Research for the Future Development of Aquaculture in Ghana

Edited by Mark Prein, Joseph K. Ofori and Clive Lightfoot

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Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)/
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

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Summary Papers of the ICLARM/IAB Workshop
Accra, Ghana
11-13 March 1993

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Published by Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)/Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Bonn and Eschborn, Germany;
Institute of Aquatic Biology (IAB), Council for Scientific and Industrial Research (CSIR), P.O. Box 38, Achimota, Ghana;
and International Center for Living Aquatic Resources Management (ICLARM), MCPO Box 2631, 0718 Makati City, Metro Manila, Philippines.

Printed in Manila, Philippines.

The ICLARM's Technical Series was developed in response to the lack of existing publishing outlets for longer papers on tropical fisheries research.

The ICLARM Conference Proceedings Series consists of conference and workshop documents which synthesize and interpret information, some of which may be new, and present new insights into existing problems.

All documents (other than abstract and summary papers) in the series are carefully peer reviewed externally as well as within ICLARM. Those published are thus equivalent to primary literature. About 600 copies of each title are usually disseminated - sold or provided in exchange or free of charge.

Prein, M., J.K. Ofori and C. Lightfoot, Editors. 1996. Research for the future development of aquaculture in Ghana. ICLARM Conf. Proc. 42, 94 p.

Cover: The first harvest. One of the new-entrant smallholder farmers who began integrated aquaculture-agriculture in the course of the ICLARM/IAB research collaboration. Photo by Mark Prein.

ISSN 0115-4435
ISBN 971-8709-43-6

ICLARM Contribution No. 956

Contents

Foreword

Since 1986, ICLARM has implemented a series of projects aimed at tackling the very difficult problem of how to develop, through research partnerships with national scientists and farmers, sustainable integrated agriculture-aquaculture systems on resource-poor African smallholdings. This work, centered in Ghana and Malaŵi, has been supported very generously and continuously by the Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) through the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Germany. This publication derives from a workshop convened under one such project, entitled "Research for the Future Development of Aquaculture in Ghana" in which the Institute of Aquatic Biology (IAB) and the Ghana Rural Reconstruction Movement (GhRRM) were ICLARM's partners from 1991to1994.

In Ghana, as elsewhere in subSaharan Africa, previous attempts to develop small-scale pond aquaculture had met serious difficulties. The history of the region is full of accounts of externally funded projects that encouraged enthusiasm for aquaculture and subsequent widespread pond construction, followed by failure and disillusionment as water shortages, lack of material inputs and management problems became the reality. Such experiences convinced many that small-scale pond aquaculture, even when integrated with other farm enterprises, was simply not feasible in the region and that larger-scale, commercial, intensive fish farms were probably the only systems that might succeed and produce significantly more fish to feed Africa's rapidly growing population.

Against this view, and against much of the policymaking to which it was leading, ICLARM and its partners took a different approach to aquaculture on African smallholdings. Their hypothesis was that small-scale integrated farming systems could not only help to alleviate the poverty and to improve the nutrition of farm families but might also provide contributions to fish supply that, although small on an individual basis, could become very significant if widely adopted. It was felt that small farm ponds, rather than fishponds per se, could facilitate much larger supplies of other produce especially vegetables. This hypothesis was tested in Ghana as part of ICLARM's integrated resources management (IRM) research thrust. With an IRM approach, all resources available to a smallholder farm family are considered, bioresource flows among farm enterprises are maximized, produce is diversified, and both productivity and sustainability are improved.

Farm ponds are potentially one of the most valuable components of IRM systems. They can raise farm productivity and improve income and farm family nutrition (through diet diversification). This can apply even in drier areas where ponds are seasonal. Aquaculture is not the sole, or even the main purpose of such farm ponds. They are multipurpose and synergistic, linking and facilitating different farm enterprises. They provide opportunities which are very different from previous attempts to turn African farmers into fish farmers or to promote integrated farming packages (duck-fish, rice-fish, etc.) devised elsewhere. Such attempts have usually failed with the farmers themselves.

The results to date are small but significant. They are among the few indications that aquaculture on African smallholdings can succeed. At the time of publication, two years after the end of the project, some 45 farmers are practicing the same methods and have evolved their own self-help organization - the Mampong Valley Fish Farmers Association - for sustaining and expanding their activities. Much more work is needed, however, to see whether such an IRM approach, with small-scale aquaculture and its water management as an enabling mechanism rather than as simply an end in itself, can succeed on a wider front in the region. ICLARM and its partners hope to continue their involvement in this exciting field of work and greatly appreciate the German support extended to the efforts described here.

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main advantages of the cooperation were the grass-roots contact maintained with the farmers and the knowledge of particular characteristics of the area.

Human health aspects surrounding the introduction and management of a stagnant, wastefed water body close to homesteads were considered from the beginning. Farmers and family members were educated on the implications of pond management (i.e., weeding) to avoid hiding opportunities for mosquito larvae and snails (in respect to malaria and schistosomiasis). In general, the farmers showed an already existing awareness of potential health hazards associated with the introduction of human excreta into ponds.

The prevailing human ecological context in Ghana was described, outlining the degraded state of the environment (deforestation, erosion, soil nutrient depletion), the high rate of population increase (2.6% per year) and the extent of malnutrition.

The potential impact of integrated agriculture-aquaculture (IAA) systems on sustainable farming practices in Ghana was outlined, based on preliminary results of the research conducted with a set of farmer-adopters in Mampong Valley. Benefits were shown in terms of production, economics and sustainability indices computed from the data collected from the monitoring of farmer experiments, as analyzed with the computer software developed at ICLARM. It was estimated that the adoption of integration by smallholder farmers on a wider basis in Ghana has potential for the improvement of food supply and farm income. It was shown that, given the existing human ecological context factors in Ghana, changes in agricultural practices are of highest importance. Further, if the growing population is to be fed from the continuously degraded land in the future, IAA systems offer a viable means to counteract this threat, but only to a certain extent.

Given the presently perceived outlook and context, it seems likely that neither IAA nor commercial aquaculture alone will provide the amounts of fish protein required by the projected population size. Together, combined with a diversity of other development options, they can contribute to, but perhaps not satisfy the projected needs.

Acknowledgements

We gratefully acknowledge the opening of the workshop with the addresses by Honorable Ibrahim Adam (Minister of Agriculture and Food), Navy Captain K.A. Buta Rtd. (Minister of Science and Technology), J.J. Meijer (Assistant FAO Representative in Ghana, FAO Regional Office for Africa), M. Bilio (Senior Adviser, Fisheries and Aquaculture, GTZ Eschborn), R.S.V. Pullin (Director, Inland Aquatic Resource Systems Program, ICLARM) and M.A. Odei (Acting Director General, CSIR).

The workshop was prepared and supported by numerous staff of IAB/CSIR, notably M.A. Odei, E.K. Abban, C. Biney, K. Agbogah, J. Opoku-Boateng and J.A. Anyen. The contribution of the following IAB staff who served as rapporteurs during the workshop is greatly acknowledged: Mathilda Ampom-Darkwa, Ruby Hammond, Osmund Ansa-Asare, Francis Amevenku, Joseph Ampofo and Kofi Agbogah.

The workshop conducted a one-day field trip to a project site of GhRRM. We acknowledge the hosting done by Alex Baah, David Y. Owusu, Patterson Gamli, Samson Sampong and Felix Afum at the Yensi Centre.

We are grateful to the farmers in Mampong-Nkwanta and Mfuam (Eastern Region) who welcomed all participants on their integrated agriculture-aquaculture farms and answered numerous questions, notably Ibrahim Ansah, Yawga Adorsu, Ofei Akunnor and Opanyin Anakwa.

The preparation of the workshop was efficiently supported by the GTZ Representative Office in Ghana through its head, Margit Gutteridge, and her very able team. We also acknowledge the presence of Mrs. Gutteridge at the workshop.

The artwork in these proceedings was prepared by Albert B. Contemprate of the ICLARM Publications Unit.

This workshop was held under the auspices of a research project funded by BMZ/GTZ in the form of a grant to ICLARM by the International Agricultural Research Program. The support through H.-J.de Haas, G. Suden and T. Schurig is gratefully acknowledged as well as the contributions of C. Wiedey, E. Kürschner and H. Franzen (German Council for Tropical and Subtropical Agricultural Research [ATSAF], Bonn) and the keen interest of M. Bilio (GTZ Eschborn).

Past Initiatives for Promoting Aquaculture in Ghana[a]

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PREIN, M. and J.K. OFORI. 1996. Past initiatives for promoting aquaculture in Ghana, p. 1-3. *In* M. Prein, J.K. Ofori and C. Lightfoot (eds.) Research for the future development of aquaculture in Ghana. ICLARM Conf. Proc. 42, 94 p.

Abstract

An overview of the past initiatives for development of aquaculture in Ghana is given. Historically, three traditional forms of aquaculture were performed. These were in the Volta River and coastal lagoons. Modern attempts have focused on inland pond aquaculture with very limited success. Support by the Fisheries Department (FD) has been limited. Attempts have been mainly by individuals without technological knowledge and failures have been numerous. Installations set up by government institutions outside of FD have been more successful. A heavy focus on commercial operations has failed and is therefore discouraged under the existing economic situation.

History of Aquaculture in Ghana

Three *traditional* forms of aquaculture (in a wider sense) exist in Ghana: (1) *acadjas* or brushparks in lagoons and reservoirs; (2) *hatsis* (fish holes) and *whedos* (mini dams) in coastal lagoons; and (3) *afani* or freshwater clams (*Egeria radiata*) in the lower Volta, where young clams are collected and "planted" in "owned" areas of the river.

The first *modern* forms of aquaculture were introduced into Ghana 40 years ago. Initial attempts were made to culture fish in especially constructed ponds. To date, the types of aquaculture introduced into Ghana are those conducted in ponds. Partly, these were built with concrete bottoms and sides but are not managed intensively like tanks or raceways.

The main species cultured are the indigenous species of tilapia, catfish and *Heterotis*. Introductions have been made with *Oreochromis macrochir*, common and silver carp, and the tiger prawn *(Penaeus monodon)*.

Aquaculture development efforts have been almost entirely in a freshwater environment. In brackishwater, experimental work has been conducted on *Penaeus monodon*. No activities have been done in direct marine and offshore environments.

[a]ICLARM Contribution No. 957.

In freshwater, the technologies used are of the extensive and semi-intensive categories. Only one case of intensive culture is known in which tilapia are cultured in net cages.

Extensive systems are dams, dugouts and small reservoirs which are regularly fished out and restocked. These systems are also termed as culture-based fisheries and have a considerable potential for optimization in the northern regions of Ghana.

Further, rice-fish culture falls into this category which was attempted in earlier years in the Upper West and East Regions. In 1992, a new attempt was started following technical advice from our project, which has produced encouraging results.

Most aquaculture activities in Ghana fall into the *semi-intensive* category. Fish are cultured in earthen ponds either in the forms of a stand-alone enterprise or of an integrated agriculture-aquaculture farming system. The technologies in operation are mostly monocultures of tilapia or polycultures of tilapia and catfish.

Overview of Past Initiatives

Generally, there have been two different aproaches to aquaculture development in Ghana.

The first type targets *communities* for adoption of communally owned and managed ponds. These are aimed at bringing benefits in the form of fish for nutrition or of cash to the community. This type is the most difficult to maintain and also has the highest rate of failures. Generally, community-based aquaculture is an unsuccessful approach compared to single-household aquaculture. The second type of approach targets individual persons or households who have landownership, or are entitled to make management decisions, and are the only beneficiaries.

The government has supported aquaculture development in Ghana through a number of field stations. These were initially intended for fingerling production, farmer demonstration and training, and some also for research purposes. Most of the stations are located below small- or medium-size irrigation dams set up by the Irrigation Development Authority. A government policy exists whereby 5% of the total area allocated for irrigation below a dam site should be constructed in the form of fishponds. This has not been adhered to.

Over the years, FD had 16 sites at which hatcheries with a total of 35 ha of grow-out or demonstration ponds were established. Today, four sites are operational. Beyond these, four other facilities exist, which belong to the Irrigation Company of the Upper Regions, the University of Kumasi, the Volta River Authority and the Institute of Aquatic Biology, respectively, and are operational with a total pond area of 14 ha.

The existing privately operated fishponds were mostly built during a countrywide program from 1982 to 1984. The Agricultural Development Bank provided loans for pond construction. Little technical advice was provided, leading to a high rate of failures and unserviced loans.

Fingerling Requirements

At an estimated operational pond area in Ghana of 125 ha and an estimated stocking rate of 15,000 fish/ha and one culture cycle per year, nearly 1.9 million fingerlings would be needed annually. This assumes that ponds are completely harvested and restocked once a year.

Problems

In previous aquaculture development efforts, little support was available for new adopters on: pond siting, pond size, necessity of drainability, design of appropriate technology inflows and outflows, pond management, fish species, fertilization, feeding, harvesting strategies, and marketing or processing.

Errors in any one of these may place the entire operation in jeopardy. This is even more the case if novices embark on setting up an aquaculture operation on their own, without any advice, as has often been the case during the 1982 "surge". If the operations involve bank loans which, through failure of the aquaculture enterprise, cannot be paid back, an entire industry falls into miscredit.

This situation is further aggravated as many of these "cash-crop" operations are not economically viable. Not only are the entrepreneurs discouraged. Aquaculture *per se* has, among many Ghanaians, attained a bad reputation. Last year, a Voluntary Service Overseas officer who was surveying existing ponds was chased off the premises by a lady who experienced serious failure with aquaculture in the early 1980s: she had invested heavily in an undrainable concrete pond and never achieved any returns. She blamed her failure on "aquaculture" *per se*. This is symptomatic of the existing situation.

Conclusion

Aquaculture as an entrepreneurial, cash-generating business on its own will be an option to only a few Ghanaians in the existing situation. Even with the right technical advice, relatively few Ghanaians are in the position to secure appropriate loans. Further, there is at present the outlook that, given the existing fish prices and competing fish supply from marine and inland fisheries, these operations are not economically viable. However, this may change in the future.

Ghana will have to try to secure adequate protein supply for its swiftly growing population and at the same time to halt the degradation of its natural resource base. A large portion of Ghana's population are small-scale resource-poor farmers. Adequate technologies that can improve their livelihood are available. These have aquaculture as only one component within an integrated farm system. The following presentations in this workshop set the basis for this rationale, and suggest methods for disseminating this approach.

Analytical Framework for Rethinking Aquaculture Development for Smallholder Farmers[a]

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LIGHTFOOT, C., M. PREIN and J.K. OFORI. 1996. Analytical framework for rethinking aquaculture development for smallholder farmers, p. 4-10. *In* M. Prein, J.K. Ofori and C. Lightfoot (eds.) Research for the future development of aquaculture in Ghana. ICLARM Conf. Proc. 42, 94 p.

Abstract

A framework for a new type of analytical approach to aquaculture development is presented. It focuses on smallholder farmers in the context of their environment and managed natural resources, and considers experiences gained in past initiatives; makes extensive use of existing information from previous studies; employs a participatory approach and bases work on partnerships among farmers, researchers and extensionists; (both government and/or nongovernment organizations) in field trials. Data analysis results in conclusions and suggestions for implementation and necessary policy and investment requirements.

Introduction

The International Center for Living Aquatic Resources Management (ICLARM) has collaborated with the Institute of Aquatic Biology (IAB) over the last two years to determine what makes sense for future aquaculture development in Ghana, especially for those systems appropriate to smallholder farmers. It is the juxtaposition of smallholder farmers and aquaculture that sets this work apart from most fisheries sector development planning.

Fisheries sector development has and must concern itself with the fact that in the recent past, marine and inland fisheries production has remained fairly static at 390,000 t (ROG-PPME/MOA 1991). This statistic could mean that the country faces a 960,000 t shortfall by the year 2020, assuming a population of 32 million people reaches the currently optimal fish consumption level of 30 $kg \cdot caput^{-1} \cdot year^{-1}$ (MacPherson et al. 1990). Aquaculture invariably is assigned a significant role in meeting the shortfall, a role in which intensive, high, external input "commercial" aquaculture activities dominate because these are the ones that can produce the amounts of fish required. Unhappily, such systems have proven to be not only beyond the means of well-off farmers but also of government. Ghana's experience in the 1980s showed that even substantial credit cannot sustain these

[a]ICLARM Contribution No. 958.

systems (Wijkstrom and MacPherson 1990). Even the less costly semi-intensive integrated systems designed for smallholder farmers demand manure and compost inputs that are beyond what their farms can produce. Such aquaculture strategies have not contributed much to reducing fish production shortfalls from either commercial or "integrated" systems. They have not contributed much to smallholder farmers either. Indeed, this story has not changed over the last decade for much of Central and West Africa: "Inspite of these external efforts and a variety of national support programs, fish farming presently is not widely practiced and after project support has ended, has not become a part of the way of life in the area" (Grover et al. 1980).

Smallholders are by far the largest group of farmers. Some 80% of the estimated 2.3 million farm families operate subsistence or mainly subsistence farms (ROG/UNICEF 1990). The Ministry of Agriculture (MOA) estimates farm sizes of 1.2 ha or less for 75% of the farming population (ROG-MOA 1988). On these smallholder farms, the main systems of farming are traditional hoe and cutlass operations, growing root crops, plantains, groundnuts and maize with poultry, goat and sheep rearing (ROG-PPME/MOA 1991). Current smallholder systems fail to meet family needs for both food and income. Across all regions, 51% of children between 12 and 23 months suffer acute protein energy malnutrition (ROG/UNICEF 1990). Sixty-seven per cent of the households did not make the poverty line income of 107,500 cedis per annum in 1986. Indeed, average farm income for that year was only 69,300 cedis (ROG/UNICEF 1990).

Income and food are further threatened in the long run by degradation of agriculture's natural resource base. Any observer's immediate impression of the Accra plains, for instance, is that they are severely degraded. The bush and grass savanna covering much of the country is a result of bush fires, herding, erosive cultivation practices and removal of firewood. Remember that 92% of rural households use wood for cooking. In 1985, 12 million m^3 of wood and charcoal were consumed countrywide and this is expected to increase to 17 million m^3 by the year 2000 (IIED 1992). Gully and sheet soil erosion hazards extend over large areas in all regions. Ashanti Region, for example, has sheet and gully erosion hazards over 11,826 km^2 (ROG/UNICEF 1990). Even the pitifully small pond areas of 109 ha have fallen by some 34 ha over the last few years (MacPherson et al. 1990).

We, therefore, have turned the primary focus of aquaculture development away from meeting fish production shortfalls and towards meeting smallholder farmers' nutritional and income needs and restoring their rapidly degrading natural resource base. Thus, we put the farmer first.

Rethinking Aquaculture Development

Lessons from African agricultural development indicate that technologies relevant to smallholders are more likely to emerge from farmer-participatory research and not from a top-down demonstration of high productivity systems (Chambers et al. 1989). Thus, for this project, we adopted two principles: one, of smallholder farmer participation in the development of technology; and two, of natural resource regeneration in the management of aquatic resources (Costa-Pierce et al. 1991; Lightfoot et al. 1991). From this perspective, alternative farming systems are developed with farmers such that: (1) aquaculture is integrated with other enterprises of existing farming systems so that synergisms can be exploited; and (2) aquaculture is seen as a mechanism to improve both overall farm system performance and management of natural resources.

Rethinking aquaculture development sees us preferring to secure many new entrants from among resource-poor farm families into fish farming rather than improving the productivity of existing fish farms. We prefer to see aquaculture as a means of securing benefits for other farm enterprises and of rehabilitating resources rather than as a stand-alone commercial enterprise to produce fish. We see the job of research as generating technologies for aquaculture to fit into ongoing farming systems and developing processes for this to occur.

However, gaining new entrants from among smallholder farmers will require special educational efforts because of their perception of fish as a free resource from lakes or rivers. Their meager appreciation of fish biology and pond hydrology could result in much disappointment. This study focuses on integrated agriculture-aquaculture (IAA) for smallholders, leaving out other aquaculture systems for larger farmers and larger water bodies.

To support this kind of development thinking, research must first evaluate present household, agriculture and fish production systems, then identify target households and natural resource systems with development potential for which options can be formulated, and lastly project their potential impacts. An analytical framework to cover these four areas of work follows (see Fig. 1).

An Analytical Framework

Stage 1 - Evaluate Present Status

Assessment of past and present aquaculture development initiatives. Secondary data from past aquaculture development initiatives by government and development agencies in Ghana are compiled and analyzed. The analysis of these efforts seeks to determine the historical background of aquaculture development in Ghana and identify reasons for success and, perhaps more importantly, failure. This process will likely occasion the use of interviews with key informants.

Analysis of secondary data on households, agriculture and current fish production systems. Secondary data on households and their current agricultural and fish production systems are compiled and analyzed. These data typically originate from government department archives and development agency project offices. Analysis seeks to summarize the existing situation for land availability and farm sizes, labor demand and supply, household budgets and farm incomes, crop and animal (including fish) outputs, and family nutrition and health status.

Rapid appraisals of existing farming and fishing systems. Informal interviews are conducted with key informants to construct farm activity calendars, bioresource flows and production system budgets. Based on recalled data, annual calendars of crop, livestock and fish production activities provide an understanding of the sequence of management actions on the farm. These are used to elicit further information on the quantity, quality and source of inputs and outputs. These data are then used to construct bioresource flow models describing how nutrients or cash flow between farm enterprises. Analysis seeks to understand the patterns, differences and limitations of present farming and fishing systems.

Stage 2 - Identify Target Households and Natural Resource Systems

Mapping of biophysical characteristics of aquatic resource systems. This activity involves both rapid rural appraisals (RRAs) and the assembly of maps and, where possible, aerial photos describing Ghana's hydrology, soil types, topography, etc. RRAs of sample villages in each agroecological zone identify the natural resource systems utilized by smallholders. Transects of these

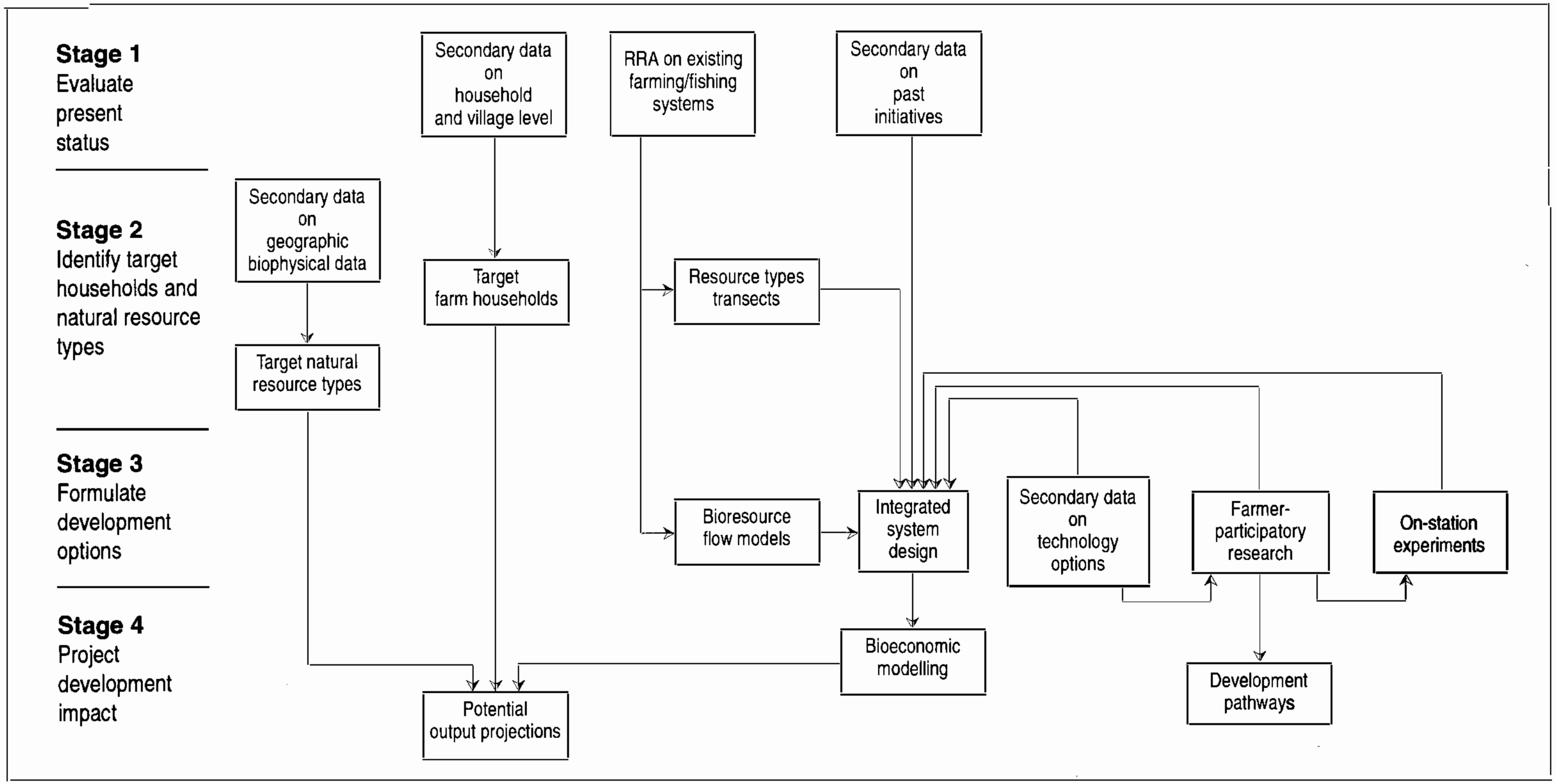

Fig. 1. Framework for ICLARM-IAB research collaboration to study potential for integrated agriculture-aquaculture in Ghana.

natural resource systems identify where water is found in sufficient supply for aquaculture. RRA data together with other maps from government (e.g., Ministry of Agriculture, Census Bureau) and development agencies (e.g., Food and Agriculture Organization) serve as a basis for targeting the most important systems for development of IAA farming systems.

