tilapia rendalli* and *Oreochromis shiranus* to investigate the effects of water quality changes and a diverse combination of low-cost pond

*The full paper will be published as: Costa-Pierce, B.A., A.A. van Dam and M.V. Kapeleta. Multiple regression analysis of fish growth as affected by water quality and inputs in aquaculture ponds. *In* M. Prein, G. Hulata and D. Pauly (eds.) Multivariate methods in aquaculture research: case studies of tilapias in experimental and commercial systems. ICLARM Stud. Rev. 20. (In press).

inputs, with or without pond stirring (used to resuspend bottom sediments and destratify the water column).

A model was defined ($r^2 = 0.71$; $P<0.001$; $n = 72$) that related specific growth rates (SGRs as %/day per 14-day sampling periods) of *Tilapia rendalli* to pond stirring; maize bran and napier grass inputs and fish initial weights as significant predictor variables. Fish initial weights, maize bran and napier grass were also significant predictors of SGRs of *O. shiranus* ($r^2 = 0.23$; $P<0.01$). Models of stirring and inputs along with water quality parameters showed that dissolved oxygen and pH were affected by maize bran and grass inputs ($r^2 = 0.59$ and 0.43; both $P<0.001$). A model relating growth data for both species to water quality showed that dissolved oxygen, temperature, total hardness and fish initial weights were the most significant predictor variables for *T. rendalli* ($r^2 = 0.63$; $P<0.001$); and dissolved oxygen and fish initial weights for *O. shiranus* ($r^2 = 0.18$; $P<0.01$).

Digestibility of Some Agricultural By-Products by African Catfish (*Clarias gariepinus* Burchell 1822) and Preliminary Investigation on the Effects of L-Ascorbic Acid (Vitamin C) in an Agricultural By-Product-Based Diet on the African Catfish

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Abstract

Digestibility of carbohydrates, lipid and protein by African catfish (*Clarias gariepinus* Burchell 1822) was determined for wood-fire dried fish waste, plantain peelings and yam peelings by the indirect chromic oxide method. Also L-ascorbic acid (AA) requirement of the fish when supplemented in graded levels (0, 30, 60, 90, 120, 240 mg/kg of diet) in wood-fire dried fish waste diets was determined.

Per cent digestibilities of carbohydrate, lipid and crude protein were 56.5, 60.1 and 75 for fish waste; 73.2, 67.3 and 71.8 for plantain peelings; and 65.7, 63.9 and 69.5 for yam peelings. Digestibilities indicate that each ingredient is good for formulating fish feeds. Sixty mg AA/kg of diet was an optimal level of AA which provided maximum growth in African catfish and prevented scoliosis and gill malformations. All fish fed an ascorbic acid-free diet or 30 mg AA/kg of diet demonstrated poor growth and AA deficiencies.

Why ANOVA is Not Very Effective in Analyzing Pond Experiments*

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Abstract

Analysis of variance (ANOVA) often fails to demonstrate significant differences between treatments in aquaculture pond experiments due to large within-treatment variability combined with inadequate numbers of replicates. This is demonstrated with a simple ANOVA applied to data from a pond experiment at the Domasi Experimental Fish Farm, Malaŵi. The probability of showing a significant difference between treatments at alpha = 0.05 was only 30%.

It is concluded that aquaculture researchers must look for analytical methods that utilize experimental variability in explaining results (such as multivariate statistics) rather than trying to eliminate experimental error and applying ineffective ANOVAs.

*The full paper is published in Aquabyte 3(3):3-5.

SESSION V
OTHER REVIEWS AND RELATED STUDIES FROM AFRICAN NATIONS AND STATEMENTS FROM DEVELOPMENT AGENCIES

Summary of Presentations

Dr. Roger S.V. Pullin

Two presentations highlighted the value of synoptic reviews on the biology and culture of native fish species used for aquaculture. From Malaŵi, Msiska summarized data on *Oreochromis shiranus shiranus* and *O. shiranus chilwae*. Rashidi did the same for *Tilapia rendalli*. The value of such synoptic reviews is twofold. First, they supply all available information and references for current and would-be researchers and extensionists, thereby maximizing the utilization of current knowledge and preventing unnecessary duplication of work. Second, they illustrate that where research for the development of culture technology for native species is of paramount importance (as it frequently is in Africa, where wild genetic resources need protection and all too often external advisers have promoted transfers of exotic species without thoroughly assessing the attributes and potential of native species), existing information in an easily accessible synoptic form is extremely valuable. Malaŵi is a leader here for others to emulate. These synopses will be published by the Food and Agriculture Organization of the United Nations (FAO). Further synopses on other African farmed fishes are needed.

Results from the Preparatory Phase of the Aquaculture for Local Community Development (ALCOM) were presented by Haight. ALCOM has worked mainly in Zambia on pond aquaculture, integrated farming systems and utilization of small water bodies for fish production. It will expand its work to greater collaboration with other Southern African Development Coordination Conference (SADCC) countries from its Harare, Zimbabwe base. It is producing an increasing number of publications, including a widely-read newsletter.

Einarsson spoke on the interests of the Nordic countries in funding aquaculture projects in the SADCC subregion. At present, the Swedish International Development Agency (SIDA) supports ALCOM while the Norwegian equivalent, NORAD, supports a fish culture project in northern Zambia. Finland supports SADCC master's students on overseas study in Finland. Mr. Einarrson's position in Malaŵi is funded by Iceland.

Coche summarized FAO's large efforts to promote aquaculture development in Africa and Negroni and Gopalakrishnan provided detailed examples from projects in Brazzaville, Congo and Chilanga, Zambia, respectively. For the latter, the so-called 'Ziba' integrated farming program also uses *Oreochromis andersonii*, a native tilapia.

Malcolm V. Dickson and Peter Fox presented an account of progress in the Central and Northern Regions Fish Farming Project in Malaŵi, funded by the European Economic Community. The first trials with native species *O. shiranus* and *T. rendalli* are very promising. Malaŵi is advancing countrywide in research and adaptive trials for aquaculture development.

A presentation on *O. niloticus* culture in Sierra Leone by A.A. Bangura and M.B. Cole presented a more cautious picture with widely varying yields and many constraints. It was, nevertheless, exemplary in its recognition of the needs for interdisciplinary, intersectoral studies and for work with large numbers of farmers.

All in all, these presentations bode well for the future of African aquaculture. Success will depend upon a holistic approach to aquaculture development, integrated with other sectors, and continued technical and financial support. Much has been learned from past mistakes. The future looks much brighter.

A Synoptic Review of the Biology and Culture of *Oreochromis shiranus shiranus* and *Oreochromis shiranus chilwae*

O.V. MSISKA, *Domasi Experimental Fish Farm, Malaŵi Fisheries Department, P.O. Box 44, Domasi, Malaŵi (Present address: Department of Research and Environmental Affairs, P.O. Box 30745, Lilongwe, Malaŵi)*

Abstract

Oreochromis shiranus shiranus and *Oreochromis shiranus chilwae* are subspecies whose taxonomic separation was only recognized in the late 1960s. *O. shiranus* spp. are the most widely distributed of the endemic tilapias in Malaŵi. Their introduction into dams and ponds makes them also the most widely cultured tilapias in Malaŵi. This synopsis reviews information on the biology and culture of the two subspecies. The contents are as follows: systematics - nomenclature, taxonomy, affinities, external morphology; distribution - natural distribution, transfers; environmental tolerance; genetics; natural stocks - abundance, bionomics and life history, food and feeding habits; culture - acclimatization to suboptimal temperatures, use of inorganic and organic fertilizers, polyculture vs. monoculture in ponds, feeds and nutrition, control of reproduction by a fish predator, stocking densities in ponds, performance in farm dams; diseases, parasites and predators; research needs for fisheries - population genetics, conservation of genetic resources; research needs for aquaculture - nutrition, genetics, water quality and economics. The synopsis will be submitted to FAO for publication.

A Synoptic Review of the Biology and Culture of *Tilapia rendalli* (Boulenger)

B.B.A. RASHIDI, *Domasi Experimental Fish Farm, Malaŵi Department of Fisheries, P.O. Box 44, Domasi, Malaŵi (Present address: Commission of the European Communities (CEC), North and Central Regions, Aquaculture Project, P.O. Box 700, Mzuzu, Malaŵi)*

Abstract

The main fish species cultured in Malaŵi are *Oreochromis shiranus shiranus, O. s. chilwae, Clarias gariepinus, O. mossambicus, Tilapia rendalli* and *Cyprinus carpio*. A series of synoptic reviews has been started, concentrating on native Malaŵian species so as to optimize their culture, discourage the use of exotic species and stimulate further research. This synoptic review on *T. rendalli* collates information on its systematics, ecology, bionomics and life history, populations and exploitation in fisheries and aquaculture. *T. rendalli* is found in many reservoirs in the region, often exhibiting faster growth than other tilapias. Because its early offspring are more exposed to predation than those of mouthbrooding species, its populations tend to be limited in many water bodies. As an herbivore, it is highly favored in polyculture because of its ability to grow on plant material rather than on expensive artificial feeds. The potential of *T. rendalli* in fish farming may be increased by developing appropriate hatchery techniques to reduce the high fry mortality experienced in the wild. The synopsis will be submitted to FAO for publication.

ALCOM'S Approach and Study Results from Preparatory Phase Activities

B.A. HAIGHT, *FAO/ALCOM Aquaculture for Local Community Development Programme, P.O. Box 3730, Harare, Zimbabwe*

Abstract

The Aquaculture for Local Community Development Programme (ALCOM) seeks to develop, test and demonstrate methods and techniques by which rural people can improve their standard of living through aquaculture. The program concentrates on measures to introduce appropriate aquaculture practices to rural communities.

ALCOM uses test studies, surveys, field trials and technical consultations to define issues, develop solutions and disseminate results. The just completed three-year preparatory phase identified and elaborated six target areas: aquaculture and farming systems; utilization of small water bodies; extension/training methods; survey methods for national planning; project design/role of women and youth; and environmental aspects of aquaculture.

A pilot project undertaken in the eastern province of Zambia has developed a participatory extension process for promoting the adoption of aquaculture by rural communities. This process involves approaching farmers through their normal communication channels; adapting and introducing proven fish farming techniques which utilize locally occurring and available resources; and conveying the message about fish farming in such a way that it provokes interest and provides the necessary information to initiate decisionmaking among farmers. Extensionist-farmer communication, including farmers' perception of fish farming, was found to be an especially important component of the introduction and adoption process. A brief, thought-provoking participatory slideshow was developed to convey to subsistence farmers the idea, the necessary means and expected results of fish farming. Pamphlets with images and text were used to convey specific information about fish farming techniques during follow-up on-farm extension visits. A module was developed to train extensionists how to apply the fish farming extension method.