Target of farm households. Secondary data sources and, where necessary, informal surveys, provide the information needed to characterize smallholder farm households. Analysis of a range of household characteristics originating from census or government statistics bureaus or from surveys conducted by other organizations identify target households. Characteristics include capital, use of external inputs, access to markets and cultural parameters such as tribal customs and issues surrounding the conservatism of new entrants. This "typology" work permits differentiation within smallholder farm households. These characteristics will be used in extrapolations of the possible outputs and benefits, given their adoption of integrated aquaculture systems.

Stage 3 - Formulate Development Options

Screening of technology options. Secondary data on aquaculture technology available worldwide are screened for possible application to smallholder farmers in Ghana. Feasibility analysis screens for technical (water and land type), economic (capital, inputs and markets) and cultural parameters (tribal customs, new entrants' conservatism). An array of technology options for small pond management that optimize aquaculture integration within a given farming system is identified.

Integrated agriculture-aquaculture system design. System design draws on both on-farm and on-station research work. RRAs and more intense farmer-participatory research develop bioresource flow models for future IAA farming systems. All natural resource systems capable of holding water for aquaculture, including swamp ricefields, are considered for integration. Experiments at IAB's Akosombo Research Station estimate the natural (baseline) productivity of selected water resource systems. Further experiments evaluate the benefits of additional nutrient inputs or management measures on fish productivity.

Stage 4 - Project Development Impacts

Bioeconomic modelling. Based on the data and information gained, hypothetical bioeconomic models are constructed for a range of household types with different crop assemblages, technical options, resource systems and ecological zones. Models seek to assess the nutritional and economic viability of the hypothetical systems based mainly on secondary data but also including the results of on-farm and on-station research. Bioeconomic models will also indicate the potential impacts of IAA systems on fish and food production, farm income and employment at household, village and regional levels. Implications in terms of policies on the input and output delivery systems, including technical advice, are indicated.

Sustainability of integrated models. Founded on the bioresource flow models constructed by farmers, existing and future integrated systems will be compared using several performance indicators for system sustainability. Values for enterprise diversity, bioresource recycling, economic efficiency and resource system capacity are computed. Analysis also compares the economic performance of different natural resource systems between integrated and nonintegrated farming. Implications in terms of policies for government research, education and extension services are indicated.

Development pathways for evolution of integrated systems. The realization of model potentials calculated here not only depends on the many external factors mentioned but also on a process for smallholder farms to evolve into IAA farms. A process for this evolution is developed through farmer-participatory research that goes beyond brainstorming hypothetical integrated systems to on-farm experimentation with technology options that overcome constraints for the farmers to initiate, improve or expand integrated aquaculture systems. Describing development pathways goes beyond the evolution of integrated farming to institutional arrangements necessary for this to occur.

Conclusion

The purpose of this research was to develop a framework for Ghana and, by implication, other African national agricultural research systems (NARS) to determine the aquaculture development potential among smallholder farmers. Our rather ambitious framework provides, in addition to, and perhaps at the expense of, the typical inventories of potential areas for development and suitability analyses, a process for development. Success with farmers, while beyond the scope of most development frameworks, does suggest the validity of our work.

Farmer-participatory research induced the evolution of IAA farming systems with new entrants to aquaculture. Indeed, this may be a better way to attract adopters than demonstrations of improved fish yields on existing fish farms or demonstration farms on station.

The orientation of intervention on the natural resource system rather than on fish production seems to stimulate aquatic resource management and integration of aquaculture into smallholder farms. However, several difficulties have emerged from its use. Firstly, mapping of natural resource system areas suitable for aquaculture has proved impossible because present mapping units for soils and agroecological zones are too large. Secondly, our bioresource flow models were too restricted to agriculture and aquaculture on the farm. This focus is a particular problem when significant proportions of household incomes stem from nonfarm sources and the utilization of common property resources for gathering fuelwood, bush meats, wild vegetables and tree leaf. This deficiency was rather a function of the lack of skills in participatory research methods than of the approach itself.

Participatory research skills however come with practice. Now that participatory research method guidelines for natural resource system transects, and mapping and bioresource flow modelling have been written, practice will be a lot easier. Through practice and, given that we now know what secondary data are needed, many shortcuts can be made in using the analytical framework. Hunting down secondary data takes a lot of time if bureaucratic wheels have not been greased. Secondary data can be requested from NARS agencies before fieldwork starts. Moreover, given that we have developed bioeconomic model templates, it is now possible to develop hypothetical models before fieldwork begins, thus saving much manpower and time.

The project has not only enabled us to develop a rapid appraisal protocol for assessing the potential of IAA development with smallholders but has also given us some insights into this development approach.

Fish are seen by smallholders as a way to improve family nutrition and to pay debts or offer gifts that build social standing and not as a cash crop like cocoa. Profit from fish sales is not the prime stimulant for adoption. Farmers know sales will be small. Rather, families look to increases in whole farm profit from holding water for vegetables and livestock, water in which fish can be grown on wastes to produce fertile mud for vegetables. Interestingly, the high labor requirements to run integrated systems are not seen as a constraint to adoption. Households do have a small labor surplus which can absorb the low but frequent requirements of integrated aquaculture. The only large labor input, digging a pond, can be shared with others and timed not to conflict with other activities.

We would not base future fish culture development programs on fish production for food or income as neither will be enough to secure adoption. From our experiences in Ghana and elsewhere, we would rather utilize a natural resource systems orientation for aquaculture development through an evolutionary pathway to IAA farming systems for improved whole farm system performance and aquatic resource rehabilitation. This, in our view, cuts the Gordian knot of African aquaculture development.

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Mapping of Aquatic Resource Systems with Areas of Potential for Aquaculture in Ghana[a]

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PREIN, M. and J.K. OFORI. 1996. Mapping of aquatic resource systems with areas of potential for aquaculture in Ghana, p. 11-19. *In* M. Prein, J.K. Ofori and C. Lightfoot (eds.) Research for the future development of aquaculture in Ghana. ICLARM Conf. Proc. 42, 94 p.

Abstract

Aquatic resource systems with potential for aquaculture development in Ghana were demarcated: lagoons, bays and estuaries; rivers; lakes and large reservoirs; small water bodies; floodplains and swamps. Where available, area estimates are given, together with data on existing aquaculture and fisheries activities. Potential technologies for further development are briefly pointed out.

Objective and Approach

The aim of this exercise was to demarcate the aquatic resource systems in Ghana to lay the basis for evaluations of the aquaculture development potential in these areas.

The existing systems were classified into: (1) lagoons, bays and estuaries, (2) rivers, (3) lakes and large reservoirs, (4) small water bodies, and (5) floodplains and swamps. Existing secondary data were used to compile maps and to demarcate these areas. Where available, area estimates are given, followed by information on existing aquaculture and fisheries activities and brief indications of further potential technologies which could be applied in these areas.

[a]ICLARM Contribution No. 959.

Results

Lagoons, Bays and Estuaries

Mensah (1979) and Weigel (1985) identified 50 lagoons of all sizes along the 536-km long coastline of Ghana (Fig. 1). Kapetsky (1991) estimated a total lagoon area in Ghana of 174 km^2 (FAO [1988] gave an area of 330 km^2 [!] for Keta Lagoon only). The lagoons are subject to an artisanal fishery, providing 5% of the total inland catch. Pauly (1976) estimated a production of 150 $kg \cdot ha^{-1} \cdot year^{-1}$ for the Sakumo-2 Lagoon. Assuming this rate for all lagoons in Ghana, this results in fish production of 2,600 $t \cdot year^{-1}$. The lagoons have been traditionally managed in the past to sustain fishery levels (Weigel 1985), but in recent decades this management has been breaking down in many lagoons (Pauly 1987;

Ntiamoa-Baidu 1991). In numerous cases today, lagoon fisheries are open-access, without regulations as to daily, weekly or annual restrictions on fishing effort. Several lagoons are in varying stages of degradation due to urbanization and pollution. Most lagoons are surrounded by mangroves which are also being heavily exploited. Traditional "culture" methods are dammed fisheries or *hatsis* and brushparks or *acadjas*, both found in the Keta Lagoon system (Mensah 1979; Weigel 1985).

The aquaculture potential in Ghana both in or around the lagoons has been pointed out by several studies (Pillay 1962; Pauly 1973, 1975, 1976; Rabanal 1985), focusing on endemic brackishwater species such as *Sarotherodon melanotheron* and *Mugil* sp. Plans have been made and trials conducted to introduce nonendemic prawns (e.g., *Penaeus monodon*) for commercial-scale operations for export.

Rivers

The network of rivers in Ghana has been mapped by the World Bank in 1986 (Kapetsky 1991) (Fig. 2). Although the southern part of Ghana is well-endowed with water, many rivers dry up during the dry season. Ghana's river system is estimated to produce fish and shellfish amounting to a total of 5,600 t·year^{-1} (Kapetsky 1991), which is considered to be an underestimate.

Fish constitute the major part of freshwater fishery (Irvine 1947), aside from crustaceans and molluscs. Freshwater shrimp (*Macrobrachium* sp.) are caught in the lowermost stretches of most coastal rivers (Prah 1982). Traditionally, there has been a clam (*Egeria radiata*) fishery in the lower stretches of the Volta River, previously providing a catch of 4,000-7,000 t·year^{-1} (Purchon 1963; Pople 1966) which has declined in recent years following the completion of the Volta Dam (Attipoe and Amoah 1989).

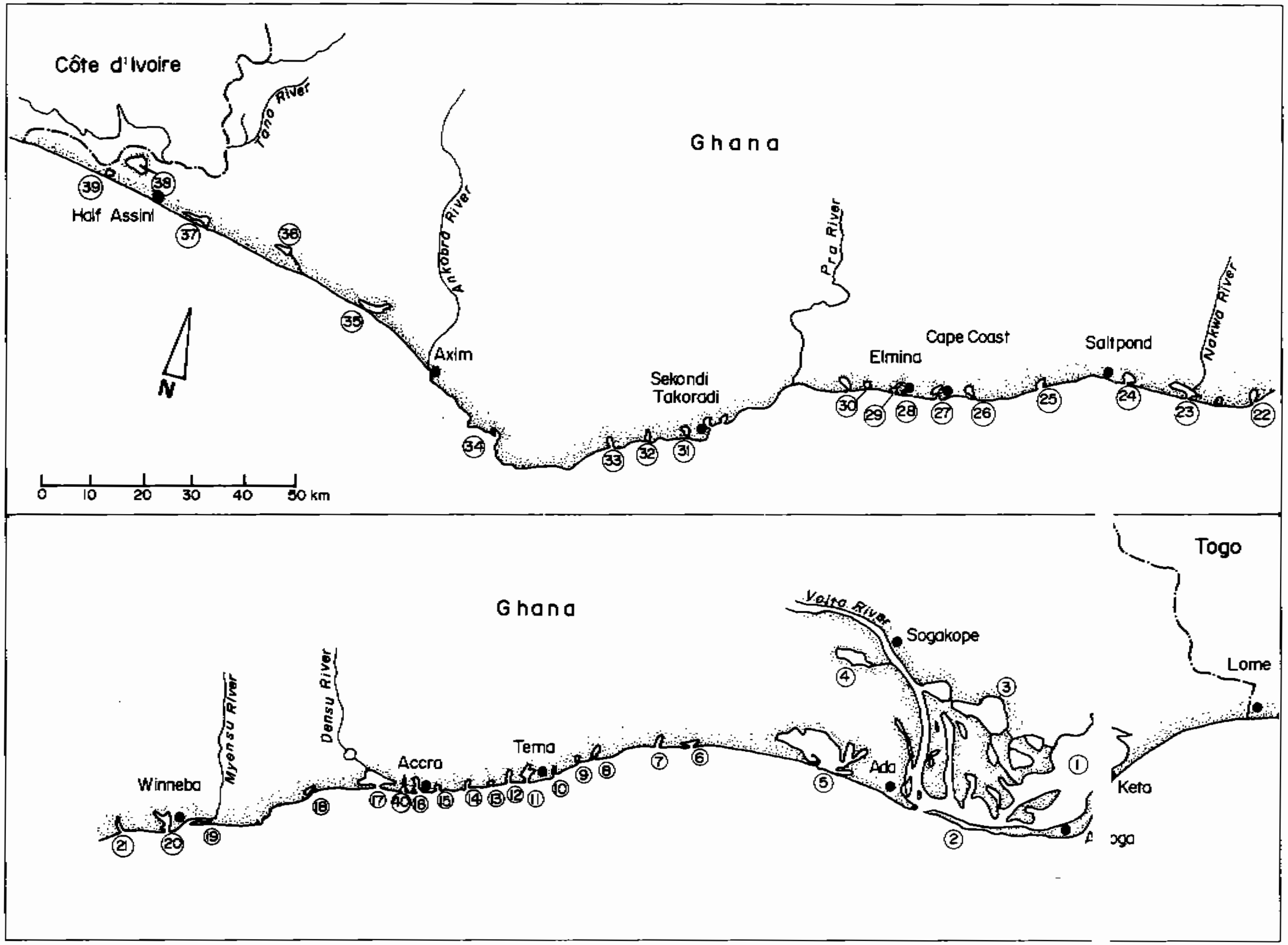
In other parts of the country, river oxbows and partitions have traditionally provided opportunity for a seasonal fishery with the reduction of water levels in the dry season (Balarin 1988).

Numerous plans exist and attempts have been made to establish aquaculture operations adjacent to rivers (on elevated banks) or on their floodplains (see below). In many cases, topography renders sites inadequate for economical operations as these either require pumping or ponds suffer from groundwater and cannot be drained regularly. In general, sites immediately adjacent to rivers are problematic.

Lakes and Reservoirs

Kapetsky (1991) conducted a water resources inventory of Ghana with a geographic information system (GIS) based on satellite imagery, resulting in an estimate of 9,485 km^2 of lakes and reservoirs (> 4 ha). The only natural lake in Ghana is Lake Bosumtwi, with an area of 32 km^2. Lake Volta was created in 1964 through the damming of the Volta River at Akosombo, resulting in a water surface of 9,345 km^2 (Vanderpuye, n.d.). About 120 km^2 of larger reservoirs exist, predominantly in the Upper East, Northern and Greater Accra Regions.

Lake Bosumtwi is a crater lake with endemic fish species and to date strict traditional fishery and management, providing an estimated catch of 319 t·year^{-1} (Kapetsky 1991). Attempts have been made at cage culture in Lakes Bosumtwi, Volta and a reservoir near Accra. The high investment costs for cage construction, operation, maintenance, fish feed and rental of the water bodies offset income generated from the relatively low-valued tilapia produced



1. Keta
2. Angaw
3. Avu
4. Wa
5. Songaw
6. Mavo
7. Jenge
8. Lalwi
9. Gao
10. Chemu
11. Sakumo-2
12. Mukwe
13. Sanga
14. Kpeshie
15. Labadi
16. Korle
17. Sakumo-1
18. Nyenya
19. Oyibi
20. Muni
21. Apabeka
22. Sumina
23. Nakwa
24. Amisa
25. Apa
26. Fosu
27. Benya
28. Elmina
29. Brenu
30. Susu
31. Hwini
32. Ajua
33. Dedowa
34. Prince's Town
35. Amansuri-2
36. Amansuri-1
37. Domini
38. Unvaiye
39. Juen
40. Lawal

Fig. 1. The 40 available names of 50 lagoons in Ghana (after Mensah 1979; Denyoh 1982; Van[illegible]n Bossche and Bernacsek 1990):

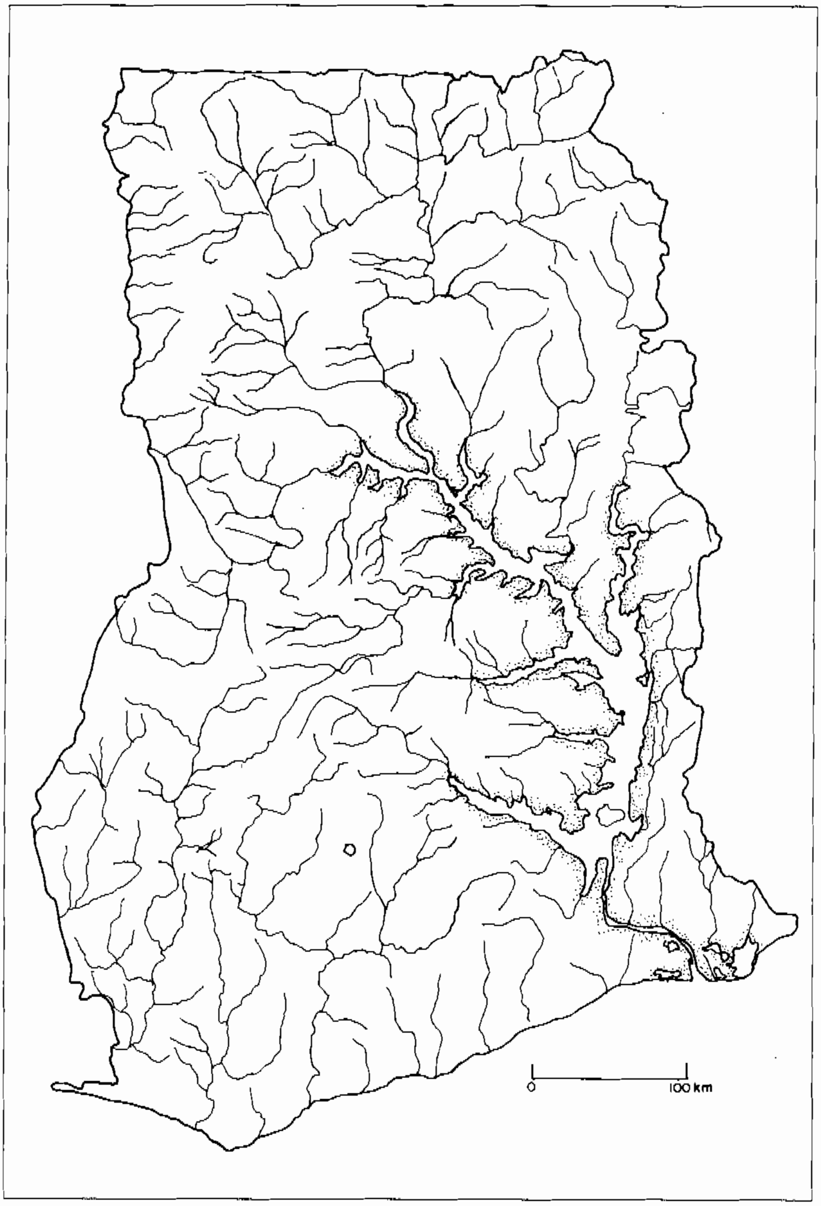


Fig. 2. Network of the largest rivers in Ghana (Kapetsky et al. 1991).

in them. Other high value species such as *Clarias* sp., *Heterobranchus* sp. and *Lates niloticus* may result in a positive economic balance. Lakes Bosumtwi and Volta have high fluctuations in their water levels, making fixed installations nearly impossible. The viability of such commercial ventures will depend on the size of the operation and on market conditions.

Small Water Bodies

Dams, dugouts and reservoirs smaller than 4 ha are considered as small water bodies. Kapetsky (1991) estimated a total area of 14 km^2 in seven regions of Ghana (Fig. 3) with a fish production of around 733 $t \cdot year^{-1}$. These have been constructed in the past 50 years to supply water to villages for domestic and livestock watering purposes. Their potential for fish production is identified, yet few villages have set up management procedures to exploit this potential systematically. Unlike in other African countries (e.g., Nigeria or Zimbabwe), a complete inventory of surface area, catchment area, water volume and fish production does not exist for Ghana.

In contrast to large lakes and reservoirs, small water bodies can be managed. Efforts are underway to enhance their use such as for dry season gardening and fish culture in small ponds close to the dam. Sociocultural aspects (leadership, ownership and access rights, magico-religious traditions) as well as training in appropriate technologies (e.g., appreciation of stock management, harvest with traps and hook-and-line) govern the further improved use of small water bodies.

Floodplains

Floodplains are lowlands experiencing seasonal flooding, either naturally or managed. For the purpose of this study, these include not only adjacent areas of small streams to large rivers and swamps but also rice paddies in irrigation schemes. Paddy rice is grown in 59 km^2 of the 70 km^2 of irrigation schemes in Ghana (Fig. 4) (IDA, pers. comm.). The integration of rice and fish culture is well known from Southeast Asia (dela Cruz et al. 1992) and shows promising potential for Ghana (see Kumah et al., this vol.). Based on an average production of 30 kg of tilapia per hectare of ricefield, the existing paddy rice-growing area in Ghana could produce 21 t of fish at a reduction in rice production of around 10%. The income from fish production generally offsets the loss through reduced rice-growing area for refuge ponds and trenches. Rice-shrimp integration is a further potential activity in irrigation schemes in Ghana. A regulation exists in Ghana whereby 5% of the area of an irrigation scheme should be constructed in the form of fishponds below the irrigation reservoir. This has not been implemented in any irrigation scheme.

Small streams can be dammed in sites with adequate topography to raise the water level to supply small ponds constructed adjacent to the streams, yet at higher elevation, so that these can be drained by gravity flow. Although many streams dry out seasonally, and their number is increasing at an alarming rate, these are the most promising opportunities for smallholder pond aquaculture in Ghana (Kapetsky et al. 1991; Prein 1993; Lightfoot et al., this vol.).

Kapetsky (1991) determined 340 km^2 of swamps (215 km^2 in the Northern Region) which are seasonal, shallow, flooded areas which dry up during the dry season and are fished seasonally.