Based on studies and surveys, pilot projects have been formulated which focus on issues relating to harvesting strategies, small water body exploitation and aquaculture farming systems.

Management of Integrated Aquaculture Systems in the Rural Sector

V. GOPALAKRISHNAN, *FAO/GRZ/Net Fish Culture Development Project, P.O. Box 350034, Chilanga, Zambia*

Abstract

Aquaculture development programs in Zambia are directed towards three target groups: commercial farmers, emergent farmers and peasant farmers. Management practices have been tested by FAO-executed projects in Zambia (funded by FAO, UNDP and Netherlands) for developing integrated fish farming systems in different parts of the country. Among the fish-animal husbandry subsystems, those using fish-cum-pigs, fish-cum-ducks and fish-cum-chickens have yielded impressive results.

Fish/pig culture is based upon a 1.5-m^2 shed stocked at 90 pigs/ha. Pigs are stocked at 20-25 kg and fattened to 100 kg live weight. Fish production averages 4-6 t/ha/year. Chickens are grown above or on pond banks of 500-m^2 ponds, with 25-30 birds adequate to fertilize a pond. If chickens are grown in a separate house, manure is added to ponds at 2.5-5.0 kg/100 m^2/day, or 17.5-35 kg/500 m^2/week. Fish

production with two crops of *Oreochromis andersonii* has reached 6,552 kg/ha/year with these fertilization regimens.

An integrated tilapia breeding pond system has been developed with a 2,000-m^2 pond and 25% of the area fenced to confine Peking ducks. *O. andersonii* broodstock are added between August and October at 30/100 m^2 at 1 (male):4 (female). Total fry and fingerlings harvested in each season from 1983-84 to 1989-90 (continuing) has ranged from 77,800 to 308,449 (188-736/female stocked).

A strategy for small fish farming, tentatively named the "Ziba" program, has been developed to promote aquaculture and encourage integrated farming with animal husbandry and crops. A 500-m^2 fishpond is developed, fertilized with 4 pigs, 25 ducks or 25-30 chickens/pond, depending on farmer preference. *O. andersonii* of 10-20 g average weight are stocked at 1,250-1,500/pond and grown for 6 months so that two fish cropping cycles per year are possible.

The Central and Northern Regions Fish Farming Project: Research, Progress and Prospects

M.W. Dickson and P. Fox*, *Commission of European Communities (CEC), North and Central Regions Aquaculture Project, P.O. Box 700, Mzuzu, Malaŵi (*Present address: 33 Roundshill, Kenilworth, Warwickshire CV8 1DW, England, UK)*

Abstract

The Central and Northern Regions Fish Farming Project started at the end of 1988 with its headquarters in Mzuzu in the Northern Region of Malaŵi. The aim of the project is to improve the supply of fish through fish farming in the project area.

A ten-minute video presents the context and physical developments in the project.

Initial research has concentrated on demonstrating fish farming methods suitable in the northern parts of Malaŵi. One of the main points in the pre-implementation reports was that much of the project area is at relatively high altitudes and would therefore be subject to temperature regimes which may be too low for good fish growth. Temperature data collected at Mzuzu (altitude 1,250 m) demonstrate that pond water temperatures have been maintained over average air temperatures, and that average water temperatures have been over 20°C since early September. This suggests a growing season for tilapia of 8-9 months/year. Pond temperatures at Limphasa (altitude 500 m) have been approximately 5°C warmer. The first meaningful production trials are still in progress. These are being carried out using fish methods developed in the Mzuzu area.

Subjects under study are:

1. comparison of growth rates between two varieties of *Oreochromis shiranus* and *Tilapia rendalli* using *madeya* (4% of body weight/day) and inorganic fertilizer. An experiment comparing the use of *madeya* to chicken broiler mash is also ongoing;
2. growth of *O. shiranus* at different stocking densities;
3. use of agricultural by-products as feed/fertilizers for *O. shiranus*, such as chicken and cattle manure, chibuku (maize beer) waste and tung oilseed cake;
4. growth of lake *Oreochromis* sp. *(O. polydon)*;
5. cage culture of *O. shiranus* and *T. rendalli*;
6. growth of *O. shiranus* from Mzuzu and Limphasa;
7. yields of rice and fish in rice-fish culture; and
8. use of fallow rice plots for fish culture.

So far growth rates are promising (specific growth rates [SGR] range 1.5-4.0 for fish of 5-25 g). Future research will concentrate on developing the most appropriate techniques for use in areas identified by the extension team.

The Involvement of the Nordic Countries in the Development of Aquaculture in Africa

O.V. EINARSSON, *Iceland International Development Agency (ICEIDA), P.O. Box 593, Lilongwe, Malawi*

Abstract

The Nordic countries are currently funding two aquaculture projects in Africa. One is the "Aquaculture for Local Community Development Programme" (ALCOM) funded by the Swedish International Development Agency (SIDA) and implemented by the Food and Agriculture Organization of the United Nations (FAO). This is a regional Southern African Development Coordination Conference (SADCC) program which aims to develop, test and demonstrate strategies, methods and techniques for assisting rural people in improving their quality of life through the development of aquaculture. The other is "Fish Culture in the northern province of Zambia", a bilateral project funded by the Norwegian Ministry of Development Cooperation (NORAD). This project will serve as a basis for rural development and fish culture in the northern province of Zambia. The project's activities have concentrated on the improvement of dry fish production and extension services, apart from the rehabilitation of a governmental aquaculture station.

Linked to aquaculture development in Africa is an M.Sc. training program offered to students from four SADCC states and funded by the Finland International Development Agency (FINIDA). The contents of this program cover biological, economic and managerial aspects of fisheries and aquaculture. The program is run by the University of Kuopio in Finland.

The Danish International Development Agency (DANIDA) and Iceland International Development Agency (ICEIDA) are currently not funding any aquaculture activities in Africa.

The Role of FAO in Aquaculture Research and Development for Africa

A.G. COCHE, *FAO Fisheries Department, Via delle Terme di Caracalla, Rome 00100, Italy*

Abstract

The Food and Agriculture Organization of the United Nations (FAO) has been deeply involved in aquaculture research and development in Africa south of the Sahara, mainly through desk studies, activities of its regional fishery bodies, various field projects and by providing direct technical support to member countries. FAO's interests have centered on applied and empirical aquaculture research and the interchange of ideas through the coordination and dissemination of information.

FAO supports desk studies on biological, technological and economic subjects related to aquaculture development. Research in individual countries is coordinated by FAO Regional Fishery Bodies such as the Committee for Inland Fisheries of Africa (CIFA) and the European Inland Fisheries Advisory Commission (EIFAC).

FAO has directly supported aquaculture field research and development projects in 25 countries south of the Sahara in the past 20 years.

Technical support from FAO headquarters staff or FAO consultants is an important part of work in Africa. FAO also supports training of nationals in its field projects through seminars, short courses and development of extension packages.

Appropriate Technology for Integrated Aquaculture for Developing Countries

G. NEGRONI, *Food and Agriculture Organization of the United Nations, BP 972, Brazzaville, Congo*

Abstract

The main guidelines of appropriate technology are explained. One practical application of appropriate technology is to integrate aquaculture with other activities to maximize production. Animal utilization integrated with aquaculture could give very good production if properly managed. Theoretical principles and practical cases are discussed. The purpose of the paper is to stimulate discussion and future research on aquaculture farming systems.

The Development of Aquaculture in Sierra Leone with Emphasis on the Fisheries Program of the Bo/Pujehun Rural Development Project

A.A. BANGURA and M.B. COLE, *Fisheries Program, Bo/Pujehun Rural Development Project, Bo, Sierra Leone*

Abstract

Sierra Leone is a coastal nation on the southwestern coast of West Africa. It has an area of 73,326 km^2 and a population of about 4.5 million. Although cattle are of primary importance in the north, fish accounts for about 85% of the total annual protein intake of the population. However, protein malnutrition is common among inhabitants, especially in the rural areas due to marketing and transportation problems.

Studies have identified the northeast as suitable for pond aquaculture since rice culture is common, land and water resources are good and a great need for protein exists in the rural area.

The Bo/Pujehun Rural Development Project has adopted an integrated multisectoral approach in agriculture, fisheries, primary health care, community development, water supply and rural roads improvement. A fish station was established in 1988 with six production ponds of 2,800 m^2, an office, classroom and store.

Fish culture has had mixed success. Initial yields discouraged farmers; this was due to small pond sizes (< 200 m^2) and poor management. The project is working with 98 fish farming families and institutions representing three ownership patterns (individual, community and institutional). The groups have about 200 ponds averaging 417 m^2. Fish production from *Oreochromis niloticus* has ranged widely, from 400 to 4,500 kg/ha/year.

Major constraints are: inadequate extension personnel; low staff morale; inadequate labor for pond construction; poor knowledge base; poor pond management; and lack of tradition in fish farming. Despite the problems, fish farming in Bo district is growing rapidly.

SESSION VI
WORKING GROUP REPORTS AND RECOMMENDATIONS

Group I
Development
Convened by Dr. B. Satia and Mr. B. Rashidi

The group reviewed the status of aquaculture in the region, including diagnosis of problems and constraints, identification of needs and recommendations to improve the situation.

A. PROBLEMS/CONSTRAINTS

The following problems and constraints were diagnosed:

1) Lack of appreciation of the diverse sociocultural and environmental conditions in the region.
2) Lack of sufficient sociocultural and economic research to help adapt existing biotechnological packages to the needs of small farmers.
3) Lack of appropriate technology.
4) Lack of adequate extension, which may range from a complete absence of extension services, to inadequacy of resources for extension and absence of appropriate extension tools.
5) Inadequate linkages between research and extension.
6) Lack of funds.

B. NEEDS

1) Governments and funding agencies must recognize the peculiarities in the various countries of the region and consider these in any efforts to develop aquaculture.
2) The sociocultural and economic background of small farmers should be taken into account in efforts to develop aquaculture.
3) In view of the diversity within the region, there is a need to develop appropriate technology for specific areas.
4) Extension in the region must be strengthened, bearing in mind the prevailing conditions in the different countries.
5) Linkages between research and extension need to be established and strengthened in many countries of the region.
6) Although the development of rural aquaculture is recognized as an important activity, financial support to the sector is very small. There is a need to provide additional and adequate support.

C. RECOMMENDATIONS

1) Improve awareness of governments and funding agencies of the diverse nature of the sociocultural and environmental conditions for aquaculture development in the region.