Conclusion

The existing inland water surfaces amounting to 315 km^2 (excluding Lakes Bosumtwi and Volta) show varying degrees of potential for enhanced fisheries and aquaculture. Some activities are based on existing traditions; in other cases, new technologies would need to be introduced and their compatibility with the ecological and sociocultural contexts must be evaluated.

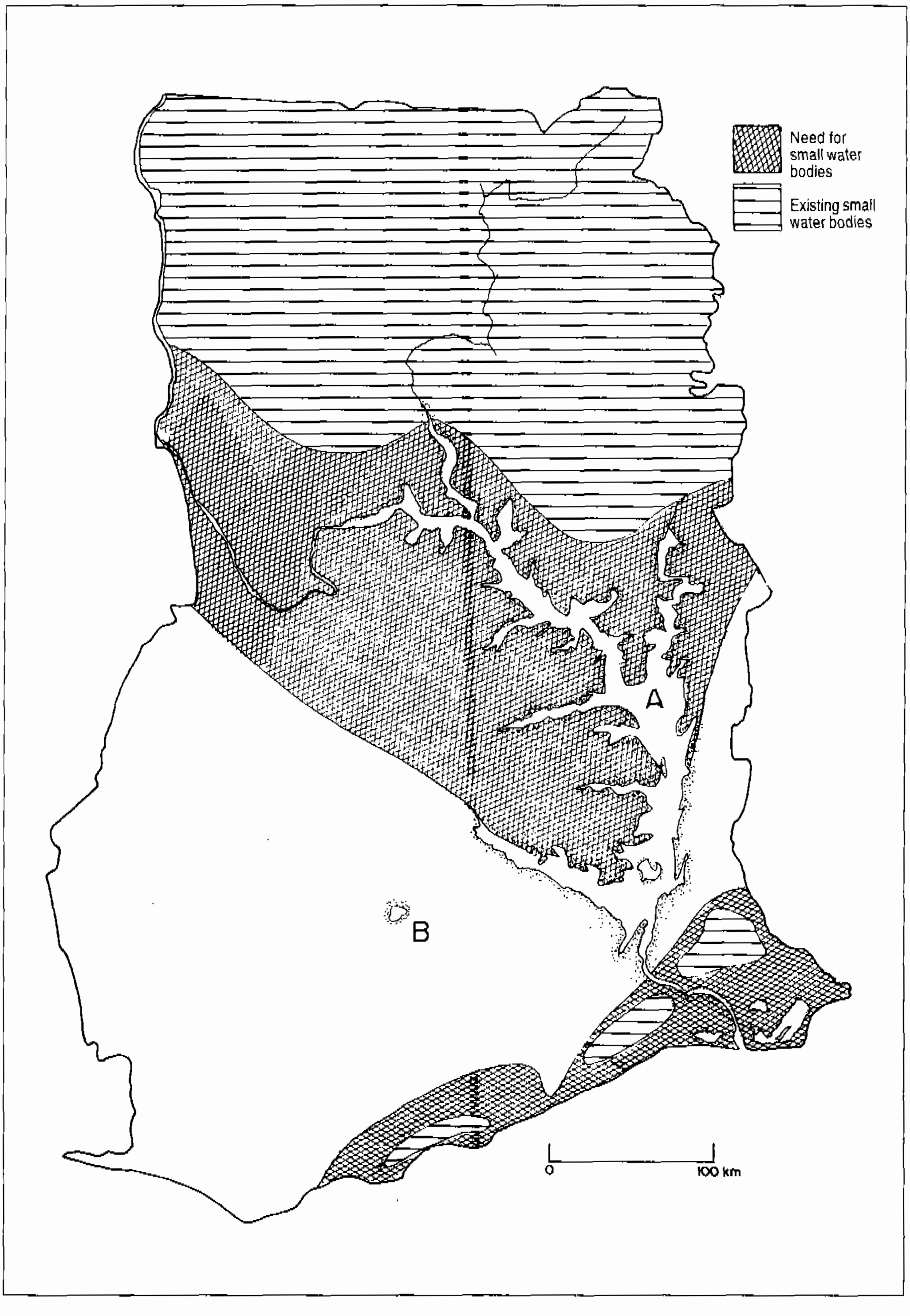


Fig. 3. Lakes Volta (A) and Bosumtwi (B), and the areas of main occurrence and identified need of small water bodies in Ghana (after Kapetsky 1991, modified).

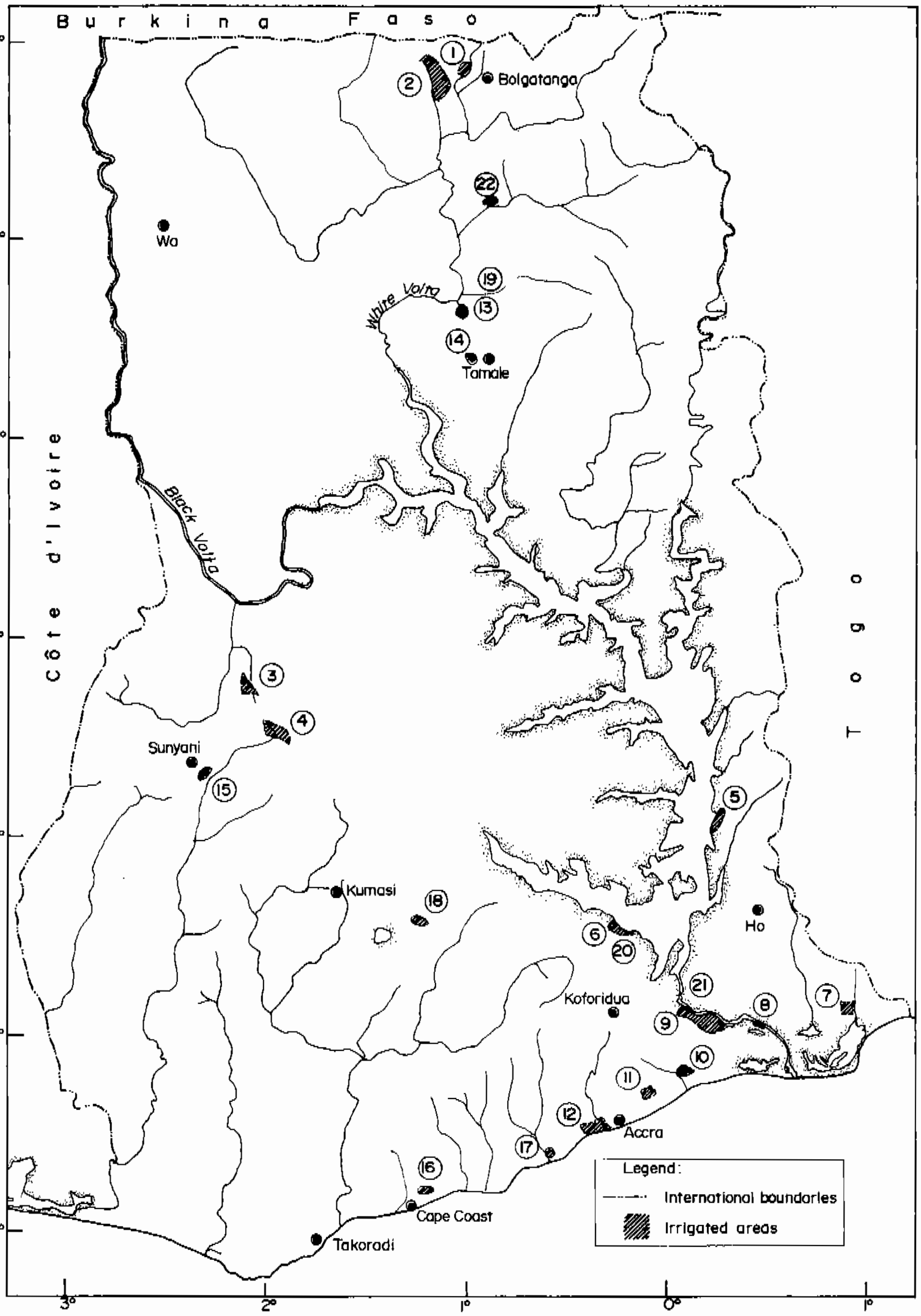


Fig. 4. Irrigation areas in Ghana (total 70 km², developed) as of 1995:
(1) Vea, (2) Tono, (3) Subinja-Wenchi, (4) Akumadan, (5) Kpandu-Torkor, (6) Amate, (7) Afife, (8) Aveyime, (9) Asutsuare, (10) Dawhenya, (11) Ashaiman, (12) Weija, (13) Bontanga, (14) Golinga, (15) Tanoso, (16) Mankessim, (17) Okyereko, (18) Nobewam, (19) Libga, (20) Dedeso, (21) Kpong-Akuse (under construction; no fishponds planned) and (22) Nasia (under construction; no fishponds planned).

Acknowledgements

We wish to thank our colleagues at the Fisheries Department in Accra and its regional offices, the Food and Agriculture Organization Regional Office for Africa, and the Institute of Aquatic Biology for helpful information, literature and discussions.

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Social and Economic Characteristics of Small-Scale Farmers in Ghana

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Abstract

A survey was conducted to assess the social and economic situation of smallholder farmers in six southern regions of Ghana: Brong Ahafo, Ashanti, Western, Central, Eastern and Volta Regions. Rapid appraisals revealed information on gender and age structure, educational and occupational background, farm household composition and structure, and landownership and tenureship.

Introduction

Agriculture, including fisheries, continues to dominate Ghana's economy. The sector contributes 52% of the total domestic output and employs 57% of the total labor force (MOA 1989). Eleven per cent of the total land area (240,000 km^2) is under cultivation. The Ministry of Agriculture (MOA) has overall responsibility for the sector. Of the many constraints facing agriculture in Ghana, the major ones are (MOA 1989):

1. difficulties with the acquisition of land and the lack of security for tenant farmers;
2. ineffective farmer organization at the village level;
3. deteriorated and inadequate infrastructure, i.e., storage and marketing facilities in the farming areas;
4. inadequate supply and insufficient distribution of inputs;
5. inadequate price and production incentives;
6. lack or insufficient flow of institutional credit;
7. low productivity stemming from the low level of adoption of new technology; and
8. inadequate extension services, declining and expensive farm labor, and weak linkages with other sectors, notably transport.

The small-scale farmer in Ghana, variously called "peasant farmer," "subsistence farmer," "resource-poor farmer," etc., still dominates the agricultural scene. His/her lifestyle and production patterns have not changed over the years. To re-echo the lamentations of one such farmer: "Were our ancestors to come back to life, they could pick up the same farming tools and go to farm on equal terms with our present-day farmers because nothing has changed since their time."

Although the adoption of new technologies by small-scale farmers has been a major rural development goal, in practice, the successes achieved have been rather limited. Recent thinking has suggested that the low adoption rate of the new technologies by these farmers may be the result of the technologies being inappropriate for their small farm situations. In particular, it is erroneous to think that production per unit area can be increased by expanding the production factors affecting the individual farmer rather than allowing him/her to operate two to four small farms (i.e., plots) in various locations. Such an approach assumes that the social, economic and cultural conditions can, and will, automatically adjust to the requirements of the new technologies.

In practice, this does not occur. The majority of farmers still cultivate the local rather than the improved varieties of crops. The alternative approach, namely, adjusting production technology to the social, cultural and economic systems encountered in rural areas, has gained some acceptance.

This work attempted to ascertain the facts relating to the social, economic and cultural conditions in which the rural farmer lives and works, and the problems arising therefrom. In particular, an attempt was made to interpret the behavioral responses of the small farmers who are confronted with various production alternatives and other activities considered to be the integral components of institutional services for rural development operations.

Area and Method of Study

This study was performed in terms of an Institute of Renewable Natural Resources, University of Science and Technology/Institute of Aquatic Biology/International Center for Living Aquatic Resources Management (IRNR/IAB/ICLARM) research collaboration in farming systems analysis and was started in September 1992. Six administrative regions in southern Ghana - Ashanti, Brong Ahafo, Eastern, Volta, Central and Western Regions - were chosen for study. In these regions, drought rather than semi-aridity is the basic and common constraint to agricultural activities. In each region, two farming communities were chosen by area frame sampling for farm/farmer surveys. Initially, the Extension Services of MOA in the district was contacted for an orientation on agriculture in the district and for assistance in the location of farming communities and farmer identification. This proved workable but the tendency was for the extension personnel to lead the team to their most successful and often well-to-do and influential farmers. The "smallness" of the farmer then became an issue, thus this method was soon abandoned. And, due to time constraints, the farmers were randomly approached on their way to their farms, where they were later interviewed.

Results

A review of the data indicated that five indices were useful to illustrate the socioeconomic characteristics, more particularly, the way of life and the attitude of the rural small-scale farmer in Ghana.

1. *Gender and age structure* is viewed as an index of the viability and sustainability of rural agriculture and its contribution to the rural and national economy.

2. *Educational background* of the farmer is considered to be a measure of his/her attitude to farming and can be a factor in his/her level of acceptance of the technical innovations in agriculture.

3. *Occupational background* of the farmer is seen as a determinant or attraction of farming vis-à-vis other occupations.

4. *Farm household composition and structure* indicate the farmers' responsibilities and financial commitments as well as the household component of farm labor.

5. *Ownership of land* or farmer status is seen as an index of the rights and obligations of the farmer in the use of land and land resources.

Thirty-nine farmers were interviewed in 22 farming communities in six regions in Ghana. The survey indicated that there are more male than female farmers (Table 1) in the survey area. Male farmers are much younger than their female counterparts (Table 1) but most of these younger male farmers, particularly in the Western and Brong Ahafo Regions, are into food crop production as a last resort. They are mostly illiterate (84%) and unskilled and are therefore disadvantaged in most other professions. The aged rural farmer on the other hand is one who, in most cases, has retired from other services (transport, civil service, teaching, etc.) and has to sustain himself and his family with food crops from his farm. Women farmers are mostly (70%) widows. A few of the young women farmers jointly own farmlands with the younger men who mostly provide the farm labor, while the women market the farm produce. The young male farmers also see food production as a very meaningful alternative to life or aim to raise capital within a very short period to finance a major project - an overseas trip or a trading venture. Fifteen per cent of all young rural farmers in our survey are either teachers or local community leaders who are part-time farmers only on weekends. The sons of migrant cocoa farmers contribute 45% of the young male farmers found in the Brong Ahafo, Central and Western Regions. Farmland can range from 0.1 to 110 ha, while cultivated land ranges from 1 to 10 ha. The rest is left fallow or is part of a cocoa or oil palm plantation.

Ownership and Tenureship of Land

Our survey showed four main types of land tenureship in the six regions.

Agricultural land acquired and owned through family connection or inheritance was very common in all regions (Table 2).

Tenant farmers were of three types:

1. *abusa* - where the farm produce is divided into three parts of which the tenant farmer takes two and the landlord one;

2. *abunu* - where the proceeds of the mature farm are divided into two equal parts of which a half goes to the landowner and the other half to the farmer; and

3. *trama* - where there is an outright purchase of the agricultural land by the leaseholder farmer, who hires a small group of subtenant or caretaker farmers.

Table 1. Age and gender of farmers in regions studied.

Region	Farmer			
	Male	Ave. age (year)	Female	Ave. age (year)
Ashanti	5	36	1	54
Brong Ahafo	2	44	2	58
Volta	7	40	1	57
Eastern	5	46	3	54
Central	3	41	1	55
Western	8	36	1	38
Total	30	(77%)	9	(23%)

Table 2. Farmer status and tenureship of agricultural land in regions studied.

Region	Landowner	Tenant	Sub-tenant	Share-holder	Lease-holder
Ashanti	1	1	1	1	
Brong Ahafo	2			1	
Eastern	6	1	1		
Volta	7	1			
Central	2	1			1
Western	8	1			

Table 3. Source of farm labor (for all activities) in regions studied.

	% of farmers employing labor type				
Region	Family	Hired	Family and hired	Permanent	*Nnoboa*[a]
Ashanti	50	33			17
Brong Ahafo	75	25			
Eastern	25	12.5	50		12.5
Volta	38	50	12		
Central		100			
Western	33	56			11

[a]Cooperative labor.

Farmland is mostly owned by the farmer through inheritance (67%) (Table 2). The small-scale farmer often operates two or more farms in different areas. The principal food crops farmed are maize, cassava, cocoyam, plantain and yam which are mostly intercropped. The small-scale farmer may operate small vegetable plots with okra, garden eggs, peppers and tomatoes, mostly for domestic consumption. Any surplus is sold locally.

Perennial tree crops like citrus and oil palm are mostly grown on pure sands, while vegetables (okra, eggplant, bell and chili peppers, and tomatoes) are normally grown on small plots of less than 0.01 ha.

Farm Household Structure and Composition

Most rural farming households are made up of aged adults and several children and teenage dependents who all go to school. This had direct consequences on the type and availability of labor for farm activities.

We found three main types of labor (Table 3): family, hired and cooperative labor (known as *nnoboa*). Family labor is the nominally unpaid service of a wife, child, nephew or niece, or of any other relation.

There were also varying combinations of two or all of the three types of labor.

There were three kinds of hired labor: (1) casual or "by day", (2) permanent or full-time labor and (3) contract.

Farm labor is a major constraint to rural agriculture. Where labor is available, the cost is high. Labor charges vary for the various farming operations but range from 500 cedis[a] to 600 cedis per day in addition to food.

Adult males contribute 70-90% of all farm labor. Nearly all farm produce (80-90%) is consumed in the household.

The survey revealed that there is very little return for the heavy labor investment of the rural farmer and nearly all farm produce (50-80%) is consumed by the farmer and his/her dependents.

The rural farmer in the survey area may meet his/her family's food requirements but cash for farm and nonfarm activities continues to be a major limiting factor. Therefore, "tailor-made" or new technologies involving investments may not be easily adopted by the average small-scale farmer.

The rural Ghanaian farmer is still a traditionalist for whom change can come only very slowly.

[a]US$1 = 625 cedis in March 1993.

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Gender Issues in Resource-Poor Farm Households in Ghana

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Abstract

A brief survey into gender-related issues on smallholder farms in Ghana was conducted. Interviews were made with members of 38 households in six southern regions of Ghana: Brong Ahafo, Ashanti, Western, Central, Eastern and Volta Regions. Subjects covered were: on-farm labor division, time allocation, access to credit, land and property, and traditional and religious beliefs in natural resource use.

Introduction

Research has shown that several development projects in the past were designed and implemented without taking into consideration the influence of gender in various stages of the development process. This is believed to have contributed to the failure of most of these projects. Consequently, several studies are now being conducted on gender-related issues and how they can be successfully incorporated into development projects to achieve the desired goals. The objective of this paper is to examine gender issues within the context of the Ghanaian rural farm household based on data and observations made in 28 farming communities in southern Ghana comprising the Ashanti, Brong Ahafo, Eastern, Volta, Central and Western Regions. Interviews were conducted with household members, men and women individually, during a quick survey of the regions (Dassah et al., this vol.)

Structure of the Farm Household

Traditionally, men are deemed to be the heads of household units in Ghana. With the 38 different farm households interviewed, 84% were headed by men while 16% were headed by women, 86% of whom were single and mostly widowed. Decisionmaking is thus led by these household heads as they control most of the family's income and expenditure. Where men are the custodians of the households, their wives usually assist with the upkeep of the household with proceeds from their separate food farms (i.e., vegetable or crop plots) as well as with work on their husbands' farms. Wives are generally responsible for most of the household chores. Within the households, a higher level of illiteracy was also observed among the adult women than among the men. All (100%) female farmers interviewed were illiterate while 70% of the male farmers had some form of education. However, this trend may change with time since almost all the farmers interviewed were providing both their male and female children with formal education.

Looking at the occupational trend of the households, it was also observed that male full-time farmers engaged in basket weaving, wood carving, masonry, fishing, etc., on a part-time basis while their female counterparts engaged in trading. The male part-time farmers were government workers, e.g., teachers and employees of the cocoa services. Their female counterparts were traders.

Division of Labor by Gender and Activity on the Farm

From the survey, it became evident that tedious farm operations such as land clearing, tree felling, grass cutting, burning, final land preparation, yam mound making and staking were normally done by the men while the women and children participated in the sowing or planting, weeding, fertilizing, harvesting and carting of farm produce for storage and marketing. Marketing of the produce was done by both men and women.

Within the forested communities, although the men may have small food farms (i.e., plots), they tend to concentrate on tree or cash crop production (mostly cocoa or oil palm). The women concentrate on food crops such as maize, cassava, plantain, yam, cocoyam and vegetables such as tomatoes, pepper, eggplant and okra, which are usually intercropped.

Both males and females reared sheep, goats and poultry on a subsistence basis.

Time Allocation

Men in most agricultural systems have different patterns of time use than women (Cloud 1982). On a typical farming day in the communities visited, a male farmer may spend from seven to eight hours on the farm and use the rest of his time either in performing minor household activities such as roof mending, attending to livestock, etc., and socializing with friends or relaxing at home. A female farmer may spend from four to five hours on the farm and use most of her time in performing household chores and maintaining human capital resources to sustain life at an acceptable level no matter what other work is undertaken.

Nonfarming days, normally taboo days which often fall on a Sunday, are used by both genders for funerals, marketing, community work, church or other part-time jobs.

Access to Credit, Land and Property

In many rural systems, women have generally less access to land, capital, credit, technology and training than men (Cloud 1982).This survey showed that within indigenous household units, most men had easier access to land than women since, in most of these cases, women may only have customary user rights but not ownership rights to the use of their farmland (Andah 1978). This is due to the tradition in which land is usually passed on from a father to a male heir. This discrimination against women in land ownership has not only reduced their status in society but has also made them economically dependent (BIRD 1986) as they tend to operate mostly under their husband's umbrella, leading to the cropping of small areas of from 0.2 to 0.6 ha on the average.

In the event of the death of her husband or a divorce, a woman may cease to have access to her farmland as well as her husband's if the land belongs to the husband's lineage. However, if a widow is in good standing with her husband's family, they may allot her a plot to work on. This may not apply to settler farmers since they may either buy the land legally or operate on some form of tenancy agreement.

Credit for farm operations was not available for either male and female farmers interviewed.

Traditional and Religious Bellefs in the Use of Land and Water Resources

Notwithstanding modernization, traditional and religious beliefs seem to be losing value. Most of the farming communities visited still adhere to them where they exist, for no particular reason, except for the fact that they have been handed down by tradition.

Taboo days are therefore still in existence, and though they may vary from one community to the other, both males and females are not to touch the land or visit the farm at all on such days. A few communities believe that the gods and ancestors of the land visit the land on such days, thus one is likely to see strange happenings on the farm. Among the farms visited in this study, this belief prevailed in the Amansie-East District of the Ashanti Region on Tuesdays. Breaching such taboos may entail warning or fining the culprit in the form of money and/or drink or sheep to pacify the gods.

Menstrual constraints on land use were generally absent. However, for streams and rivers, such constraints may prevail, e.g., in Kofigyan, a village in the Wassa-West District of the Western Region, females of all ages are banned from entering the Huni River on Thursdays as well as during their menstrual periods. Also, in the Sefwi area in the Western Region, menstruating women crossing the River Bia, for example, may drown as they are believed to be unclean to the gods of the river.

Understanding the role of gender in development at the rural level cannot be overemphasized as it can also make a substantial difference as to whether growth-oriented projects succeed or fail (Perkins 1984).

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Post-Production Issues and Aquaculture Development in Ghana

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Abstract

An overview is presented on the preferences for food items in Ghana, with particular reference to fish. Cost is the main factor affecting the selection of animal protein sources, of which fish is of highest preference. Cured fish (smoked, salted, dried or fermented) is preferred over fresh or canned. Size is the least important factor in the selection of fish and fish products.