2) Increase research efforts to adapt aquaculture technology appropriate to local conditions.
3) Develop and promote effective extension services.
4) Promote better communications and collaboration between research and extension services.
5) Governments should provide adequate and sustained support for aquaculture development.

Group II
Integrated Systems Research
Convened by Drs. K. Ruddle and C. Lightfoot

The group focused on two areas: (a) present and likely future research issues; and (b) research approaches and mechanisms that should be used to address those issues.

A. Research Issues

1. CONCEPTUAL

a) Sustainability; investigate its meaning and measurement;
b) integration; investigate its basis and rationale.

2. TOPICAL

a) Determine the sustainability of IFS and its long-term impacts on the environment;
b) determine the scope of traditional ecological knowledge;
c) identify resources and other factors that favor development of IFS: e.g., agricultural by-products; water management; adoption of rice farming; etc.
d) determine the level of access to and type of management of common property resources as factors affecting potential resources for IFS;
e) identify biophysical and socioeconomic constraints experienced by existing operators of IFS and new entrants;
f) determine the strategies for and costs of Integrated Pest Management that may be possible through IFS;
g) determine the public health risks associated with the use of livestock manures in aquatic environments;
h) determine the ability of farmers to cope with the additional management complexities of IFS;
i) evaluate and understand different IFS.

3. DESIGN AND DEVELOPMENT OF INTEGRATED FARMING SYSTEMS

a) Design integrated farming systems (IFS) with recycling of resources, low-risk, low-cost inputs and appropriate characteristics for specific locations;
b) conduct IFS surveys to enhance understanding of such systems;
c) evaluate the environmental, nutritional, economic, equity and other impacts of IFS;

d) develop an understanding of the opportunity costs and compromises of and among different combinations within systems;
e) determine the acceptability of the IFS to small-scale farmers;
f) determine the kinds of baseline information needed to understand and design IFS;
g) determine the required levels of external inputs for IFS;
h) determine the possible arrays of components of IFS and their proportions and interactions.

4. IMPLEMENTATION

a) Determine the nature of institutional linkages required to implement and sustain IFS, including linkages with component research;
b) determine and assist information feedback among user groups, researchers and extensionists;
4) determine the personnel requirements and labor and gender issues involved in IFS and supportive research and extension.

B. Research Mechanisms and Approaches

An interactive approach is essential for IFS research. It must include on-farm participatory research with resource-poor farmers and computer-assisted bioeconomic modelling, both of which must be integrated with on-station testing of IFS and problem-solving component research. The objective is to prepare detailed farm- and regional-level scenarios for extension and rural development planning.

1. BIOECONOMIC MODELLING OF IFS

a) Investigate the resource base and quantify the on-farm flow of resources among IFS components;
b) simulate manipulation of resource flows to improve level of integration and yields and reduce inputs in IFS;
c) analyze household nutritional and economic status and requirements.

2. REGIONAL/ECOSYSTEM LEVEL STUDIES

a) Determine the types of linkages and interactions of IFS with the external environment and the economy;
b) undertake agroecological mapping of land capabilities for IFS;
c) employ Geographical Information Systems (GIS) for extrapolation of models and their potential impact;
d) determine the ethnohistorical background and socioeconomic context of IFS and their implications for future development.

3. ON-FARM RESEARCH

a) Undertake participatory research with farm households to design IFS.

4. LINKAGES WITH ON-STATION RESEARCH

a) Feedback information and questions/problems to on-station researchers on IFS components.

5. LINKAGES WITH EXTENSION

a) Undertake IFS pilot projects;
b) organize "Show and Tell" demonstrations of IFS to target groups;
3) provide seminars/workshops.

6. NETWORKING

a) Develop national and international networks of institutions and researchers to facilitate exchange of ideas and information and to share the research tasks.

Group III
Aquaculture Component Research
Convened by Drs. R.S.V. Pullin and B.A. Costa-Pierce

The group defined Aquaculture Component Research (ACR) as problem-solving by discipline. The scope of discussions included the social and biotechnical sciences. The results are summarized in the list that follows. This can be called a 'shopping list'. The group makes no apology for this or that no prioritization is given. Setting priorities would have been an exercise taking a very long time and still a consensus may have not been achieved.

The group recognized the weakness of the research base for aquaculture development in Africa and recommended sustained support for research in all the listed problem areas. The list may not be exhaustive as the group's time was limited.

There was a consensus on identification and inclusion of the listed topics. There was, however, one topic that was controversial, namely, research for the development of human waste (excreta) reuse in aquaculture. It is listed as a research topic but there was a polarization of views on this. Some felt that with population growth, urbanization trends, and with the recognition in other regions that human wastes are in fact "out of place" valuable resources and can/should be reused, Africa should also pursue research in this area. There was, however, a view that since consumer attitudes to produce fish raised on excreta would be so negative, and that there would be health risks, human excreta reuse was not an appropriate research topic. The topic is included here so as not to put up barriers for those who do see a future for this type of aquaculture and want to do research for its safe development.

General topics on which the group felt needed much more research was needed were on gender issues and the role of women in aquaculture.

1. Social Science

a. Macroeconomics	Fish supply/demand Support policy for fish production (capture/culture) Support/policy for production of competitive produce Multiplier effects of aquaculture development

b. Institutional relationships	Extension mechanisms (intersectoral aquaculture-agriculture activities) Institutional roles in research (basic, applied, etc.) and information dissemination to government, farmers Grass roots institutional support (clubs, village development committees) at the local, regional, national and international levels Research coordination within and among institutions Research/extension interface Intersectoral cooperation between ministries on nutrition, health and environmental issues
c. Human nutrition	Impact of aquaculture on human nutrition Dietary habits (which fish, what form, frequency of consumption, etc.) Partitioning of fish harvest among consumers (by sex, age, seniority, social status)
d. Public health	Environmental pollution by aquaculture Water-borne diseases (assessment of prevalence; minimizing risk of workforce; pond siting to minimize risk; vector and intermediate host control and its effects on nontarget species) Other occupational hazards (from wastes, feed components, predators, rats, snakes) Health impacts from multiple use of ponds (washing utensils, bathing, drinking) Food preparation
e. Socioeconomics	Land tenure and other property relationships including gender issues Demographic and economic characteristics of fish farmers Farmer's attitudes to risk and innovation Attitudes to technological innovation and attitudes to options for resource use Attitudes to technologies and those advocating change Sectoral policy issues
f. Household (Microeconomics)	Resource assessments (labor, income, etc.) Profitability of aquaculture enterprises Distribution of produce (home consumption, exchange, gifts, sale, festivals) Marketing aspects (transportation, processing, prices) Longitudinal research (dynamic changes/future trends)
2. Biotechnical	
a. Fish nutrition	Resources available (quality, quantity, availability) for fish feeds

	Proximate analysis of feed components Palatability/feed acceptance studies Digestibility and conversion of feeds Low-cost feed formulations Environmental interactions of feeds and feed components Protein-energy relations Anti-nutritional factors (storage methods, etc.) Human waste (excreta) reuse in aquaculture vs. other options Nutritional requirements of target species
b. Fish reproduction	Low-cost hatchery systems Factors affecting reproductive performance (nutrition, water quality, other environmental factors) Reproductive biology of candidate species Factors affecting seed quality (survival, growth)
c. Fish genetics	Documentation of genetic resources Evaluation of wild and on-farm genetic resources Utilization of genetic resources in genetic improvement programs to produce better breeds for low-cost aqua-culture systems Genetic manipulations (chromosomal manipulations, sex control, etc.)
d. Fish health	Parasite infestations and diseases in relation to environmental factors (stocking, density, season) Effects of low-level infestation and infections on growth, etc. (long-term monitoring) Diagnostic techniques, description of host reactions/pathology Use of local materials in stress control, prophylaxis and chemotherapy
e. Research methods	Assessment of the appropriateness of conventional methods for analysis of aquaculture experimental data A survey of analytical tools used in other fields of science (e.g., ecology, econometry) that might be applied to aquaculture research (quantitative methods) Development of new analytical tools for aquaculture research Modelling for use both as a research planning and analysis tool.

Working Group Participants

GROUP I
DEVELOPMENT

Mr. J.D. Balarin
Mr. H. Chavula
Mr. F. Chikufumbwa
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Mr. O. Einarsson
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Mr. B. Haight
Mr. M. Kapeleta
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Prof. J. Mlia
Mr. J. Mutambo
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Dr. G. Otte
Mr. B. Rashidi
Dr. B. Satia
Mr. Saulosi
Dr. T. Twongo
Mr. P. Vincke

GROUP II
INTEGRATED SYSTEMS RESEARCH

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Mr. A. Bangura
Mr. A. Chinkhadze
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Mr. K. Tchikati
Mr. A. A. van Dam
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GROUP III
AQUACULTURE COMPONENT RESEARCH

Mr. G. A. Banda
Dr. S. Chiotha
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Dr. B. Mgbenka
Mr. Miti
Mr. O.V. Msiska
Mr. J. Ofori
Dr. R.S.V. Pullin
Mr. R. Zweig

FISHERIES DEPARTMENT POLICY GUIDELINES TO CONTRIBUTE TO THE GOVERNMENT OF MALAŴI'S NATIONAL OBJECTIVES FOR AQUACULTURE

The Chief Fisheries Officer of the Fisheries Department, Ministry of Forestry and Natural Resources of the Government of Malaŵi, Mr. B. Mkoko, has summarized the national policy guidelines for aquaculture development in Malaŵi as follows:

Development policies for 1987-1996 will seek to promote aquaculture development as a means of raising rural farm incomes and increasing the supply of fresh fish in rural areas. To attain its policy goal, the Fisheries Department will work to create an environment which will enable as many farmers as possible to equally participate in and enjoy the benefits of aquaculture. All directly or indirectly connected with Fisheries Department will work to this end of helping farmers participate in aquaculture.

The operational objectives for the Fisheries Department are to:

1. facilitate the dissemination of aquaculture and integrated agriculture-aquaculture farming system technologies;
2. generate aquaculture production technologies and integrated agriculture-aquaculture farming system strategies in participation with farmers;
3. identify new opportunities in aquaculture particularly in the culture of alternative indigenous species; and
4. provide information to guide policy formulation.