Introduction

In Ghana, the per caput consumption of fish is one of the highest in Africa. In a recent survey (Nketsia-Tabiri 1993), it was found that the preference for fish is high compared to other animal protein foods (Fig. 1A). The fishing industry provides employment and income to a large segment of the Ghanaian population. Activities involving marine and freshwater fishing have forward and backward linkages which make the industry important to the country's economy (Sefa-Dedeh et al. 1989).

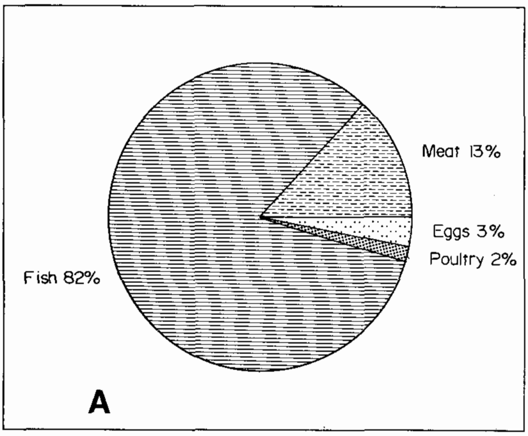
Even though Ghanaians on the average have a high preference for fish, current production and distribution systems cannot satisfy the demand. In addition, the perishable nature of the commodity is such that strategies need to be put in place to ensure that fish and fish products are available in all parts of the country, especially in areas far removed from water bodies.

Aquaculture and products from aquaculture can play a significant role in improving the nutritional status of Ghanaians. This paper discusses some of the post-production issues that need to be considered in the development of aquaculture on a sustained basis.

Selection of Fish Products

The main factors considered in the selection of animal protein by Ghanaians are cost, nutritional value and taste (Nketsia-Tabiri 1993).

It is evident that the average Ghanaian consumer will consider the *cost* of the protein source. If commercial aquaculture is to make headway in Ghana, its products



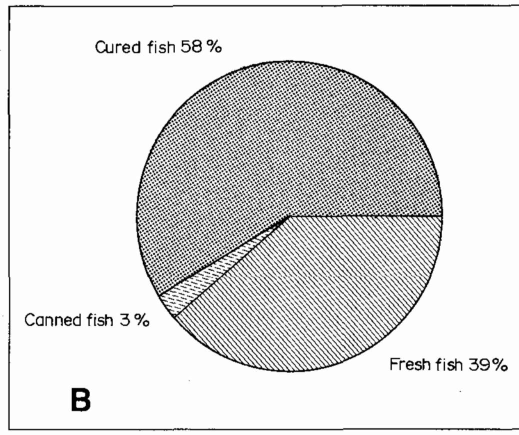


Fig. 1. Consumer preference for: (A) animal protein products and (B) fish products in Ghana.

Table 1. Factors considered in the selection of animal protein sources in Ghana.

Factors	Frequency (%)
Cost	41.6
Nutritional value	26.8
Taste	18.9
Beliefs and habits	7.9
Availability	2.4
Convenience	1.2
Family size	0.6
Financial status	0.6

consumer acceptance. However, the size of the fish is the least of the factors considered by the consumer in the selection of fish products (Fig. 2). This should guide those in aquaculture development not to target the production of large fish. The size preference is indirectly linked to cost and eating habit. A few will want to have large fish but for the majority this is not critical in fish selection.

must be competitive. If these aquaculture products are more expensive than the alternative available, the consumer may not patronize them. It is important that the fish consumption patterns and preferences of the communities in which aquaculture is to be promoted are clearly understood. For example, if tilapia is the fish of choice, in what form will it be presented to the consumer?

Ghanaian consumers utilize fish more often in cured form than as fresh or canned (Fig. 1B). Cured fish in the form of smoked, salted, dried or fermented are popular. Simple curing techniques must be made available to the producers for the effective control of post-harvest losses and increased

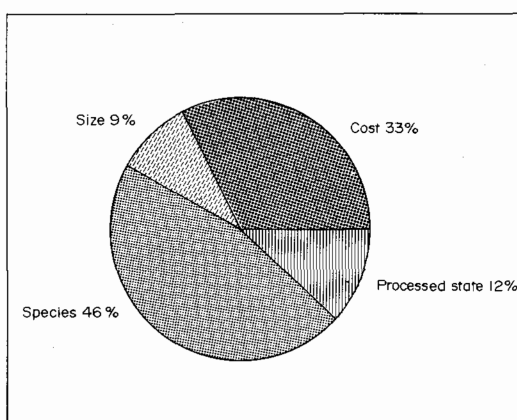


Fig. 2. Factors influencing the selection of fish as food in Ghana (adopted from Nketsia-Tabiri 1993).

Processing Operations

In Ghana, tilapia is processed into salted, dried, smoked or fried forms.

Salting develops flavor, color and texture. Simple salting systems are required. Also, the optimization of salting and fermentation to produce high-quality products with good shelf stability is critical.

The drying method can have an important effect on fish product quality. In Ghana, fish drying is usually done in the open sun with associated contamination. For the effective promotion and delivery of aquaculture products, new designs of simple solar driers should be constructed in the community.

Simple smoking ovens which can handle small quantities efficiently must be promoted. Examples from the fish processors near Weija Lake should be used (Sefa-Dedeh et al. 1989).

The general strategy for processing aquaculture products must be the use of simple innovative techniques which do not require extensive capital outlay yet are efficient.

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Rapid Appraisal of Low-Input Aquaculture Systems[a]

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Abstract

An overview of the existing aquaculture systems in Ghana is presented, focusing on low-input systems. Information was collected using rapid appraisals through site visits. With the help of farm transects, bioresource flow diagrams (where applicable) were made in the course of interviews. Existing problems and immediate options and potentials are pointed out.

Objective and Approach

The purpose of this study was to gain an understanding of the existing situation of aquaculture systems in Ghana in general and to assess low-input systems in particular. This information was to lay the basis for further studies, based on the patterns, differences and limitations of existing aquaculture practices. Previous reviews on the situation of aquaculture in Ghana were done by Balarin (1988), Food and Agriculture Organization (FAO)/World Bank (1989) and MacPherson et al. (1990).

On-site visits and informal, unstructured interviews were conducted with key informants (owners, caretakers, farm staff, relatives, fisheries extensionists, staff of irrigation projects) who provided recall data to construct farm maps, farm activity calendars, bioresource flows and natural resource type transects. Additionally, smallholder farms not performing any form of aquaculture were visited in several regions to study potentials and constraints for adoption of some form of aquaculture.

Annual calendars of fish production activities provide an understanding, both for the researcher and the farmer, of the sequence of management actions on the farm. These can be used to elicit further information as to the quantity, quality and source of inputs and outputs. Qualitative data, which were used to construct resource flow diagrams describing how nutrients are moved between farm enterprises (Ofori et al. 1993), are complementary to the technical information obtained through farm visits (Vincke and Awity 1991; Ofori et al. 1993).

[a]ICLARM Contribution No. 960.

Existing Aquaculture Operations

Few commercial fish farms exist and are operational in Ghana. Nearly all were established after 1980 and few are producing fish economically. Tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) are the most common species grown.

Fish farms are generally owned by individuals, and not companies, most of which are located in the Ashanti, Greater Accra, Eastern, Central and Volta Regions. Some owners are entrepreneurs operating other commercial enterprises who have invested profits made from such activities into fish culture. For them the primary purpose of fishponds is, in many cases, a matter of status. Often, customs and social hierarchy require that fish are given to family and community members as gifts. The size of the fish can be of importance.

Ponds were mechanically dug at high cost but without drainage facilities, proper water supplies and dike construction. In most cases, ponds are not adequately managed and production is much lower than potentially achievable.

Most ponds are fished less than once a year, are not drainable and therefore require borrowing or purchase of a net. Further, they are not dried, restocked and very few nutrient inputs such as fertilizer, manure or feedstuffs are provided (Fig. 1).

Reasons for low production are: (1) wrong or inadequate siting, design, construction and maintenance of ponds; (2) missing or inadequate knowledge of the essentials of fish husbandry (reproduction, pond fertilization, pond biology, fish reproduction and feeding); and (3) wrong perception of possible production levels and associated investment costs and returns.

An often expressed need for large bank loans for initial investments is commonly linked with an unwillingness to seek or follow expert technical advice. Most operations have been abandoned.

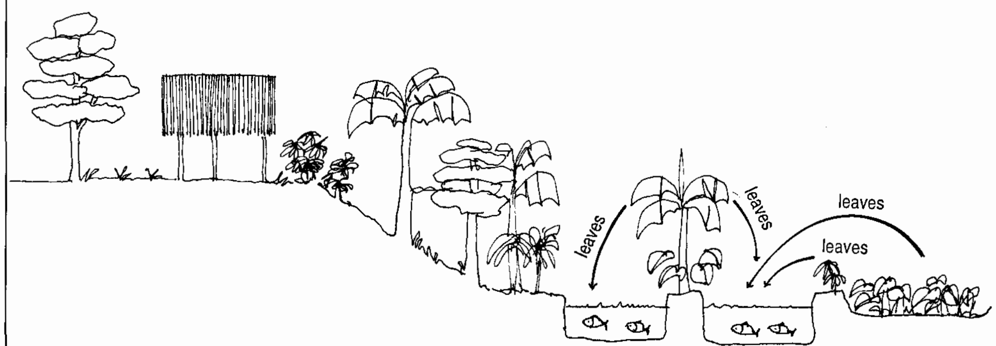
The extension service of the Fisheries Department usually concentrates on this group of fish farmers in their efforts.

Smallholder subsistence aquaculture hardly exists in Ghana. Existing cases are usually undrainable ponds in waterlogged areas, receiving few nutrient inputs, thus leading to low fish production. There is practically no awareness of necessary and appropriate aquaculture technology, and of options for integration and increased utilization of on-farm residues such as manure and plant wastes. People embark on pond construction and operation without prior knowhow, leading to numerous failures. In all cases, the ponds do not produce enough to support the families by fish production alone. Ponds are often haphazardly maintained or even abandoned, and fish stocks in them can be several years old since nets for their harvest are not available and neither is external support. Most examples of this type of aquaculture are located in the Western, Ashanti, Central, Eastern and Volta Regions.

Reservoir-fed ponds in irrigation schemes are a more recent development but can generally be considered a failure. In Ghana, a law exists in which five per cent of the area of developed land below the reservoirs of irrigation schemes should be in the form of fishponds. In a few cases, these were implemented, always in the form of a cluster of ponds at sites directly below the dams. The quality of ponds built by the construction companies ranges from poor in acidic and saline soil (such as in the Dawhenya irrigation area) to good with well-built monks and water supply channels and drains (such as in the Tono and Vea irrigation schemes; see Fig. 4 in Prein and Ofori, this vol.). Often these were not maintained adequately, thus required expensive rehabilitation after only a few years.

The incentive behind these operations was to lease the ponds to individuals who, on top of the pond lease, would have to pay for water supply, fingerlings, feeds and fertilizer inputs, and other operational

Farm transect:
Joseph Amponsah
Kapuepue, Sefwi Wiawso
9 April 1992



Resource type	Upland (Urban area)	Midland	Lowland
Soil type	Sandy loam	Sandy loam	Clay loam
Water source	Rain	Rain	Groundwater (waterlogged, partly undrainable)
Crops, vegetables and trees		Plantain	Cocoa, Oil palm, Cassava, Cocoyam, Sugar cane, Plantain
Fish			Tilapia, Catfish
External inputs			Kitchen + household wastes (4 pails/week to 6 ponds) Slaughterhouse waste Wheat bran
Harvest			One pond: 50 kg *Clarias* @ 40,000 cedis 200 kg *Tilapia zillii*, *Oreochromis niloticus*

Fig. 1. Example of a successfully operating fish farm in the Western Region of Ghana, with some reuse of on-farm by-products. Income from fish culture is used to supplement household income, which is mainly from a business in town.

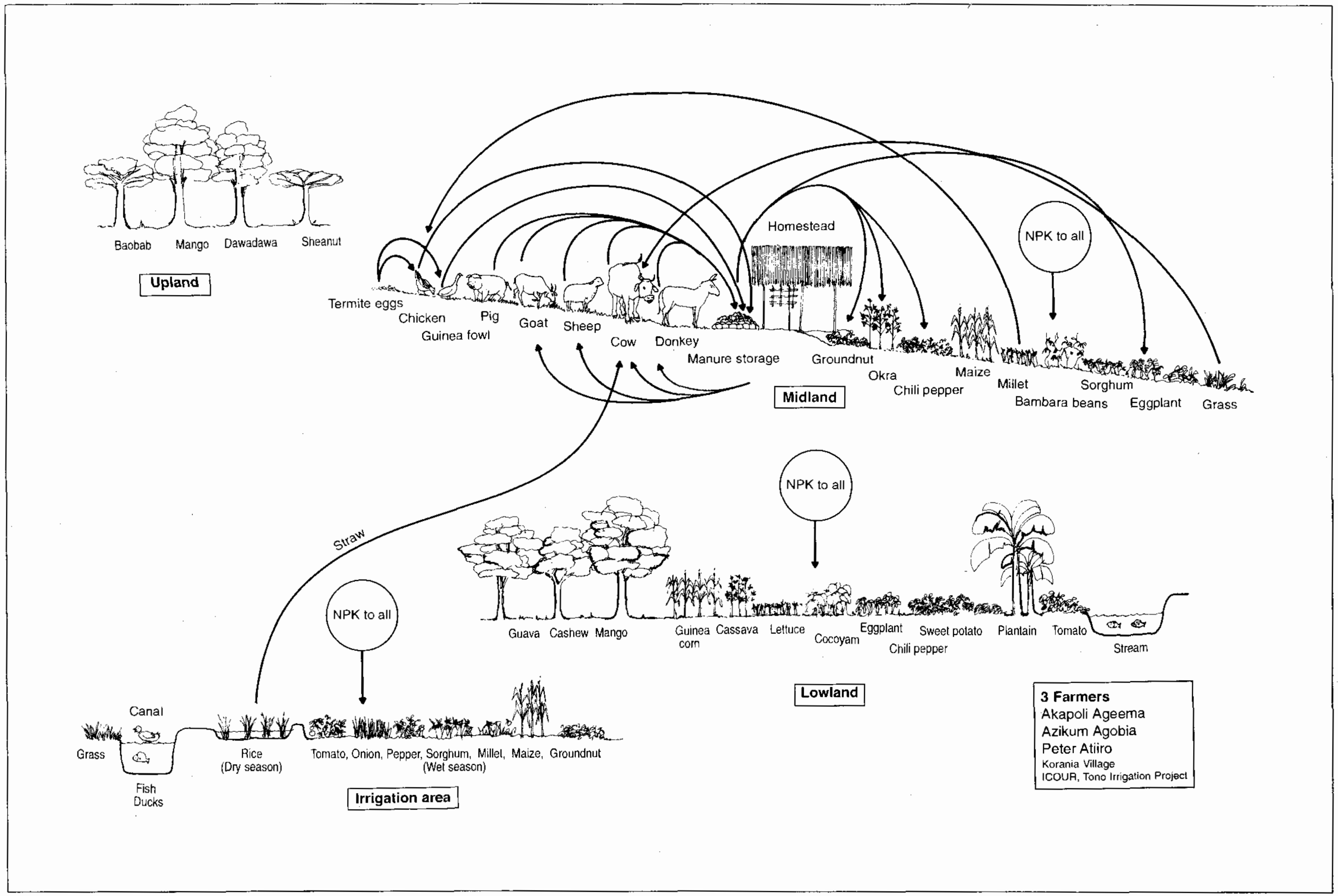


Fig. 2. Bioresource flow diagram of farming activities in the area of an irrigation scheme in the Upper East Region of Ghana. Recycling flows are shown as well as external inputs in the form of inorganic fertilizer (NPK). Household consumption, market sales and other inputs to the farm are not shown. Opportunities for fish culture are given within the irrigation area, either in the form of rice-fish culture or integrated fishponds. Problems with pesticide application in surrounding plots must be considered.

expenses. Fingerlings are not commonly available. Little or no technical training or advice was provided, and most people failed and lost considerable investments. Operators could not reside at their ponds and often had to travel long distances from their homes or farms to the ponds, making daily management and security enforcement difficult (Fig. 2).

A more useful approach would be to construct individual ponds at adequate sites throughout the entire scheme, thus enabling farmers who already rent plots in these areas to visit their ponds daily and manage them appropriately as these are adjacent to the other fields they farm on. Security would be greatly increased and opportunities for reuse of farm wastes would arise. Additionally, a farmer-to-farmer spread of technical knowledge about fish husbandry would occur as ponds would be visited by neighboring farmers daily.

The high technical level of pond construction is unnecessary as simpler systems are easier to maintain and expand. Many schemes have patches of undeveloped sloping lands which are inadequate for irrigated plots but are ideally suited for drainable pond construction, given proper soil quality.

Aquaculture in association with *village dams* or *small water bodies* in the northern regions of Ghana has been considered but not implemented. A large proportion of the small dams dries out during the dry season and therefore will provide necessary top-up water for fishponds below the dams only for part of the dry season. Combinations with dry season gardening are possible. These water bodies serve multiple purposes such as domestic water for drinking and washing, livestock watering and, to a lesser extent, fish production. Health hazards have been identified. Sociocultural issues of ownership, management and distribution of benefits must be solved first before practical approaches are attempted (see Fastenau, this vol.).

Conclusion

Aquaculture operations exist in Ghana, but only a few function today. Production is very low due to failures in adequate siting, construction and management. Fish farmers and extension personnel have little knowledge of appropriate technology. Education, training and follow-up are necessary to create this knowledge among farmers and to enable success stories. Currently, the many unsuccessful experiences with fish farming have discouraged further activities. New entrants into smallholder integrated agriculture-aquaculture pose the most imminent and viable option for an increased and sustained level of aquaculture production in Ghana, which at the moment is around 300 $t \cdot year^{-1}$.

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Experiments for Integrated Agriculture-Aquaculture System Design[a]

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Abstract

Growth experiments with Nile tilapia (*Oreochromis niloticus*) were conducted at the Akosombo Research Station in Ghana to provide baseline data on (a) natural productivity of unfertilized ponds and (b) fish productivity with low rates of cow and chicken manure input, resembling the situation on nutrient-poor smallholder farms. Fish in unmanured ponds displayed weight loss after a short initial increase, resulting in insignificant growth over a six-month period. Fish growth in experimental ponds receiving chicken manure was higher than in ponds receiving cow manure, equivalent to a production of 1.55 and 1.94 $t \cdot ha^{-1} \cdot year^{-1}$, respectively. A newly constructed pond concurrently operated by a new entrant farmer receiving on-farm residues and household scraps showed the highest production, equivalent to 10.2 $t \cdot ha^{-1} \cdot year^{-1}$.

Introduction

As part of investigations on agriculture-aquaculture integration, on-station and on-farm experiments using farm and household wastes and residues as inputs for fish farming were carried out. On-station experiments using ponds receiving no inputs and manure, respectively, were conducted at the Aquaculture Research and Development Center at Akosombo to obtain baseline data on tilapia production. Two sets of experiments were conducted.

The first set of experiments involved the determination of tilapia growth and production under conditions of zero or no nutrient input in newly rehabilitated ponds without any fertilization history. Three 0.1-ha ponds were each filled with fresh water and then stocked with *Oreochromis niloticus* fingerlings of the average weight of 13.6 g at the rate of 2 $fish \cdot m^{-2}$. Four 0.2-ha ponds which had been previously used for fish production were used in a related experiment. Two of the ponds (ZPF1), although fertilized before, had

[a]ICLARM Contribution No. 961.

remained unused for over six months. The other two (ZPF2) had been recently fertilized and used. These were similarly filled and stocked with *O. niloticus* fingerlings of 11.6 g average weight at 2 fish·m^{-2}.

In the second experiment, each of the four ponds, which measured 0.1 ha, were limed with quicklime at the rate of 200 kg·ha^{-1}. Thereafter, each set of two ponds was initially fertilized with cow and chicken manure at rates of 1,500 kg·ha^{-1} and 500 kg·ha^{-1}, respectively, and then filled with water. Subsequent manuring rates were reduced to 500 kg·ha^{-1}·week^{-1} and 200 ha^{-1}·week^{-1} for the cow and chicken manure, respectively. These were applied twice a week. The ponds were stocked with *O. niloticus* fingerlings with the average weight of 6.6 g.

An on-farm fish production trial in a 77-m^2 pond belonging to a farmer collaborator, Ibrahim Ansah, was monitored as the third experiment. *O. niloticus* fingerlings (all-male, hand-sexed) with the average weight of 17.3 g were stocked at the rate of 3 fish·m^{-2}. The pond was then fertilized with a combination of dry chicken and goat manure. A total of 150 kg was applied over a period of six months. Farm wastes such as cassava dough, household food waste, and leaves of cocoyam, cassava, papaya and cabbage were added to the pond as feed. Ponds were sampled biweekly for growth measurement using dragnets. Additionally, the dissolved oxygen (DO), pH, temperature and Secchi depth of the pond water were monitored weekly. Alkalinity was measured after filling the pond.

Results and Discussion

Fish size in the three new ponds with zero input showed an initial increase but thereafter stagnated for a period before declining (Fig. 1). Growth differences between ponds were noted. This was attributed to differences in pond turbidity as

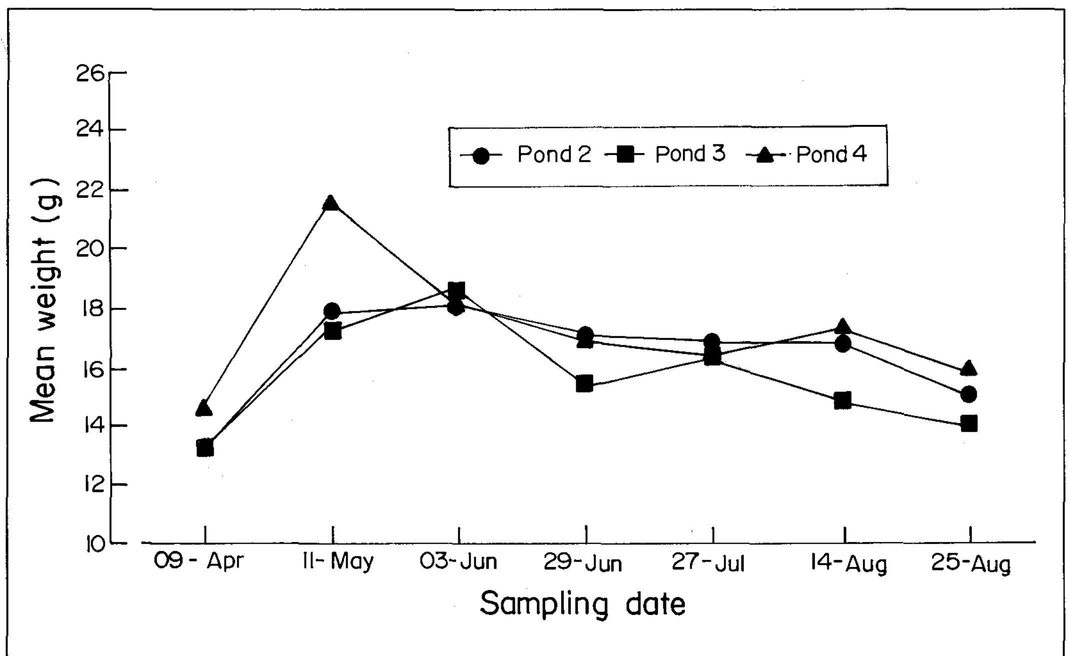

Fig. 1. Change in weight of mixed sex *Oreochromis niloticus* in three new 0.1-ha ponds with zero inputs.

highly turbid ponds (i.e., low Secchi disk readings) exhibited lower fish growth. Turbidity was caused by soil runoff from the bare pond dikes. The average fish yield per pond was 21.3 kg, representing a decrease in biomass of 21%. This yield corresponded to a gross production of 577 kg·ha^{-1}·year^{-1}.