CONFERENCE PROGRAM

RESEARCH FOR THE DEVELOPMENT OF TROPICAL AQUACULTURE TECHNOLOGY APPROPRIATE FOR IMPLEMENTATION IN RURAL AFRICA
2-6 APRIL 1990
CHANCELLOR COLLEGE, ZOMBA, MALAŴI

SUNDAY, 1 APRIL 1990

1430	Bus Departs Lilongwe Hotel for Zomba
1730-1900	Registration of International Delegates at Kwacha Hall of Residence, Chancellor College, University of Malaŵi, Zomba

MONDAY, 2 APRIL 1990

0700-0815	Registration at Conference Secretariat (First Year Biology Laboratory, Chancellor College, Zomba)

I. Opening Ceremonies

	Master of Ceremonies: Representative from the Ministry of Local Government Chairperson: Chief Fisheries Officer a) Domasi Inauguration: Venue: Domasi Experimental Fish Farm
0815	Bus Departs Chancellor College Main Car Park via Zomba Fisheries Department Office for Domasi
0900-1030	Cutting of Ribbon to Open New Complex at Domasi, Tour of Facilities
1030	Transport to Chancellor College and Assembly in Lecture Theatre I a) Opening Ceremonies Venue: Lecture Theatre I, Chancellor College, Zomba
1100-1200	(1) Welcoming Address by the Master of Ceremonies (2) Welcoming Address by the Director of the Aquaculture Program of ICLARM (3) Welcoming Address by the Representative from GTZ (4) Welcoming Address by the Representative of the University of Malawi (5) Official Opening by the Minister of Local Government The Honorable Mr. Edward C.I. Bwanali, M.P.
1200-1300	Group Photograph and Refreshments in Senior Common Room
1300-1410	Lunch Break

II. Conference Organization Session

	Venue: Lecture Theatre I, Chancellor College
1410-1420	Introduction to Conference Objectives (R.S.V. Pullin)
1420-1430	Adoption of Working Groups (J.D. Balarin and B.A. Costa-Pierce, Working Group Coordinators) Suggested Working Groups and Leaders: Group I: Development Chairperson: B. Satia Group II: Integrated Systems Research Chairpersons: K. Ruddle and C. Lightfoot Group III: Aquaculture Component Research Chairpersons: R.S.V. Pullin and B.A. Costa-Pierce

III. Session on Background Social, Cultural, Bioeconomic and Technical Basis

Venue: Lecture Theatre I, Chancellor College
Chairperson: K. Ruddle
Rapporteur: D. Ng'ong'ola

1430-1500 "The Evolution of Fish Farming in Malaŵi" (O.J.M. Kalinga)
1500-1530 "The Status of Aquaculture Research and Development in Malaŵi" (O.V. Msiska)
1530-1615 Refreshments in Senior Common Room, Chancellor College (SCR)
1615-1645 "The Status of Fish Farming in Zomba District" (R.P. Noble and S. Chimatiro)
1645-1715 "An Economic Analysis of Fish Farming in Malaŵi" (B. Kandoole and M.M. Mkwezalamba)
1800-1930 Cocktail Reception
Venue: Senior Common Room, Chancellor College
Hosted By: The Principal, Chancellor College

TUESDAY, 3 APRIL 1990

Venue: Lecture Theatre, Chancellor College
Chairperson: B.F. Kandoole
Rapporteur: C. Lightfoot

0830-0900 "Farm Household Decisionmaking with Reference to Fish Farming in Zomba District, Malaŵi" (G. A. Banda)
0900-0930 "Entrepreneurship in Integrated Small-Scale Fish Farming" (G.G. Mills)
0930-1000 "Aquaculture Innovation — Its Diffusion and Adoption in Central Malaŵi" (J.S. Likongwe)
1000-1045 Refreshments (SCR)
1045-1115 "Land Rights, Security of Tenure and Fish Farming Development: The Case of Zomba and Mwanza Districts, Southern Malaŵi" (P. Kishindo)
1115-1145 "Socioeconomic Constraints to Fish Farming Integration and Impediments to the Acceptability of Fish Cultured in Manured Ponds in Malaŵi: The Case of Dedza Hills and Lilongwe Northeast Rural Development Projects" (D. H. Ng'ong'ola)
1145-1215 "The Role of Aquaculture in Household Food Security, Nutrition and Health Status in Central Malaŵi" (R.B. Ayoade)
1215-1245 "Sociodemographic and Socioeconomic Profiles of Fish Farmers in the West and Northwest Provinces of the Republic of Cameroon" (B.P. Satia, P.N. Satia, and A. Amin)
1245-1400 Lunch Break

IV. Session on Ecology of Smallholder Farms

Chairperson: O. V. Msiska
Rapporteur: B. A. Costa-Pierce

1400-1430 "Principles and Methodology of Ecological-Economic Modelling of Integrated Agriculture-Aquaculture Farming Systems" (R. Zweig)
1430-1500 "On-Farm Biotic Resources for Small-Scale Fish Farming" (R.P. Noble and S. Chimatiro)
1500-1530 "The Potential of Fishponds in Bilharzia (Schistosomiasis) Transmission" (S.S. Chiotha and C. Jenya)
1530-1645 "A Survey of Fish Poison Plants in Malaŵi — Their Traditional Uses and Potential Roles in Integrated Fish Farming" (J. Seyani and S.S. Chiotha)
1645-1700 "Molluscicidal and Piscicidal Properties of Indigenous Plants" (S.S. Chiotha, J.H. Seyani and E.C. Fabiano)
1700-1715 "Molluscicidal Components of Plant Origin" (J.D. Msonthi)