The pattern of fish growth in the ponds with previous fertilization history closely followed that of the first experiment. In this case, however, growth was slightly higher. Fish yield per pond averaged 49.2 kg and 97.2 kg, respectively, for ZPF1 and ZPF2 ponds.

In ponds receiving manure, fish growth was higher with the chicken than with the cow manure. The average final weights of the fish were 16.7 g and 10.5 g after 79 days for the chicken and cow manure, respectively. These represented a daily fish production of 4.2 and 3.2 kg·ha^{-1}·day^{-1} and a gross production of 1,039 and 1,552 kg·ha^{-1}·year^{-1}(Fig. 2), respectively.

Growth of fish receiving on-farm residues and wastes was the highest (Fig. 3). The total fish yield from the pond was 33 kg, equivalent to a gross production of 10.2 t·ha^{-1}·year^{-1}. The mean weight of fish was 152.5 g and ranged from 75 to 300 g.

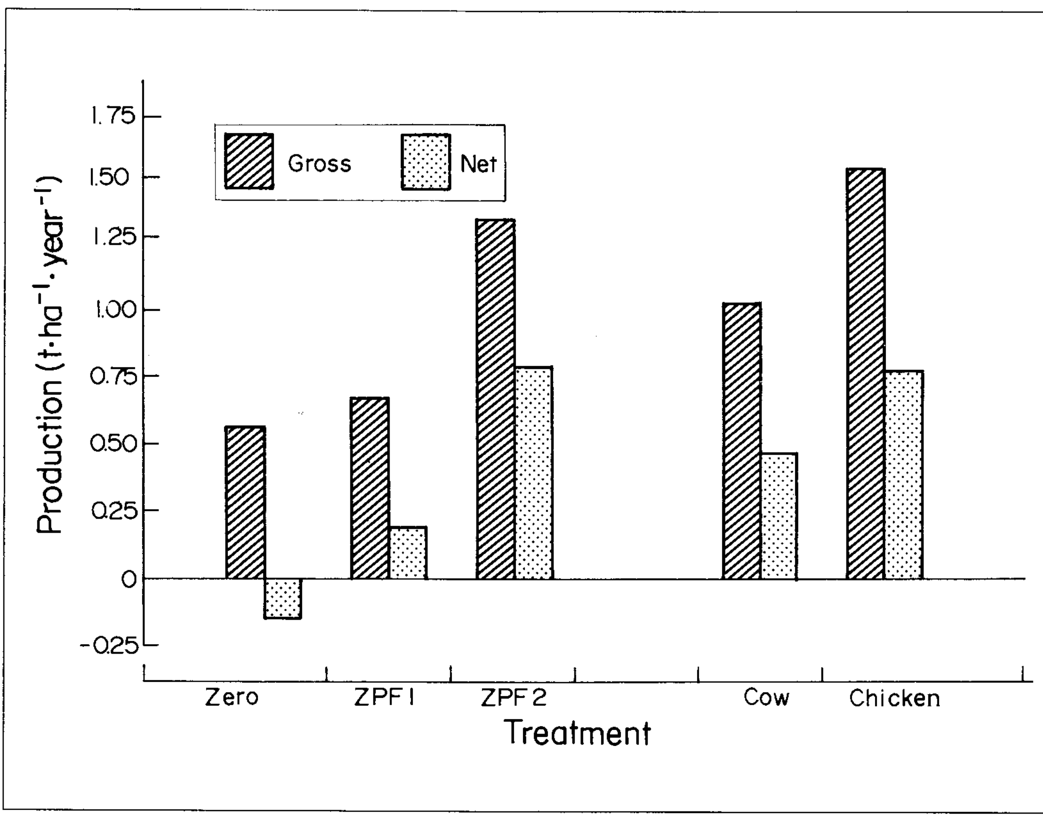

Fig. 2. Extrapolated gross and net productions of *Oreochromis niloticus* in ponds with and without inputs. Zero = zero inputs in new ponds without fertilization history; ZPF1 = zero inputs in ponds with previous fertilization but unused for six months before experiments; ZPF2= same as ZPF1 but used until before experiments; cow = cow manure fertilization of previously unfertilized ponds; chicken = chicken manure fertilization of previously unused ponds.

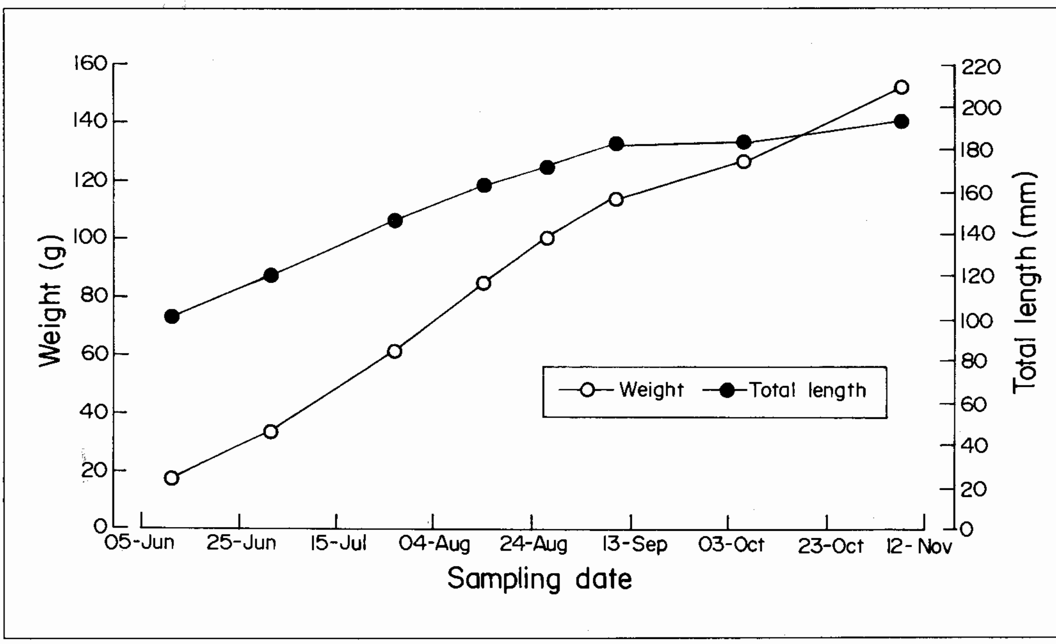

Fig. 3. Growth of handsexed *Oreochromis niloticus* males in the 0.0077-ha farm pond of Ibrahim Ansah (Mampong-Nkwanta, Ghana) receiving chicken and goat manure, and farm residues.

The decline in fish growth in the zero input experiment was expected. The low nutrient levels did not encourage growth of algal and other foods which are essential to maintain and promote growth after any initially available food resource in the water was used up. The fish lost weight; most of them died and this affected overall pond production.

The situation was different in ponds with previous fertilization histories. Production was higher in the recently used pond than in the "fallow" pond. This could be attributed to the leaching of nutrients from the pond as a result of the long period of exposure to weather elements like rainfall. Production in the recently used pond, however, did not indicate another good yield if the pond was cropped another time.

Obviously, the overall growth attained in the manured experiments was low. This was attributable to human error in the manuring schedule which resulted in a lower quantity of manure being applied. However, the overall response of fish growth to the different manure conforms to observations in the literature (Hopkins and Cruz 1982; Pullin and Lowe-McConnell 1982; Owusu-Frimpong et al. 1990, 1991, 1992).

Fish growth in the pond receiving farm and household wastes and residues was highest. It can be inferred that fish production can be increased fivefold with on-farm and household wastes as inputs.

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Rice-Fish Culture Experiments in the Tono Irrigation Scheme

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Abstract

Rice-fish culture trials were conducted on test plots in a large irrigation scheme in the Upper East Region of Ghana. Two different systems, both with refuge ponds on one side of the ricefield were evaluated. One had a lateral trench around the entire ricefield. The other had only a single central trench. After 105 days, rice yields ranged from 1.6 to 4.1 $t \cdot ha^{-1} \cdot year^{-1}$. Lateral trenches prevented the rat infestation of the rice crop which enabled the highest rice yields. Fish production ranged from 133 to 142 $kg \cdot ha^{-1}$ in 105 days. Results encouraged farmers to embark on trials on their own irrigation plots, which were ongoing at the time of the workshop.

Introduction

Agriculture in the Upper East Region of Ghana is determined by such factors as rainfall, temperature, sunshine, relative humidity and soil types. The average rainfall for the region is fairly low and on bad years the amount of 500 mm has been recorded. The distribution is also erratic and half of the year is dry. These factors necessitated the construction of the Tono and Vea dams with their irrigation schemes.

The main occupation of the people outside the irrigation schemes is farming. Crops grown include millet, sorghum, cowpea, groundnut and rice. Soils are generally poor due to excessive use and are treated yearly by applying farmyard manure to the farms.

Farmholdings are small (0.5 ha) and cropping is very intensive including multiple cropping. Under irrigation, however, rice is the major crop and crops can be grown successfully twice a year. Potential areas of 565 to 700 ha and 896 to 1,000 ha during the wet and dry seasons, respectively.

were programmed for rice production between 1987 and 1992. Out of these, about 80% was cropped during these years.

The common rice varieties grown include IR8, GR18, GR19 and Admy-26. For purposes of this trial, a new variety BW 348-1 was used, maturing in 92 days, fairly tall at 90 cm, with good tillering and a potential yield of 6 t•ha^{-1}.

Rice-fish culture is a new introduction in the project and its objectives are:

1. to demonstrate and promote fish culture in the ricefields;
2. to increase protein consumption and income for the rural people; and
3. to investigate the contribution of stocked fingerlings to fish yields from the ricefields.

The presence of a reservoir with an area of 1,860 ha provides a ready source of water for fish farming and rice production in two seasons annually. Annual fish yield from the Tono reservoir was estimated to be 172 t•year^{-1} (Payne 1986) or around 90 kg•ha^{-1}.

Catches from the reservoir declined from 149 t in 1986 to 68 t in 1990, with a consequent reduction in the number of interested fishers from 239 in 1985 to 108 in 1991. Most of the fishers went into farming (ICOUR 1992).

In 1987, five fish farmers rented ponds from the Irrigation Company of the Upper Regions (ICOUR). The number was reduced to four in 1988; in 1992, the company could not get interested farmers to rent the production ponds, so it temporarily administered the ponds on a commercial basis.

As both the fish farmers and retired fishers are seeking alternative income sources, rice-fish farming could serve as an alternative means of livelihood to these small-scale farmers on the project.

On 29 September 1992, a workshop on rice-fish culture was organized by the Institute of Aquatic Biology/International Center for Living Aquatic Resources Management (IAB/ICLARM) Collaborative Research Project at Tono involving 26 participants, two of whom were small-scale farmers growing rice in the irrigation scheme. The rest were staff of the Extension Division (ICOUR).

Method

A demonstration was initiated on the project at the Agronomy Research site of ICOUR by participants of the workshop. Two systems of integrated rice-fish designs with trenches were implemented.

The first system had a rice plot of 53 m^2 (7.8 x 6.8 m) and a refuge pond of 10 m^2 (1.5 x 6.8 m) with a depth of 1 m. Lateral trenches 40 cm wide and 40 cm deep were dug around the ricefields connected to the pond to permit the fish greater mobility from the refuge pond to the ricefield. Plastic pipes screened with mosquito netting material were used as inlet and outlet for the plot.

The second system had a rice plot of 44 m^2 (7 x 6.3 m) and a refuge pond of 9.5 m^2 (1.5 x 6.3 m) with a depth of 1 m. A single central trench 40 cm deep and 40 cm wide was dug along the middle of the rice plot emanating from the refuge pond. Plastic pipes with mosquito netting material were also used as inlet and outlet for the plot.

Rice Agronomy

The rice variety used for this demonstration was BW 348-1. It was nursed in and transplanted into the two trial plots.

The interior spacing between the rice plants was 20 x 20 cm. The seedlings were neatly transplanted in rows and fertilized at the rate of 90 kg N, 60 kg P, 60 kg K per hectare. A shallow water level of 3 cm was maintained where the rice was transplanted.

Fertilizer application was done in two portions. Half of this was applied as basal fertilization and the other half of the inorganic fertilizer was mixed with half of the dose of ammonia and applied four weeks after transplanting. The remaining top dressing of ammonia was applied at the booting stage of the rice. At the final top dressing, the water level was increased to 10 cm.

Fish Culture in the Rice-Fish System

Nile tilapia (*Oreochromis niloticus*) of mixed sex were stocked in both ponds at an average weight of 20 g and a stocking rate of 4,000 fish•ha^{-1}.

Fish were released into the refuge pond of the ricefield one month after transplanting the rice, with the water level in the ricefields maintained at 3 cm and in the laterals at about 40 cm. No supplementary feeding was given to the fish in the refuge pond.

Results

Both fish and rice were harvested on 19 January 1993 after 3.5 months of rice culture. The ricefield in System 2 (i.e., without the surrounding trench) was devastated by rats.

The fields were harvested by draining the ricefields completely. Fish were guided into the refuge ponds in which the water level was reduced to only a few inches. Fish were then caught with a hand net, counted and weighed. The recovery rate was determined for the two systems.

A quadrant of 1 m^2 was used to sample an area of 4 m^2 from the two rice plots. Rice yield from System 1 was 4.1 t•ha^{-1} while that from System 2 was 1.6 t••ha^{-1} (Table 1).

Average weights of 75 and 65 g were recorded for fish from Systems 1 and 2, respectively. Recovery rates were 50% and 46.6% for Systems 1 and 2, respectively (Table 2).

Discussion

The results indicate the potential of rice-fish integration in irrigation schemes in Ghana (Tables 3-5). The low yield recorded for rice from System 2 (1.6 t•ha^{-1}) was due to the invasion by rats which caused the destruction of about 60% of the rice yield.

Rice yield from System 1, however, was very good (4.1 t•ha^{-1}) compared to the average yield for rice on the Tono Project in 1992 (3.0 t•ha^{-1}). This was because the rats could not cross the lateral trenches around the ricefield to get into the rice plot. Rice yields on the Tono project for the past seven years (1985-1992) ranged between 2.5 t•ha^{-1} and 5.5 t•ha^{-1} (ICOUR 1992).

Although tilapia have been found to act as predators in paddy fields by consuming the larvae and adults of insects, and are also known to control weeds, no information was gathered in this respect during the study. However, the fish benefited from

Table 1. Rice yields from two experimental rice-fish culture plots in the Tono irrigation scheme, Ghana.

Plot no.	Plot size (m^2)	Rice variety	Dry weight (kg)	Harvested area (m^2)	Yield (t•ha^{-1})
1	53	BW 348-1	1.70	4.0	4.05
2	44	BW 348-1	0.65	4.0	1.62

Table 2. Fish yield *(Oreochromis niloticus)* from two experimental rice-fish culture plots in the Tono Irrigation scheme, Ghana.

Plot no.	Pond size (m^2)	No. of fish stocked	Stocking weight (g)	Final weight (g)	Yield ($kg \cdot ha^{-1}$)	Recovery rate (%)
1	10	30	20	75	11.3	50
2	10	30	20	65	9.1	47

the natural food in the ricefields as a result of the fertilizer. Research work has demonstrated that even in ponds receiving a high level of supplementary feed, about 50% of the body weight of the fish is derived from the natural food chain in the pond and not directly from the supplementary food (Swift 1985).

The difference in rice yields from the two systems was probably due to the greater mobility of the fish in System 1 than in System 2. Consequently, the fish from System 1 may have benefited more from plankton accumulation from their rice plots than the fish from System 2. The low recovery rate for the fish in both systems is attributed to the loss of fish as a result of the nightly overflooding of the ricefields by a neighboring farmer.

Table 3. Farm budget for fish culture (1.0 ha) in the Tono Irrigation scheme, Ghana. Values in cedis unless otherwise specified.

Cost		
Irrigation levy	=	21,000
Fingerlings ($2 \cdot m^{-2}$)	=	220,000
Rice bran	=	32,000
Pito (local beer) waste	=	13,000
Inorganic fertilizer (NPK)	=	188,000
Lime ($CaCo_3$)	=	24,000
Labor	=	72,000
Total input	=	570,000
Returns		
Yield at 100 g per fish	=	2,000 kg
Market value per kg	=	300
Total revenue	=	600,000
Net returns	=	274,000
% on investment	=	84%

US$1 = 625 cedis.

First Adopters of Rice-Fish Culture

The farmers were invited to see for themselves the harvesting of the experimental plots described above, They expressed appreciation for the results. Several farmers have asked the Fisheries Unit of ICOUR to help them implement the integration of rice-fish culture in their ricefields in the coming seasons.

This dry season, two of the participants, Aduni Navro and Charles Akumasah, adopted System 1 in which a refuge pond is attached to a rice plot with lateral trenches around the whole rice plot.

Navro maintained a rice plot of 810 m^2 (26.2 x 30.9 m) and a refuge pond of 29 m^2 (14.5 x 2 m), while Akumasah had a rice plot of 324 m^2 (27.2 x 11.9 m) and a refuge pond of 33 m^2 (11.9 x 2.8 m).

Both farmers pregerminated the rice seeds of the Admy-26 variety for three days and randomly transplanted five to six seedlings per plant stand after one month. Inorganic fertilizer (NPK) was applied at 90 kg N, 60 kg P and 60 kg K per hectare. The time of growth to harvest of this rice variety is approximately four months.

Mixed sex Nile tilapia (*O. niloticus*) of 20 g average weight were supplied to both farmers at the stocking rate of 4,000 $fish \cdot ha^{-1}$. Fish were kept in refuge ponds. After one month of transplanting, they were released into the ricefields.

Cow dung was applied as bottom dressing to the refuge ponds at the rate of 1,500 $kg \cdot ha^{-1}$ and weekly applications of

Table 4. Farm budget for rice cultivation (1.0 ha) in the Tono irrigation scheme. Values in cedis unless otherwise specified.

Cost		
Irrigation levy	=	21,000
Land preparation	=	25,000
Seed	=	9,750
Fertilizer	=	94,400
Labor	=	120,000
Chemicals (pesticides)	=	10,000
Total input	=	280,150
Returns		
Yield in bags 4.05 t (at 82 kg per bag)	=	49 bags
Cost of one bag of rice	=	12,000
Total revenue	=	588,000
Net returns	=	307,850
% on investment	=	109%

Table 5. Farm budget for rice cultivation in the Tono irrigation scheme (1.0 ha). Values in cedis unless otherwise specified.

Cost of fish culture		
Fingerlings (6,000)	=	66,000
Rice bran	=	1,600
Pito (local beer) waste	=	1,300
Input	=	68,900
Cost of rice cropping		
Irrigation levy	=	21,000
Land preparation	=	25,000
Rice seeds	=	9,750
Fertilizer (NPK + NH_4SO_4)	=	94,400
Labor	=	120,000
Pesticides	=	10,000
Input	=	280,150
Returns from fish		
Yield 100 g per fish	=	600 kg
Market value per kg of fish	=	300
Revenue	=	180,000
Returns from rice		
Yield 4.05 t	=	49 bags
Cost per bag	=	12,000
Revenue	=	588,000
Total input	=	349,650
Total revenue	=	768,000
Net returns	=	418,350
% on investment	=	119%

300 $kg \cdot ha^{-1}$. Farmers also fed fish daily with rice bran and pito (local beer) waste at the rate of 5% of body weight based on a weekly sampling. After six weeks of growth, Navro's fish had reached the average weight of 60 g and those of Akumasah reached 70 g.

The experiments are continuing. Levels of dissolved oxygen (DO), pH and water are measured weekly, and farmers are advised to ensure that the water levels in the fields and ponds do not fall below 40 cm. Nile tilapia has been known to thrive well in good pond conditions with stable pH levels between neutral and alkaline. Nile tilapia can withstand low oxygen levels below 6 $mg \cdot l^{-1}$ (Swift 1985).

Harvesting of rice and fish will be done simultaneously at the end of the growing season (approximately May 1993). Fish will be counted and weighed, and recovery rate will be noted. Both rice and fish will be costed and returns on investments will be noted.

ICOUR's support as of now involves free transport to and from farms and free fingerlings. In the next season, farmers are expected to purchase their own fingerlings at ICOUR's subsidized rate. Interested farmers will be advised to maintain nurseries on their farms.

Conclusion

Preliminary results of fish growth from the two adopters have shown that the growth of fish could be greatly enhanced in paddy fields, and further suggest that rice-fish integration is a possible alternative means of farming which could increase the protein supply and household income of the rural farm households in the Upper East Region. Two limitations likely to be observed with the introduction of rice-fish culture in the Tono project are the overflooding of rice plots by neighboring farmers and the inadequate supply of fingerlings. Possible areas in which the

Fishery Unit of the Tono irrigation scheme intends to experiment are stocking density and weight of fish in rice-fish culture.

Acknowledgements

Special thanks are due to Charles Akumasah and Aduni Navro for cooperating in the adoption trials on their ricefields and also to the staff of the ICOUR Fisheries Unit for their support in the trials.

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Strategic Considerations for Aquaculture Development in Northern Ghana
(Or Why a Team Leader of a Regional Rural Development Program Participated in a Workshop on Aquaculture)

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Abstract

The operational approach of the Programme for Rural Action (PRA), a regional development program located in the Northern Region of Ghana, is presented. One of its aims is to assist communities in the management of reservoirs and other natural resources. Administrative mechanisms through district assemblies are enabled by Ghana's recently introduced decentralization. Alternative uses and management options are discussed in view of community management capacities and development options. The latter are to originate mainly from the inherent funds administered by the districts. The potential role of, and existing constraints to, the development of fisheries and aquaculture in reservoirs are pointed out within the context of this development assistance project.

The Project in Brief

PRA is a regional rural development program in two districts, namely, Nanumba and West Gonja, of the Northern Region of Ghana. It is jointly implemented by the Northern Region Rural Integrated Programme (NORRIP) on behalf of the Ghanaian Ministry of Finance and Economic Planning and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) and the German Ministry for Economic Cooperation and Development (BMZ).

Over the long term, PRA, like numerous other large-scale rural development projects, aims at improving the living conditions of the rural population of the target districts. However, PRA becomes quite different when looking at the purpose of the present phase which reads: "Pre-conditions for sustainable use of the development potential in the districts established."

Preconditions in the project team's view are:

- development-oriented social organization on a community level;
- development-oriented, efficient and cost-effective organization of district-level institutions;
- two-way communication between communities and district-level institutions; and

- stabilized or preferably increasing local resource base (human, natural and financial).

What does This Mean in Terms of Project Activities?

- PRA intends to strengthen community organization and mobilization to increasingly take on community-level development. Participatory village-level problem analysis, identification of potential solutions and subsequent decisionmaking are essential. Awareness needs to be created on a community level for low-cost problem solutions within reach of the communities' resources. In addition, communities need to learn about the external support, i.e., district support, to their own development efforts.
- Ghana introduced decentralization in 1988, establishing 110 districts. The Provisional National Defense Council Law 207 as well as the 1992 Constitution gave considerable legislative power to the district assemblies which are the second highest legislative body in the country. Assembly decisions are to be executed by the district administration and 22 decentralized government departments.

PRA aims at improving cooperation among the assembly, the administration, the district-level departments as well as the nongovernment organizations. In addition, organizational development aims at the efficiency of the aforementioned institutions.

- The district, as the lowest level of government, and the communities need to establish channels that allow a two-way communication process. Assembly persons, as well as recognized local opinion leaders, are to play a crucial role in enhancing communication and cooperation between the two levels. Formal and nonformal trainings are to facilitate improved communication and cooperation.
- A development process will require resources. Improvements in human resources combined with sound and efficient use of natural resources will ultimately generate financial resources that allow for improvements in facilities and services. PRA supports this process by education and training, applied research, studies, etc., as well as by the program financing of projects in fields of known and proven solutions.

How does Aquaculture Tie in with the Development Process?

Looking at the situation in northern Ghana, one of the major problems is scarcity of water. Various technical solutions from boreholes to surface water collection systems are implemented at present, groundwater sources being preferred for health reasons. However, PRA's West Gonja District is situated in a geological area with low groundwater potential. Drilling costs reach prohibitive levels due to a very low success rate. This situation requires a careful look into surface water collection systems, i.e., dams and dugouts.

Construction costs of the latter are considerable compared to costs of boreholes and hand-dug wells. Cost-benefit considerations led the project team to investigate the potential areas for economic use of surface water systems. The most obvious areas are dry season gardening, improved livestock management and - indirectly - aforestation of catchment areas.

Discussions in cooperation with the Fisheries Department revealed that communities with surface water sources in the past requested the department to harvest their dams or dugouts. Some communities were reported to have gained considerable additional income and/or nutritional value out of these by-chance exercises.

PRA decided to explore the potential of these water sources for aquaculture. Having no specialists in the field of aquaculture on the project team, PRA came into cooperation with the Institute of Aquatic Biology (IAB). PRA and IAB have concluded an agreement on a one-year research program to define the potential of aquaculture in surface water supply systems in northern Ghana.

Should the research project prove the feasibility and viability of aquaculture in dams and dugouts which are at the same time drinking water sources for the respective communities, then:

- dam/dugout designs need to be modified to cater to the requirements of aquaculture; and
- concepts for community management which integrate aquaculture into such multi-use systems need to be identified, field-tested and established.

Conclusion

To end this brief presentation, let us go back to the initial question. This author became interested in aquaculture through the backdoor. Rather prohibitive construction costs of surface water systems forced the PRA team to look into ways and means to make productive use of these surface water supply systems to justify construction costs. Besides the obvious benefits, reports on present fish yields in dams and dugouts brought aquaculture into the team's consideration.

The Potential Impact of Integrated Agriculture-Aquaculture Systems on Sustainable Farming[a]

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Abstract

Farmer-participatory experiments on integrated agriculture-aquaculture (IAA) on smallholder farms in Ghana were conducted. Based on preliminary results, the potentials of this integration technology for transforming existing, traditional farming systems to become more sustainable clearly exist. Household economics, together with four sustainability indicators, show that farms which adopt IAA become more sustainable. Additional environmental benefits as well as increased awareness among farmers as to the effects of their activities can be achieved. Possible measures for policy formulation towards widespread adoption are suggested.

Introduction

Future development programs must not only put the means of food production into the hands of the poor to improve family nutrition and incomes but must also do this in such a manner that production is sustainable. This means that the environment or natural resource base that supports production must not be damaged. Indeed, due to present destructive farming systems, most natural resource systems used by agriculture must actually be restored or rehabilitated if sustainable production is to be realized. The following statistics demonstrate just how destructive current practices are.

Soil erosion from African cropland is 70 $t \cdot ha^{-1} \cdot year^{-1}$; 100,000 ha or 1% of African countries' forest area are deforested every year; 140 million ha or 80% of African rainfed land are desertified; and 5 million ha or 30% of irrigated lands are saline in subSaharan Africa (WRI 1988). In Ghana, gully and sheet soil erosion hazards extend

[a]ICLARM Contribution No. 962.

over large areas in all regions. Ashanti Region, for example, has sheet and gully erosion hazards covering over 11,826 km^2 (ROG/UNICEF 1990).

This study takes up the challenge so elegantly presented by Simmonds (1986): "The need for new farming systems development on fragile soils in the lowland wet tropics is agreed to be acute (and has been agreed to be so for decades), but there is yet little or no generalized vision as to how they might be accomplished. Somewhere, somehow, experienced researchers must step outside the component technology and make imaginative guesses; and development agencies must be persuaded to try those guesses in practice, even at the risk of making some expensive mistakes."

The new farming system studied here is IAA. Detailed descriptions of this system based on examples from Ghana can be found in Ofori and Prein (this vol.) and Ofori et al. (1993). Before proceeding with an assessment of its potential impact, a discussion on what we mean by sustainability is warranted.

Agriculturalists have devised many ways to interpret sustainability. Most definitions, however, fall into three categories: agroecology, ethics and sustainable growth (Harrington 1992). It is the first category, agroecology, that concerns us. This category defines sustainability in terms of maintaining system productivity when subject to stress and perturbation (Conway 1967), and looks to its achievement through diversity of enterprises over time and space, nutrient recycling, efficient use of moisture and sunlight, and reduced incidence of pests (Altieri 1987). In a similar manner, we look at sustainability in terms of ecologically based farming that promotes species diversification (trees, livestock, fish and vegetables), nutrient recycling and rehabilitation of natural resource systems. We add to this an economic dimension as farm systems must be economically efficient, i.e., profitable, if farmers are to adopt them.

Sustainability Indicators

For this comparison of IAA farming systems with existing nonintegrated systems, we have used species diversity, bioresource recycling, natural resource systems capacity and economic efficiency as our indicators for sustainability.

Diversity is the number of species cultivated. A weakness here is that it does not take account of the extent of the cultivation. We speculate that diversity contributes to sustainability through biocontrol of pests, reduced risks through compensation by one species for reduced production in another and maintenance of a larger range of germplasm.

Recycling is the number of bioresource flows. A weakness here is that it does not take account of the volume of flows. We speculate that recycling contributes to sustainability through reduced pollution, utilized wastes, and more N and P in more available forms.

The capacity of the natural resource systems is the total output from each system including internal and external flows expressed in monetary terms divided by the number of resource systems. A weakness here is that it does not take account of the external inputs to detect resource mining. We speculate that capacity contributes to sustainability through greater offtake and reduced offsite effects.

Economic efficiency is profit or net income which is gross return minus total costs. A weakness here is that it does not take account of the arbitrary nature of assigning opportunity costs for inputs, especially bioresources.

Comparison of Farming Systems

The dataset used to compare integrated aquaculture and nonintegrated systems comes from a survey of 44 farmers in the Central, Volta and Eastern Regions. From this survey, we selected four nonintegrated farms and one with aquaculture integration. These farms were selected because they were the only nonintegrated farms that could be called smallholder. Farm size ranged from 1.6 to 4 ha. There were no smallholder integrated farms. This example was the only one and it had 24 ha. Such a sample can only be used for illustrative purposes. We will use the before and after aquaculture integration data from our five farmer cooperators in Mampong. For comparative purposes, we have put all farms on a 1-ha basis. However, because the level of integration was low compared to our cooperator farmers in Mampong, we used here a suboptimal comparator.

Keeping these cautionary notes in mind, the comparison of whole farm economic performance shown in Fig. 1 suggests that integrated farms have a potential for larger gross incomes. However, net income differences are much smaller because costs, especially labor, are high in integrated systems. Nevertheless, the potential for cash income through sales of vegetables and animals, but not including fish, is higher under integration. It is interesting and important to note that fish have very little effect on income.

Potential Impact on Sustainability

Integration offers a potential for greater performance in all sustainability indicators. Fig. 2 shows integrated farms to have more species diversity, more materials recycled, greater capacity from their resource systems,

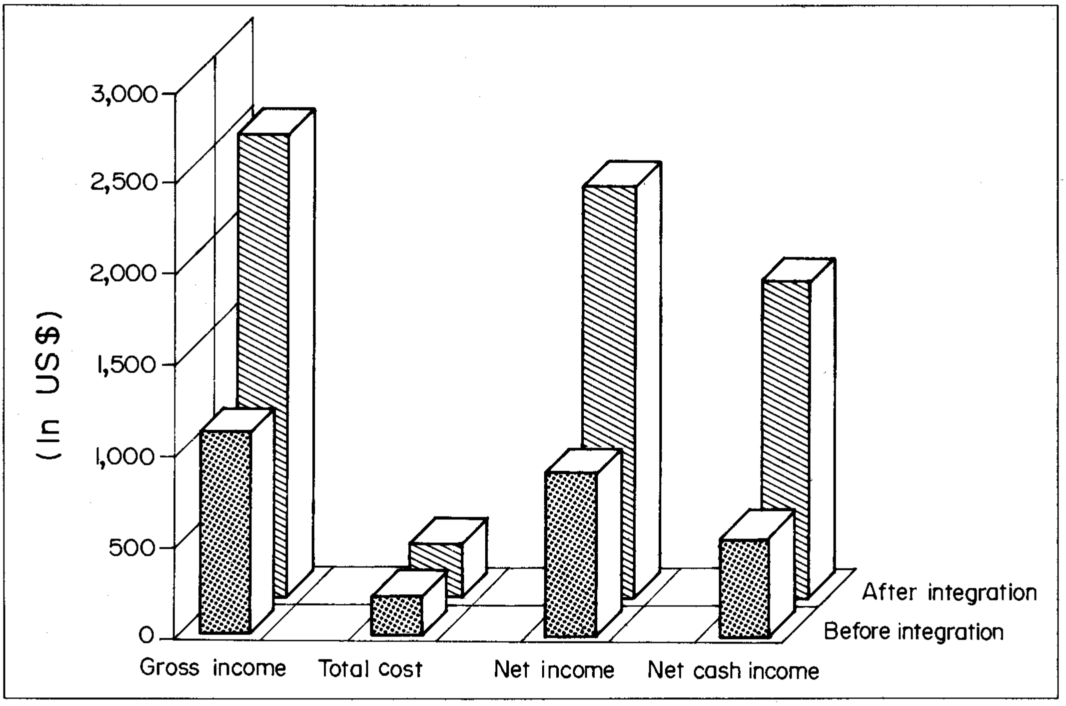

Fig. 1. Economic performance before and after integration on a case study farm in Mampong-Nkwanta, Eastern Region, Ghana.

and higher economic efficiency. Efficiency differences, however, are very small because of the higher labor and material inputs on integrated farms.

Impact on Recycling

Integrated farms display five bioresource flows: maize stover to goat and sheep, cassava peels and leaves to goat and sheep, plantain peels and leaves to goat and sheep, cassava tuber to tilapia, and waste maize grain to tilapia compared to the two flows (maize stover to goat, cassava/plantain/ yam peels to goat) on existing farms.

Theoretically, the bioresource flows could be increased if manure were used in ponds, pond mud on vegetables, in irrigation of trees and vegetables, in watering of animals, vegetable waste to feed fish, and fodder grasses and legumes to feed fish and livestock. Of course, existing farms could have more recycling without integrating aquaculture like grass to livestock but there would be fewer opportunities.

Impact on Diversity

Integrated farms cultivated 11 species as follows: goat, sheep, tilapia, catfish, maize, cassava, plantain, pepper, sugarcane, oil palm, cocoa. The nonintegrated farms cultivated four species chosen from maize, cowpea, soyabean, plantain, cassava, goat, yam and cocoyam.

Diversity could be greater on integrated farms if rice were planted in the pond, if vegetables were grown on pond banks, if leguminous and fruit trees were planted on banks, if ducks and chickens were raised over the pond, and if fodder grasses and legumes were grown on dikes. Even on existing farms, vegetables could be grown, but their performance would be poorer because pond mud fertilizers would not be available.

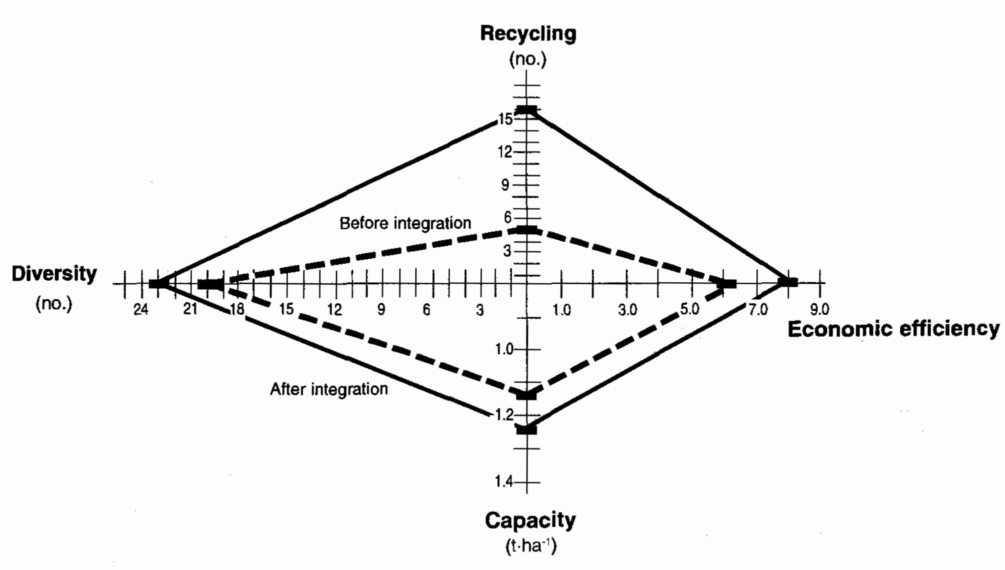

Fig. 2. Site of four sustainability indicators for a case study farm in Mampong-Nkwanta, Eastern Region, Ghana.

Impact on Natural Resource System Capacity

The average value of output from the natural resource systems of integrated farms was $976 compared to the $514 average value of output for nonintegrated farms. All values are in US$.

If pond mud and water were placed on vegetable gardens and tree nurseries, if trees were grown in alleys in midlands or contours in uplands, and if other integration opportunities were exploited, then the resource system capacity would rise even further.

Impact on Economic Efficiency

Integrated farms gave $1,265 net income or profit for the whole farm compared to $1,027 net income from the existing farm. However, potential profits from integrated farms are greater if farmers diversify into vegetables, if external material inputs especially fertilizers and sprays are substituted for internal bioresources, if crops are multistorey (i.e., animals over pond) and if labor does double duty (i.e., weeding for crop yields and feeds for livestock, or fish and pond dredging for pond maintenance and fertilizing vegetables).

Conclusion

Most of the potential benefits presented are speculative. We have no data on response functions, so predictions for farmers cannot be made. Getting the answers will require testing the effects of component technology change on the farming system and, more importantly, testing new IAA farming systems. While methods for component technology testing are well developed, this is not the case for testing new farming systems. We know that nongovernment organizations (NGOs) or development project-supported model farms will not work. What is needed is an evolutionary process with alternative end points and pathways for the transformation of existing smallholder farming systems into integrated systems. The needed participatory monitoring and evaluation protocols we have started in Mampong look promising but are not in place or properly developed. We fear that much stands against this ever happening.

While the Fisheries Department policy favors the integration of agriculture and aquaculture, will it be for the smallholders or the present richer fish farmers? The attraction to existing fish farmers is strong. Not only is it favored by current recommendations of the Food and Agriculture Organization but also by our finding that fish produced on smallholder farms is small and much of it is not marketed. Sticking with the smallholders will require a commitment to household nutrition, poverty alleviation and natural resources management and not to fish production. This is always hard for commodity-defined institutions.

Disciplinary and/or commodity separation in research and extension institutions and government ministries will not foster the needed synthetic research and development thinking. Similarly, the separation of government extension institutions and NGOs will not foster joint planning and implementation of support programs. One can only hope that these results can make a difference in Ghana.

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The Potential Role of Integrated Management of Natural Resources in Improving the Nutritional and Economic Status of Resource-Poor Farm Households in Ghana[a]

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Abstract

An evaluation was conducted on the potential impact of the introduction of integrated agriculture-aquaculture (IAA) into existing farming systems on household nutritional levels and cash incomes in Ghana. The fish culture component is small-scale, based on extensive or semi-intensive pond systems. Farming systems were modelled with simple bioeconomic spreadsheets based on existing and actually measured information. The results demonstrate that the addition of a vegetable field and pond to the modelled farming systems could directly improve household nutrition. In particular, an indirect effect was achieved through a considerable increase in household incomes. Based on an analysis of the protein, carbohydrate, proximate minerals and vitamin content of the food items, nutrient levels are marginally improved by the addition of a pond and vegetable field, whereas vitamin supply is significantly improved. In the 14 farming systems modelled, household cash incomes improved between 229 and 679%. However, a major portion of this is attributable to vegetable production. The contribution of cultured fish was only 2 to 4%, depending on pond size.

Introduction

The likely ability of Ghana to satisfy domestic food demand from national sources is increasingly undermined by its rapid population growth under seriously deteriorating environmental conditions. The implications of this scenario for already impoverished and nutritionally vulnerable small-farm families give rise to grave concern.

In this paper, the demographic and environmental situations are discussed and the demand for and supply of principal food commodities are analyzed briefly. The characteristics of resource-poor farm families are then described in terms of land, labor, household budgets and capital formation, and nutritional and health situation. The provisional results of 13 small-scale farm models are also presented and the potential role of IAA in enhancing both the nutritional

[a]This paper is a combined version of two individual presentations given by the author at the workshop, which were entitled: (1) Aspects of the human ecological context of resource-poor farmers in Ghana; and (2) Integrated agriculture-aquaculture systems and their potential role in satisfying future food demand in Ghana.

and economic status of farm households is demonstrated. A brief projection of the potential of IAA is made at the national level.

Demographic Context

The demographic situation in Ghana is alarming. The current population is an estimated 14.6 million (ROG 1989). The annual rate of population increase is 2.6%. At this rate, the population would double in about 27 years (Fig. 1). However, government policy aims to reduce the rate of increase to 2% per year by the year 2000 (ROG-IRD 1989).

In Fig. 1, population growth has been projected to the years 2000 and 2020 based on three growth rate scenarios: the current 2.6% per year, which would give a population of about 18 million by 2000 and 32 million by 2020, and 2% per year officially targeted from 2000 (prior to that year, the rate of 2.6% was used), which would give a population of 18 million in 2000 and 28.4 million in 2020. For comparison only, since for cultural reasons the rate is unlikely to be achieved, the rate of 1.5% per year from the year 2000 is also included. That would result in a population of 25.5 million in 2020. (However, World Bank projections are based on the rate of 3% per year [IBRD 1989].)

A further important demographic characteristic of Ghana is its youthful age structure. Children (0-5 years of age) now comprise 20% of the total population, and those 0-15 years are almost half (47%) of the total. This has important implications for future population growth rates, employment generation, provision of social services and physical infrastructure and, of more immediate concern, for food supply.

Further, with a population of 32 million in the year 2020, the area of agricultural land per caput would decline from 1.95 ha (1988) to 0.43 ha (2020). The food

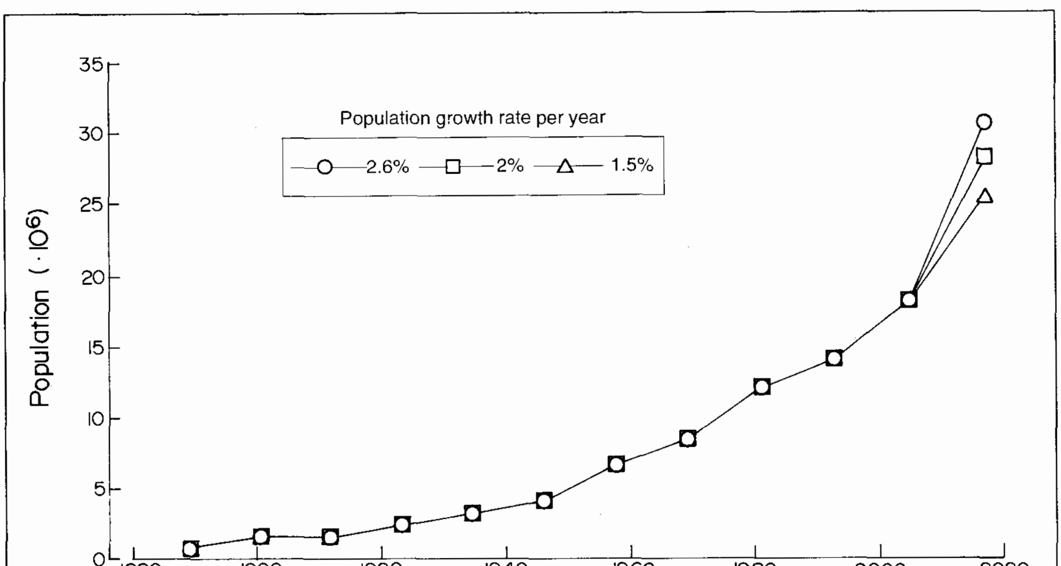

Fig. 1. Ghana: historical growth and population projections, 1880-2020.

security implications, at least at the household and community level, are obvious.

Physical Environment

The above demographic scenario is unfolding in the context of increasingly difficult environmental conditions. These include such natural factors as climatic regime, hydrological conditions, natural hazards and, more insidious, the anthropogenic factors of greatly accelerated and all-pervasive soil erosion, localized desertification and forest destruction. These factors of human origin exacerbate the impact on society - particularly rural society - of the natural factors.

Climate

Rainfall in Ghana is both highly seasonal and often unreliable. Southern Ghana enjoys a bimodal rainfall distribution (i.e., two seasonal peaks per annum). This sustains two crop seasons and so permits a higher rate of crop production per unit area. Northern Ghana, in contrast, has a unimodal rainfall pattern, a single rainy season that severely constrains unirrigated crop production.

Hydrological Conditions

Since Ghanaian agriculture is almost entirely rainfed, variability of rainfall is a major cause of crop failure. Water shortage in the dry season is an endemic problem. It often becomes extremely serious in rural areas.

Wells and boreholes are often dry for long periods. This means that women and children must often travel long distances each day to manually fetch the domestic water supply, a task that makes inordinate demands on their energy and daily time allocation, with obvious health implications.

Natural Hazards

Climatic variability (and long-term changes) and bush fires are the main natural hazards in Ghana. Floods and droughts have been widespread in recent years. For example, serious floods occurred in 1989 in the Volta, Brong Ahafo, Ashanti, Eastern, Western and Northern Regions. There was widespread destruction of dams, which in turn had a serious impact on agricultural and domestic water supplies during the following dry season.

Soil Erosion

Whereas soil erosion and replenishment is a natural phenomenon, *accelerated* erosion is of human origin. Deforestation for lumber, charcoal and fuelwood production and the creation of agricultural areas, reduced fallow periods in cultivation cycles, as well as poor soil management and conservation are leading to greatly accelerated soil erosion throughout Ghana. All regions are under threat (Fig. 2).

Desertification is widespread in the Northern and Upper Regions of Ghana, particularly where population densities are high and the land is intensively cultivated (Anon. 1991). The Greater Accra Region is also at risk.

Slight to moderate sheet erosion is most severe in the Greater Accra Region, where in excess of 90% of the area is affected. As would be expected, it is least in the forested Eastern, Central and Western Regions. From 30 to 50% of all other regions are classified as suffering from slight to moderate sheet erosion.