WEDNESDAY, 4 APRIL 1990

Venue: Lecture Theatre I, Chancellor College

V. Results of Biological Research

Chairperson: S. Williams
Rapporteur: J. Likongwe

0830-0900 "Fry Production of *Oreochromis shiranus* in Hapas" (A.O. Maluwa)
0900-0930 "Ash as a Liming Agent in Fishponds" (D.M. Jamu)
0930-1000 "Effects of Different Feeding Rates of Maize Bran (*Madeya*) on *Oreochromis shiranus* and *Tilapia rendalli* Juveniles in Polyculture" (W.K Kadongola)
1000-1030 "Use of Napier Grass (*Pennisetum purpureum*) and Maize Bran (*Madeya*) for Small-Scale Aquaculture in Malaŵi" (F.J.K.T. Chikafumbwa, W.K. Kadongola, D.M. Jamu, J.D. Balarin and B.A. Costa-Pierce)
1030-1100 "Combinations of On-Farm Resources (Napier Grass, Maize Bran and Wood Ash), Urea and Stirring for Small-Scale Aquaculture (J.D. Balarin, B.A. Costa-Pierce and F.J.K.T. Chikafumbwa)
1100-1130 "Some Impacts of Manual Pond Stirring on Aquaculture Ponds in Malaŵi (B.A. Costa-Pierce)
1130-1200 ""Multivariate Analysis of *Tilapia rendalli* Growth as Affected by Water Quality Changes and Inputs (Napier Grass, Wood Ash, Maize Bran) in Aquaculture Ponds in Malaŵi" (M.V.Kapeleta, B.A. Costa-Pierce and A.A. vam Dam)
1200-1400 Lunch Break
1400-1430 "Relative Performance of Alternative Pond Harvesting Techniques" (E.K.W.H. Kaunda)
1430-1500 "A Proposed Pond Management System for Small-Scale Fish Farmers in Southern Malaŵi" (G. Otte)
1500-1530 "Preliminary Results of Integrated Chicken-Fish Culture in the Rural Areas of Congo" (E. Kali-Tchikati)
1530-1600 Refreshments (SCR)
1600-1630 "Digestibility of Some Agricultural By-Products by African Catfish (*Clarias gariepinus* Burchell 1822) and Preliminary Investigation on the Effects of L-Ascorbic Acid (Vitamin C) in an Agricultural By-Product-Based Diet on the African Catfish" (B.O Mgbenka)
1630-1700 "Why ANOVA is Not Very Effective in Analyzing Pond Experiments" (A.A. van Dam)
1700-1730 "Participatory Methods for Integrating Agriculture and Aquaculture: Examples of Farmers' Experiments in Rice-Fish Integrated Farming" (C. Lightfoot)

THURSDAY, 5 APRIL 1990

VI. Session on Other Reviews and Related Studies on African Aquaculture

Venue: Lecture Theatre I, Chancellor College
Chairperson: R.S.V. Pullin
Rapporteur: R. Noble

0820-0840 "A Synoptic Review of the Biology and Culture of *Oreochromis shiranus shiranus* and *Oreochromis shiranus chilwae*" (O.V. Msiska)
0840-0900 "A Synoptic Review of the Biology and Culture of *Tilapia rendalli* Boulenger" (B.A. Rashidi)
0900-0920 "ALCOM's Approach and Study Results from Preparatory Phase Activities" (B.A. Haight)
0920-0940 "Management of Integrated Aquaculture Systems in the Rural Sector" (V. Gopalakrishnan)
0940-1020 Refreshments (SCR)
1020-1040 "The Central and Northern Regions Fish Farming Project: Research, Progress and Prospects" (M. Dickson and P. Fox)
1040-1100 "The African Aquaculture Research Programme of the Nordic Countries" (O.V. Einarsson)

1100-1120	"The Role of FAO in Aquaculture Research and Development for Africa" (A. Coche)
1120-1140	"The Development of Aquaculture in Sierra Leone with Emphasis on the Fisheries Programme of the Bo/Pujehun Project" (A.A. Bangura and M.B. Cole)
1140-1200	"Appropriate Technology for Integrated Aquaculture for Developing Countries" (G. Negroni)
1200-1400	Lunch Break
1400-1530	Working Groups Session Group I: Lecture Theatre I Group II: Lecture Theatre II Group III: 4th Year Biology Laboratory
1530-1600	Refreshments (SCR)
1600-1645	Video Presentation on Catfish Culture (G. Negroni)

FRIDAY, 6 APRIL 1990

0800-1230	Free Time
1230-1400	Lunch Break

VII. Discussion Session of Recommendations and Conclusions

	Venue: Lecture Theatre I, Chancellor College
	Chairperson: B. Mkoko
	Synthesis of Working Group Recommendations
1400-1430	Group I: Development by Drs. B. Satia and B. Rashidi
1430-1500	Group II: Integrated Systems Research by Drs. K. Ruddle and C. Lightfoot
1500-1530	Group III: Aquaculture Component Research by Drs. R.S.V. Pullin and B.A. Costa-Pierce

VIII. Closing Session

	Venue: Lecture Theatre I, Chancellor College
	Chairperson: B. Mkoko
1530-1600	Refreshments (SCR)
1600-1630	Final Discussion Session/Recommendations
1630-1700	Closing Ceremonies (Lecture Theatre I)
1700-1900	Cocktail Reception Venue: Senior Common Room, Chancellor College Hosted by: GTZ and ICLARM Representatives

LIST OF PARTICIPANTS

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