Severe sheet erosion accompanied by gulley formation is widespread throughout Ghana. It is most serious in the Western (70%), Eastern (57%), Ashanti (50%) and

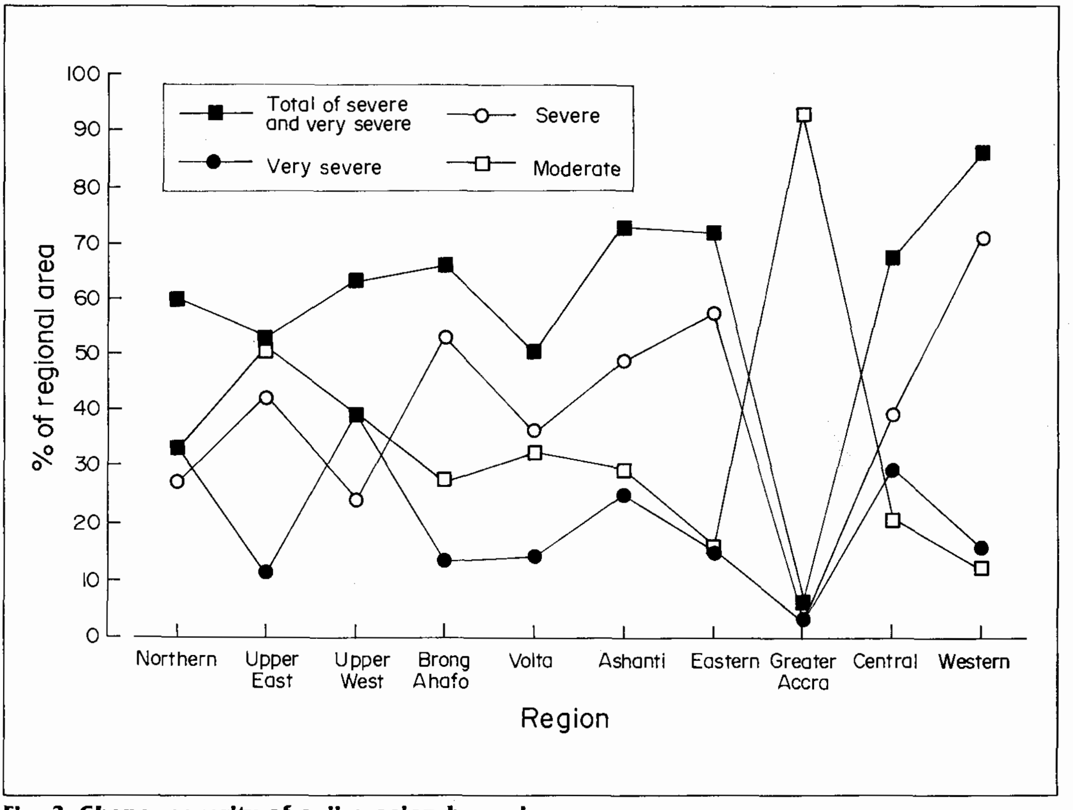

Fig. 2. Ghana: severity of soil erosion by region.

Brong Ahafo (53%) Regions but is of serious concern throughout Ghana.

Very severe sheet erosion accompanied by gulley formation is more widespread than the severe category. Apart from the Greater Accra Region, where the problem is relatively slight, proportions of regions severely affected range from a "low" of 50% in the Volta Region to a high of 87% in the Western Region.

Declining Soil Fertility

Soil fertility under systems of shifting cultivation - the main agricultural system practiced in Ghana - was traditionally maintained by the use of a multi-year fallow period. But population pressure has now led to a more continuous use of the farmland, and fallow periods have been either shortened or eliminated.

Such solutions as planted fallows, cover cropping, mulching, alley cropping and minimum tillage are all labor-intensive and, thus, because of expense, have not been widely adopted. (The cost of labor is a major constraint to agricultural development in Ghana.)

Thus, inorganic fertilizers are used to maintain soil fertility. Without these supplementary nutrients, soil degradation is likely to become irreversible, crop yields will decline, and the human-carrying capacity of the land will continue to decrease, but at an accelerating rate.

Quite apart from, and certainly not to belittle, the ecological arguments against the use of inorganic fertilizers, is that their application in the amounts required to recover degraded soils is economically infeasible in Ghana. For example, just to replace the amount of nitrogen removed annually by staple food crops would require the annual application of the equivalent of 332,000 t of ammonium sulfate. And to provide the phosphorus would need some 116,000 t of superphosphate or 330,000 t of 15:15:15 compound. In contrast, in 1989 the total fertilizer imports of Ghana amounted to a mere 45,000 t (FAO 1989a).

Forest Destruction

Deforestation is a major problem throughout Ghana. Southern Ghana has now some 1.7 million ha of forests. But these are being degraded or destroyed at the annual rate of about 2% of their total area. At this rate, by the year 2020 there will no longer be a forest industry in Ghana (ROG 1991).

Charcoal burners are responsible for much forest destruction in the Transition Zone (ROG 1991). In northern Ghana, especially in the Upper East Region, economically important trees formerly left in the farmland have been felled to provide domestic fuelwood. In areas of high population density in the savanna zones, woodlands and park savanna are experiencing serious depletion at the rate of about 20,000 ha•year^{-1} (Friar 1987).

Not only does this deplete and degrade timber resources, it also destroys the habitat for the fauna so important for providing the farmer with bush meat (wild animals such as deer), an important source of income (see below). It also destroys the source of complementary plant foodstuffs. On the other hand, when grasslands develop in formerly forested areas, certain animals like the grasscutter (*Thyronomys swinderianus*), a major item of bush meat, are able to expand their range.

[a]US$1 = 625 cedis.

Social Implications of Environmental Conditions

Since the direct annual cost of environmental degradation is estimated conservatively at 4% of the gross domestic product of Ghana, this would be about 42 billion cedis•year^{-1}.[a] This means that Ghana would, for environmental reasons, be foregoing annually 4% of its *potential* national economic output. Agriculture imposes the greatest single cost at 28.8 billion cedis•year^{-1} or 69% of the total cost of environmental degradation (Convery and Tutu 1990).

This implies that present positive economic growth rates are not sustainable because they are being maintained at the expense of future growth; i.e., economic growth is based on undermining the biological and physical foundations of future productivity (Convery and Tutu 1990; Anon. 1991).

The principal short-term impacts are:

- an irreversible loss of productive land and thus an increased population pressure on remaining productive areas;
- a loss of soil fertility and thus declining crop yields, leading to direct and indirect (through price increases) hunger and nutritional deprivation among the poorer segments of society, and therefore increased health problems;
- a decrease in household, community and national food security;
- a decrease in water supply;
- a decrease in fuelwood supply; and
- an increased expenditure for food, fuel and fertilizer imports which,

since they cannot be paid for by exports from a declining resource base, will require increased international assistance.

To summarize the Ghanaian context: population (therefore, food demand) is growing rapidly and the environment (therefore, food supply) is degrading. Thus, food demand in Ghana will go increasingly unfulfilled.

National Food Supply and Demand

Analysis of the range of yields of staple food crops for the period 1970-1986 demonstrated that none were achieving their theoretical potential yields (ROG 1987) (Figs. 3 and 4).

None of the yields of cereal crops achieved more than 35% of their potential productivity. Cassava also yielded only about 34% of its potential rate. However, yam (at 58%) and cocoyam (at 68%) came nearest to attaining their potential yields.

At the national level, with the exception of cassava, for which the supply exceeded demand by 57%, the supply of all staple crops fell far short of demand: yam (133%), maize (131%), rice (59%), and millet and sorghum (2%) (ROG 1987).

Slight variations in this general picture occurred at the regional level. Cereal production exceeded demand in the northern regions of Ghana. Thus, maize production exceeded demand in the Upper West (10.8%), Northern (25.9%) and Brong Ahafo (25%) Regions; rice production exceeded demand in the Northern (10%), Upper West (2.9%) and Upper East (0.6%) Regions; millet and sorghum production exceeded demand in the Northern (26.1%), Upper West (25.8%) and Upper East (20.3%) Regions. Also in the north, yam production exceeded demand: Upper West (29%), Northern (104.1%) and Brong Ahafo (126%) Regions. For cassava, the excess of production over demand was more widespread: Brong Ahafo (292%), Central (93%) and Western (48%) Regions (ROG 1987).

Given the scenario of rapid population growth combined with declining soil fertility and environmental degradation outlined above, it is hard to be optimistic of Ghana's future ability to achieve the policy objective of national food security. Increases of both the productivity per unit area cultivated and the area under cultivation would have to be dramatic to realize that policy goal. This is demonstrated by the projections on food demand (Fig. 5).

Holding the annual per caput food demand constant to satisfy demand in the year 2000, the following increases over present production (1987) are required: maize (98%), rice (192%), millet and sorghum (41%), cassava (35%) and yam (1,737%).

Again, holding the per caput demand constant, the following rates of increase over present (1987) production are required to meet demand in the year 2020 (at the medium and high rates of population increase): maize (206% and 231%), rice (352% and 390%), millet and sorghum (117% and 135%), cassava (109% and 127%) and yam (3,575% and 3,870%).

Projected Demand for Fish

Various projections have been made of future fish demand in Ghana. Computation here is based on the "herring" (*Sardinella aurita*) catch because herring is the main fish consumed in rural Ghana, and on animal protein supply and demand.

Taking the average normal adult protein requirement of 14.25 kg·caput^{-1}·year^{-1} and projecting it for the 2020 population figure of 28.45 million persons, the annual total animal *protein* demand of Ghana will be 405,412 t.

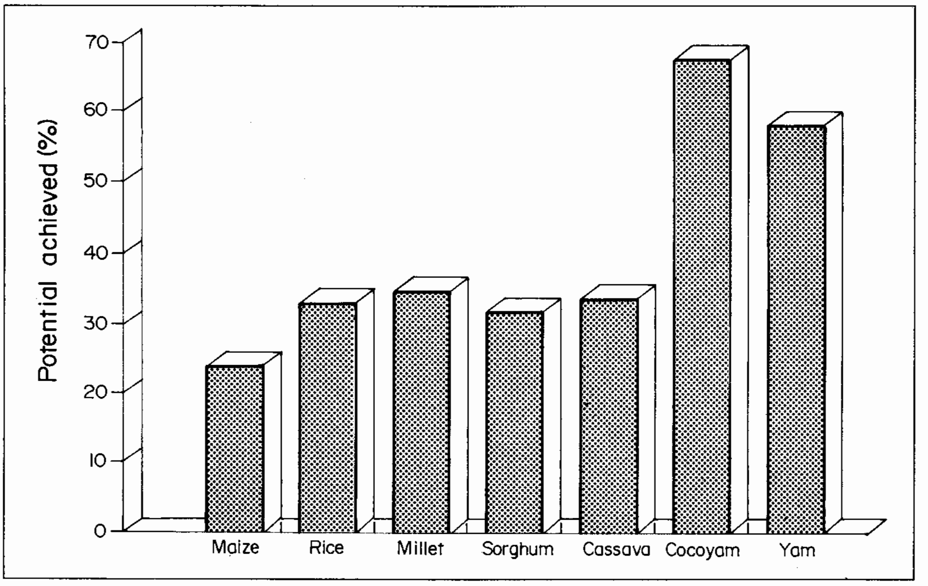

Fig. 3. Productivity of staple crops as percentage of potential yields, 1970-1986.

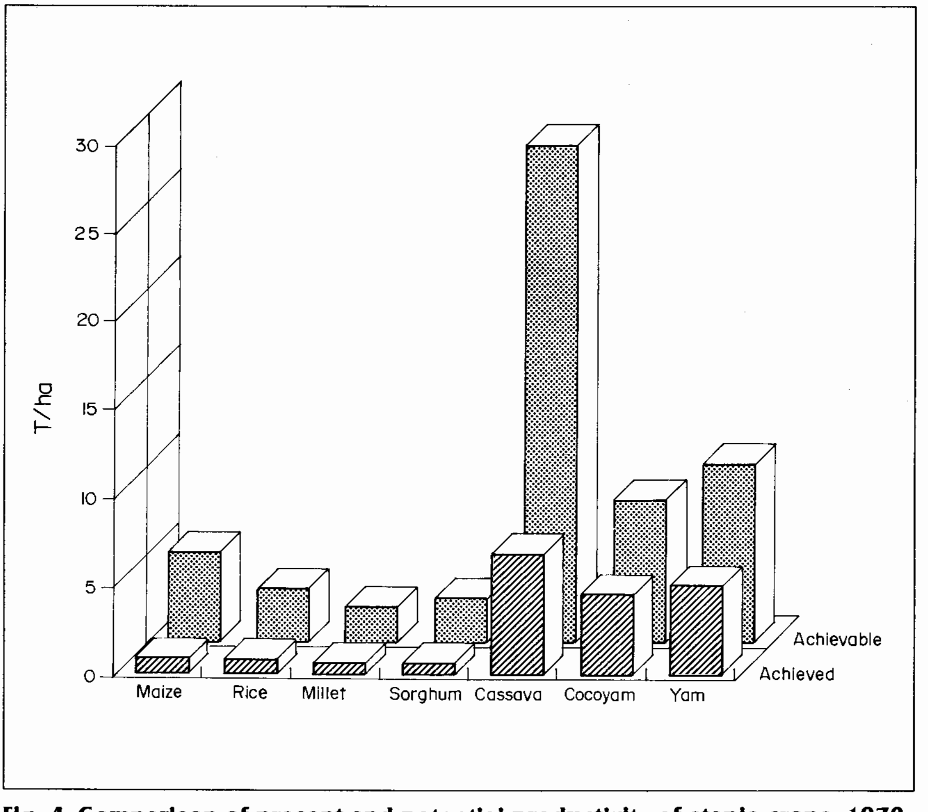

Fig. 4. Comparison of present and potential productivity of staple crops, 1970-1986.

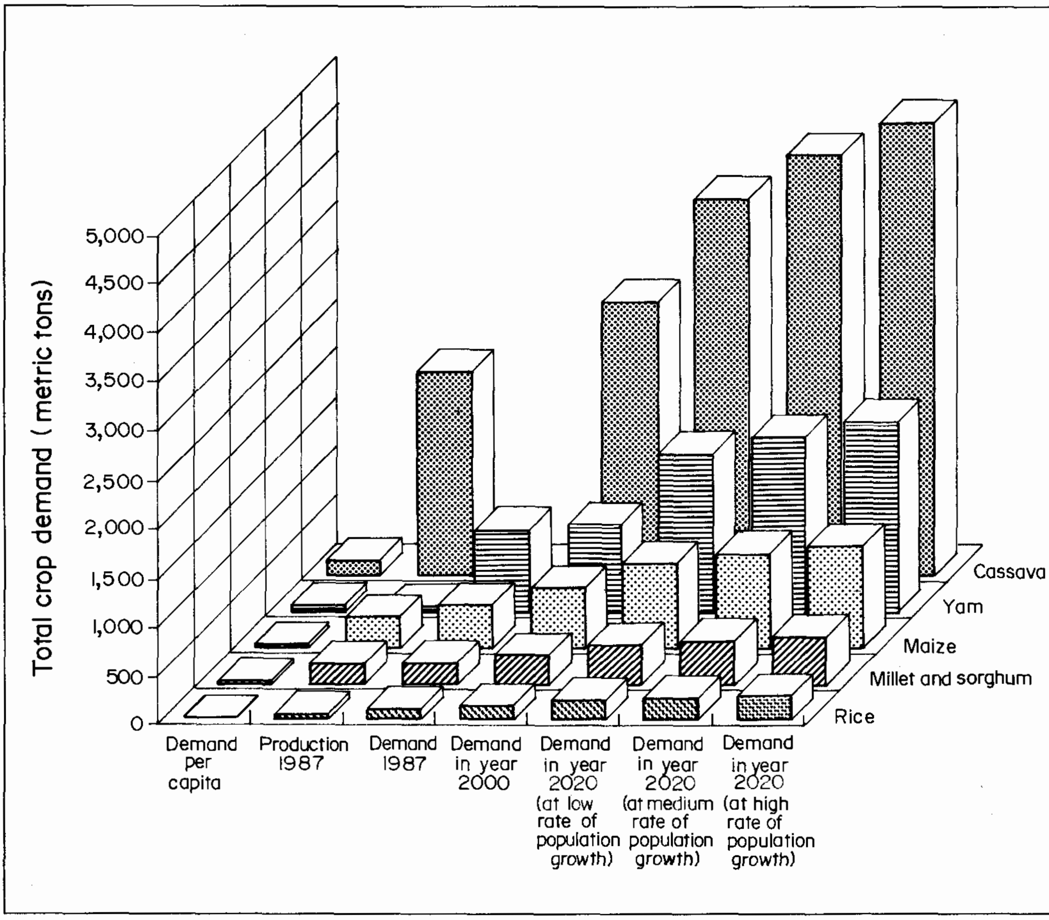

Fig. 5. Actual demand per caput and production for 1987 and project demands for years 2000 and 2020 of cassava, yam, maize, millet and sorghum, and rice.

Now, turning to the supply side, fresh herring consists of 20.6% protein and smoked herring, 66.8% protein (Eyeson and Ankrah 1975). Further, if we assume, as at present, landings of 300,000 t·year^{-1}, of which 225,000 t are smoked and 75,000 t marketed fresh, there is a current production of protein from herring of 168,450 t·year^{-1}.

Thus, to attain the 2020 protein demand, a herring landing of 750,000 t would be required, an increase of 2.5 times over the present figure. This would translate into a supply of 26.36 kg·caput^{-1}·year^{-1} (wet weight) of herring.

However, conventional wisdom, in the absence of reliable stock assessment data, asserts that there is limited potential for further marine fisheries development since stocks are already exploited at a high level (e.g., FAO 1989b). Nevertheless, the Government of Ghana would like to double fish availability from the current annual average landings of 300,000 t. But this cannot be accomplished from resources available in Ghanaian waters (FAO 1989b).

Further, as observed above, if present extraction rates continue, Ghana will be without forests by the year 2020. If that is the case, even if 750,000 t of herring were landed, there would be nothing to smoke them with! Fuelwood would simply either not be available or be far too expensive for use in fish smoking unless fuelwood plantations were made. But then these would compete with the by then precious land needed for food production.

So, another economical processing or distribution technology would have to be substituted if herring is to remain affordable to the poor rural people. But since other forms of processing yield far smaller amounts of protein per fish, the size of the landings would again have to be increased proportionately.

This illustrates vividly, if in a very simplified way, one linkage among environmental degradation (forest destruction), environmental pressures in other ecosystems (the sea) and poverty (need to provide inexpensive fish). The interlocking complexity of this example of the resource-environment-poverty problem facing Ghana is crushing.

Some Characteristics of Resource-Poor Farms and Farm Families

Land

In Ghana, slightly over 80% of the farms are used either mainly or entirely for household subsistence purposes (MOA 1988) (Fig. 6). Cash cropping is of greatest importance in the southern part of the country. Only in the Western Region is cash cropping the predominant form, although it is of above average importance in the Western, Brong Ahafo, Eastern and Greater Accra Regions.

About 25% of Ghanaian farmers have just one farm (cultivated plot) on their total landholding. Further, 75% of all farmers have three farms or less, each of 0.4 ha or less, giving a total holding size of 1.2 ha or less. Further, 55% of the nation's farm-holdings are less than 1.5 ha in area and the median size is 1.44 ha (MOA 1988).

The already deficient crop yield of such small farms (see below) is exacerbated by post-harvest food losses. An estimated 20% of harvest crops, primarily grains and legumes, is lost mainly because of inadequate storage facilities (Sefa-Dedeh 1981).

Labor

Traditional (i.e., unmechanized) agriculture depends mainly on household labor, with 90% of farm labor being supplied by the farmer and his family (Ewusi et al. 1983). Average rural households consist of five members (1970 census) (Ewusi et al. 1983). Those in the north are larger: Northern Region, 7.1 and Upper Region, 6.5. There is an average of three children per farm family.

Women play a very large role in Ghanaian agriculture, with 70.3% (1970 census) of the women farmers engaged in food crop cultivation. They outnumber the men in the cultivation of staples and vegetables.

A further problem is the aging of the agricultural labor force. Since young males prefer alternative occupations, the male farm population is aging. For example, whereas the total agricultural labor force increased by 22,714 persons during the period 1960-1970 (the latest for which such data are available), the main increase occurred in those above 45 years of age. In contrast, absolute decreases occurred among younger males (Addae-Mensah 1979).

In traditional agriculture, all tasks are performed by manual labor, using mostly hand hoes and bush knives (cutlass). This is performed by family members and

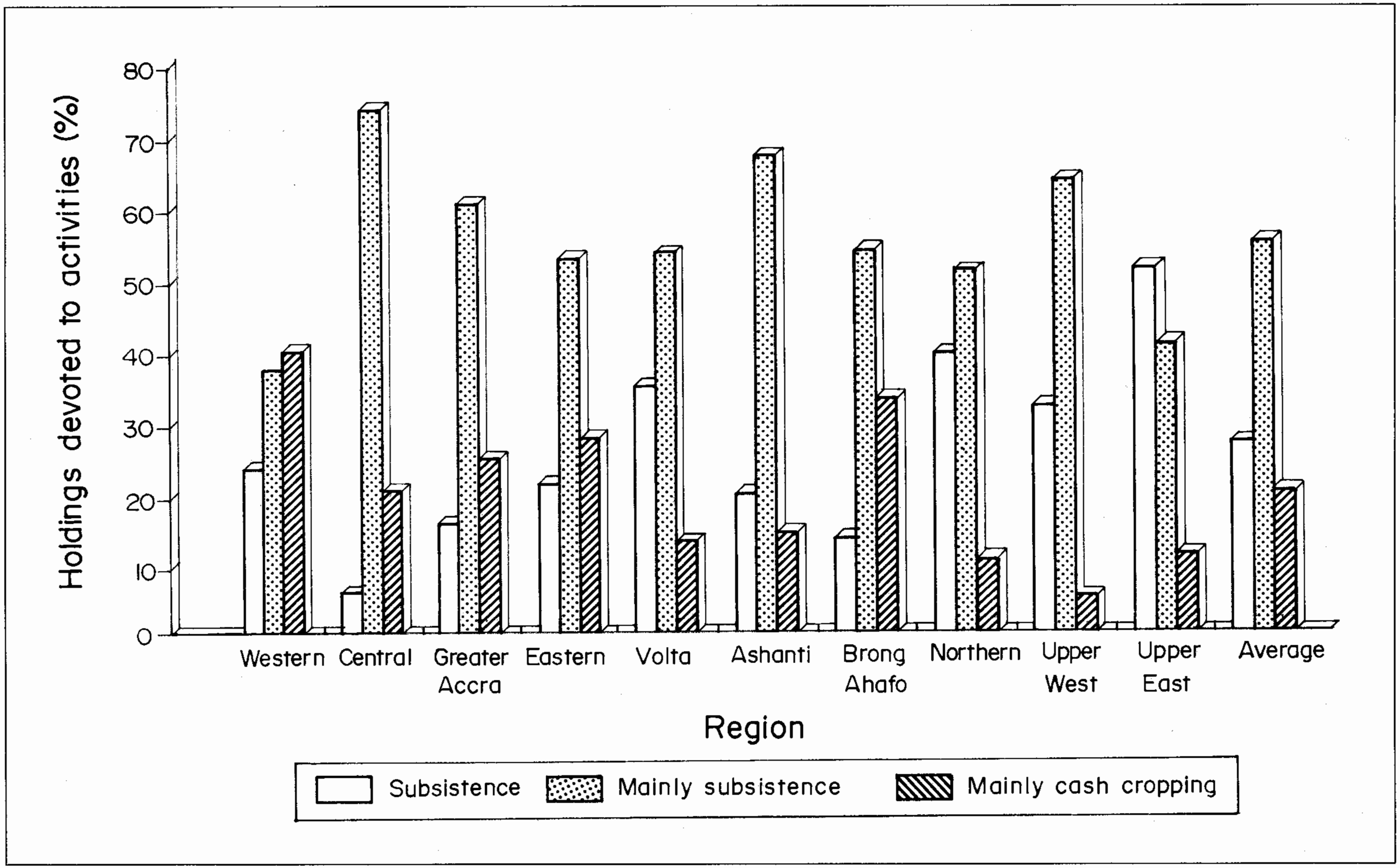

Fig. 6. Percentage of holdings devoted mainly to household subsistence and to cash cropping by region.

supplemented for particular tasks during seasons of peak demand by hired, casual labor. In Adidwan Village, Sekyere District, Ashanti Region, for example, 82% of total labor input was supplied by the family (Mensah 1987). Hired labor is used to supplement family labor for land clearance, yam mounding, ridging, weeding and harvesting.

Apart from female-headed households, males make a greater labor input to agriculture than females. In Adidwan Village, Ashanti Region, for example, males contribute 68% of total inputs. However, labor specialization by gender is evident only for land clearance in which the heavy tasks of tree felling are performed by men.

At the community level, as exemplified by Adidwan Village, there is a large oversupply of family labor (Fig. 7). However, depending on household composition and size, labor constraints could occur in January, March, April and August when land clearance makes major demands on supply.

Labor demands vary widely according to the crop assemblage cultivated. In Adidwan Village, they range from 69 person days·ha^{-1} for a maize-cocoa combination to 537 person days·ha^{-1} for a shallot-chili pepper-eggplant-cocoyam combination. As a general rule, maize and pulses are the least labor-demanding crops, whereas vegetables and various admixtures of them with starchy staples have the highest labor demand.

Household Budgets and Capital Formation

Among resource-poor small-scale farmers in Ghana, the principal means of capital formation is through the sale of farm products (Fig. 8) and complementary foods, such as bush meat, and products from wild plants. This is often supplemented by off-farm sources of income, particularly during the agriculturally slack months. However, although unavoidable as a means of obtaining cash to buy such necessities as medicine and to pay various fees, it is important to note that the sale of farm products, in particular, staple products, exacerbates an already precarious nutritional situation in resource-poor households (see below).

The data obtained through protracted field research in Adidwan Village, Ashanti Region (Mensah 1987) have been used to exemplify household economics in this representative part of central Ghana.

Gross Margin by Crop Enterprise

The combination of yam-chili pepper-tomato yields the highest gross margin (225,451 cedis), the highest return on labor inputs (767 cedis per person day) and the highest gross return per unit cultivated (170,857 cedis·ha^{-1}). Shallot cultivation gives the lowest return, with a gross margin of -45,700 cedis, a return on labor of -188 cedis per person day and a return on area cultivated of -40,581 cedis. Maize, peanut and maize-cassava all show negative rates of return. In general, vegetable and yam cultivation yield the highest gross margins and return to labor inputs, despite their high labor demand and therefore actual or opportunity costs.

Production Costs

The high cost of labor is the principal reason for the poor economic performance of cropping enterprises. Labor expenses are high for yam, peanut, vegetables and shallot. This is exacerbated by the high cost of seed for shallot and yam.

Farm Cash Flows

In Adidwan Village, average net farm cash flows are positive at 13,476 cedis per farm and 6,811 cedis·ha^{-1}. However, severe

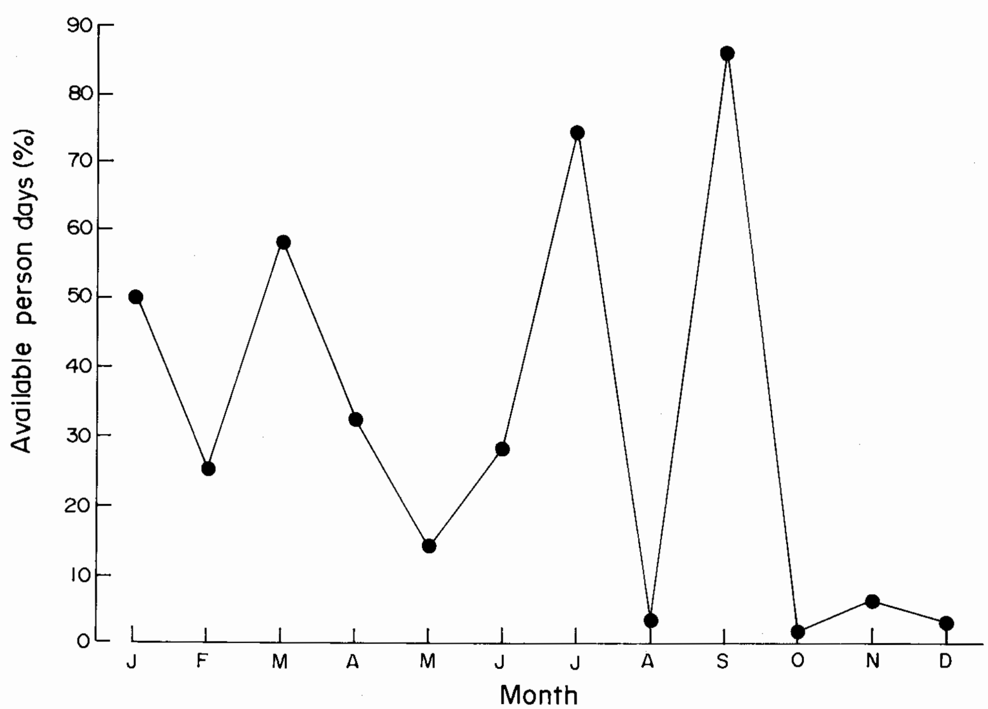

Fig. 7. Monthly family labor absorption by farm activities in Sekyere District, Ashanti Region, as percentage of available person days.

constraints are evident when cash flow is analyzed by month (Fig. 9). High expenditures for labor and planting inputs cause negative cash flows for half the year (January to June). Thereafter, they turn positive for the remainder of the year as crops are harvested and sold, and hired labor demands are reduced.

Net Returns per Household

Net returns for most farmers in Adidwan Village are negative. Male-headed households have an average net return of 5,142 cedis and those headed by females, an average of 947.5 cedis. Returns per hectare and per person day of labor are low and mostly negative.

Net Farm Income

Average net farm income in Adidwan Village is 48,947 cedis. Those of male-headed households exceed those of female-headed households by 15,783 cedis.

Return to household labor inputs (the major productive resource) averages 24,350 cedis. Those of male-headed households exceed those of female-headed households by 1,331 cedis.

Household Incomes and Expenditures

In Adidwan Village, for example, farm activities provide just over 98% of the household income. The balance is derived from nonfarm activities.

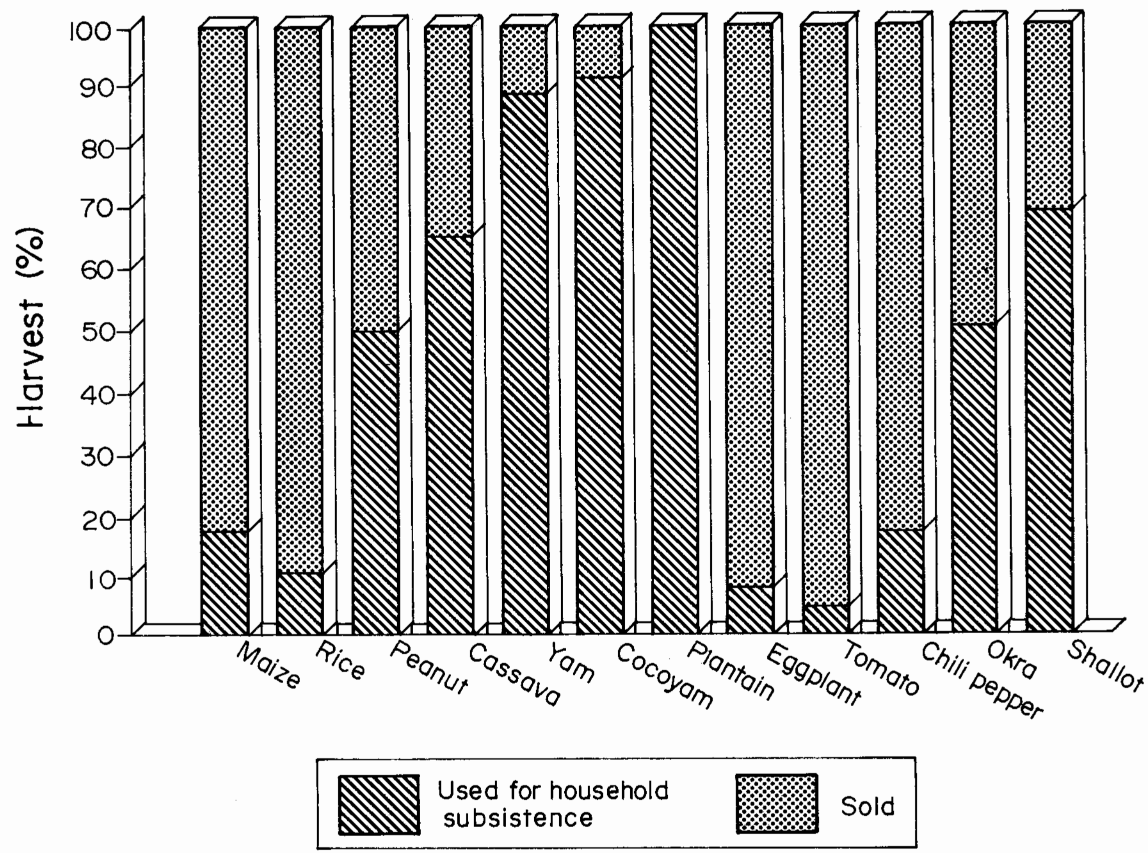

Fig. 8. Use of farm crops for household subsistence and sale in Sekyere District, Ashanti Region by crop.

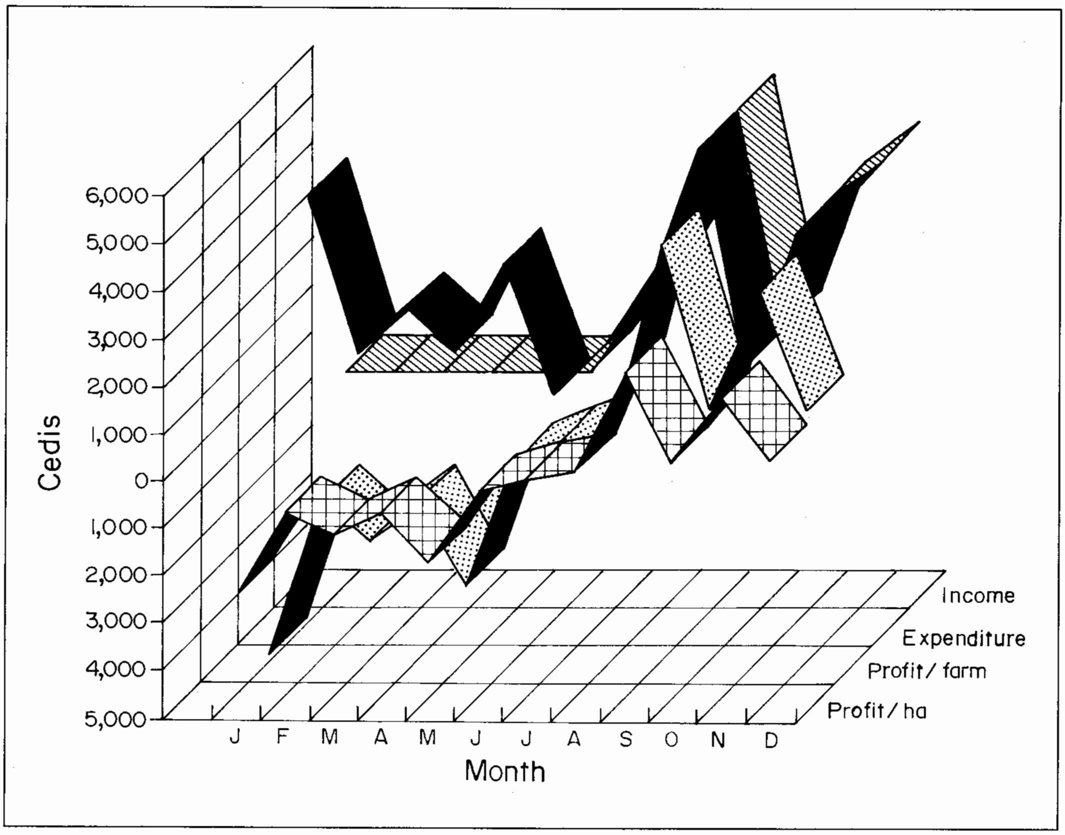

Fig. 9. Monthly cash flows of small-scale farm households in Sekyere District, Ashanti Region.

Elsewhere, however, the situation may be considerably different, such as in areas where bush meat provides a major source of farm household income. In Ghana, farmers who hunt as a sideline depend on bush meat for both food and cash income (Asibey 1977). Unfortunately, reliable and recent data are not available to ascertain either levels of consumption or income. But a mid-1970s study of 80 farmers revealed that they sold 2,804 kg of bush meat in 27 days and earned an average of US$42.34·caput^{-1} or US$1.56·caput^{-1}·day^{-1} (at the then prevailing exchange rate). One farmer had an average annual income for the period 1974-1975 of US$1,515 (Asibey 1977). Such is the value of bush meat so that one farmer's income from its sale greatly exceeded the cash value of his maize crop (Asibey 1980).

The sale of bush meat is a critical source of capital for the resource-poor farmer. As Asibey (1977) observed, "without such support from hunting, most of the small-scale farmers in Ghana could not have carried out the farming of cocoa...."

Given this major financing role of bush meat, it is not surprising that nowadays many Ghanaian farmers "...no longer hunt for their domestic use alone but also largely for the urban and other population centers where bush meat is relatively more expensive" (Asibey 1974a). Such is the value of bush meat that hunters prefer to sell their kill and purchase fish, which is much cheaper than bush meat, for household consumption (Ntiamoa-Baidu 1987).

Informal discussions repeatedly reconfirmed this. This factor, together with the high urban demand for bush meat, is one major cause of the overexploitation of wild fauna (Ntiamoa-Baidu 1987).

In Adidwan Village, food purchase comprises 73% of the average household expenses. The principal nonfood purchases are clothing (47%), funerals (19%), health costs (16%) and schooling (7.9%). Expenditures exceed income by an average of 33,700 cedis. Thus, there is little chance to accrue savings that could be used to capitalize new farm enterprises.

Nutritional and Health Situation of Resource-Poor Farm Families

Most rural Ghanaians are hungry for at least part of the year. Prevalent hunger is a serious cause of malnutrition in the country (ROG-UNICEF 1990). However, conditions are worst in the north of the country, where a single, annual rainy season permits only one crop cycle a year. Health conditions are worsened because the hungry season and that of highest labor demand coincide. Cultural factors also deprive women of food relative to men. Thus, during the food-short season, 36% of the women are severely underweight compared with 19% during the rest of the year, whereas the proportions for males are 23% and 3%, respectively (IBRD 1989).

In general, diets are protein-deficient. Among vulnerable groups, this leads to the disease known as kwashiorkor, which results from a deficiency of protein quantity and quality. A primary caloric deficiency leads to a condition known as marasmus. Kwashiorkor and marasmus often go together in rural Ghana.

Smoked and fresh marine and freshwater fish are the principal sources of animal protein in Ghana. The supply of fish is estimated at 10.4 $g \cdot caput^{-1} \cdot day^{-1}$ compared with 7 from milk and its products (excluding butter), 44 from meat and offal, and 2 from eggs (Sefa-Dedeh 1981).

Small quantities of fish are generally consumed daily. The main source is marine fish, particularly the seasonally abun-

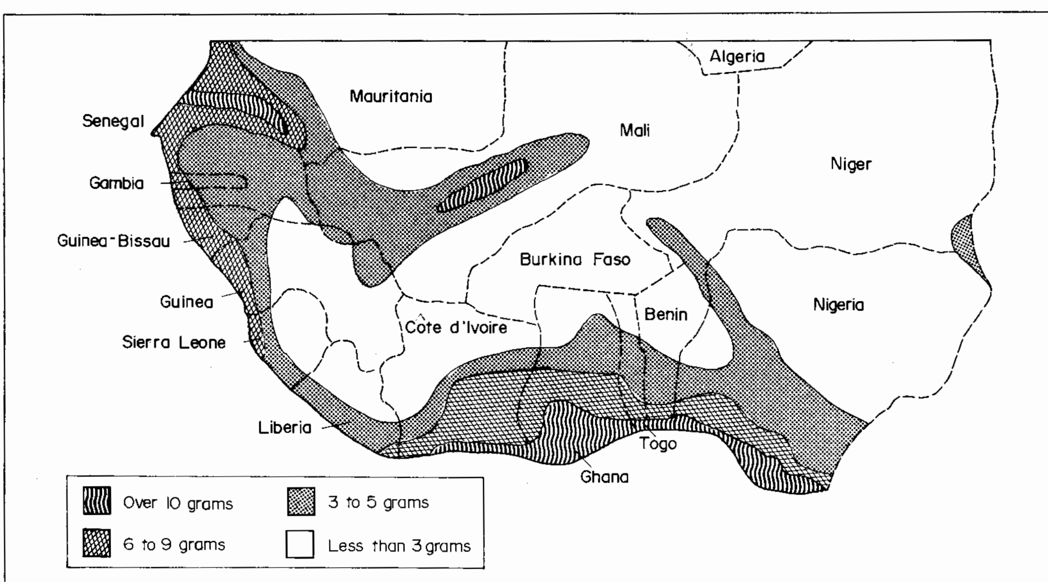

Fig. 10. Daily per caput fish protein consumption in West Africa (adapted from Annegers 1973).

dant herring. Herring is mainly consumed fresh in the coastal regions; elsewhere, smoked is the preferred form. Consumption is greatest in the coastal and west-central parts of Ghana at an estimated 10 $g \cdot caput^{-1} \cdot day^{-1}$ compared with 6 to 9 $g \cdot caput^{-1} \cdot day^{-1}$ in the interior of the southern part of Ghana, 3 to 5 $g \cdot caput^{-1} \cdot day^{-1}$ in the northern-central area, and less than 3 $g \cdot caput^{-1} \cdot day^{-1}$ in the northern zone (Annegers 1973) (Fig. 10). However, these figures should be treated with caution since they are 20 years old, probably do not include freshwater fish, and almost certainly were not based on comprehensive household surveys.

Fish is usually consumed, usually together with a dietary staple, as an ingredient of a soup or stew (Whitby 1968; Dede, n.d.). During the peak season, fish may be marketed fresh. However, most of the catch is smoked to preserve product quality for long distance transportation to the interior and for long-term storage. Sun-dried fish is also powdered and used as a flavoring ingredient in soups and stews. Fermented fish is similarly added as a condiment.

In Ghana, it was estimated that 75% of the population regularly consumes, when seasonally available, bush meat, the meat of wild animals principally small mammals, snails, birds, caterpillars, termites and other insects (Asibey 1986, cited in Falconer 1990). But there is no reliable information on household levels and frequency of bush meat consumption (Falconer 1990). For Ghana, most estimates are derived from the research conducted by Asibey who found that, in two districts of southern Ghana, bush meat contributed 44% and 31% of the protein consumed (and fish, another 35% and 31%) (Asibey 1986).

The national daily per caput consumption of bush meat has been estimated at 1.8 g (Clottey 1971) and 1.7 g compared with 1.6 g from domestic sources (Asibey 1974a). A 1968 nutrition study estimated that, in Ghana, 9 $g \cdot caput^{-1} \cdot day^{-1}$ of bush meat and 1 $g \cdot caput^{-1} \cdot day^{-1}$ of snails were consumed in rural forested areas compared with 1 $g \cdot caput^{-1} day^{-1}$ and 9 $g \cdot caput^{-1} \cdot day^{-1}$, respectively, in coastal areas (where marine fish are of far greater importance) (Genelly 1968).

Although many farm households keep smaller domestic animals (chickens, goats and sheep), they are not usually a regular source of animal protein (Asibey 1974b). Rather they are consumed only at festivals or ceremonies. Mainly they are sold, often as a last resort, to purchase staple foodstuffs or inputs required for cropping, as in the Dagbon area of northern Ghana (Abu 1992). The grasscutter (*Thyronomys swinderianus*) has been successfully domesticated and raised experimentally in Ghana. In many parts of Ghana, livestock raising is precluded by endemic trypanosomiasis.

Principal sources of vegetable protein are the cereals millet (*Pennisetum* sp.), sorghum (*Sorghum* sp.), maize (*Zea mays*) and African rice (*Oryza glaberrima*). Cereals are of greater dietary importance in the drier areas of the country, although maize is grown throughout Ghana.

Legumes are also an important source of vegetable protein. Those of principal importance in Ghana are peanut (*Arachis hypogaea*), pigeon pea (*Cajanus cajan*), chickpea (*Cicer arietinum*), lima bean (*Phaseolus lunatus*), kidney bean (*P. vulgaris*), cowpea (*Vigna unguiculata*) and bambara groundnut (*Voandzeia subterranea*). The most widely consumed throughout the country is cowpea (Sefa-Dedeh 1981).

Wild plants from the forests and the cropped and fallow fields, which provide *inter alia* leaves, nuts, oils, fruits, roots and fungi, impart diversity and flavor to the Ghanaians' basic diets, as well as supply them with protein, energy, vitamins and essential minerals. They are an important reserve resource during food-short seasons, especially prior to the new harvest, when old food stocks have largely been either consumed or sold. Unfortunately, there are little useful data on the frequency and rate of consumption of such products or of their nutritional value (Falconer 1990). In one Ashanti Region village, 28 plants were commonly gathered and consumed, mostly as snacks or as flavoring agents in sauces and soups (Osei-Owusu 1981). The oil palm (*Elaeis guineensis*), from secondary growth vegetation, is probably the wild plant most widely exploited throughout West Africa. The fruit and kernel provide edible oil, and the sap is processed into palm wine and alcohol. The palm is estimated to provide 10% of the total energy consumption of regional diets and is an important source of vitamin A (Nicol 1972, cited in Falconer 1990).

Diet composition in resource-poor farm households in Ghana is primarily a function of the staple crops grown on the farm. Low protein-calorie ratios of under 10% occur principally in humid areas unsuited to grain cultivation and where the staples are starchy root crops, particularly cassava and cocoyam. Thus, protein energy malnutrition (PEM) is a major problem for resource-poor farm families in the humid regions of Ghana.

Low ratios of 10-11.9% occur in areas where the main crop combination is rice-maize-yam. In contrast, the drier savanna zone, where the principal crops are millet, sorghum and legumes, which are consumed with small quantities of fish, exhibits moderate rates of 12.0-13.9% (which are comparable to the rates for Europe and North America).

Not all members of resource-poor, small farm households have equal access to food produced on-farm. Thus, some food deficiencies within the small-farm family arise because access to food, particularly to proteins, is unequal. Male heads of households, in their supposed role as principal food providers, often have rights to the choicest portion of a meal, especially to the meat (Sefa-Dedeh 1981). Further, depending on ethnic group, protein-rich food may be denied by taboo to children, and pregnant and lactating women. In parts of Ghana, such persons are denied meat, eggs, milk, fish, snails and lobsters (Dovlo et al. 1975). Thus, those with least access are the two most nutritionally vulnerable groups: children, and pregnant and lactating women.

Malnutrition is a serious problem for women and children in rural Ghana (ROG-UNICEF 1990). The problem has several major facets: PEM together with associated micronutrient deficiencies, food shortage (especially in the preharvest months) and food consumption.

Protein Energy Malnutrition

A 1986 survey revealed that, among preschool children, per caput calory intake was only 40-70% of requirements (ROG 1986). The same survey also showed that 58% of children aged 0-5 years were 80% below the age-for-weight standard (alarmingly, this was twice the rate recorded in the first such survey conducted in 1961-1962); 40% were 80% below the weight-for-height standard (a measurement of wasting or acute undernourishment); and 8% were suffering from either kwashiorkor or marasmus. The survey showed that 51.5% of children below the age of five were below 90% of the standard, and thus were stunted or clinically malnourished, as measured by height-for-age.

Rates of malnutrition varied among the regions. The Upper East, Upper West, Northern and Western Regions exhibited the worst conditions.

Women, particularly those either pregnant or lactating, were badly affected by PEM. A 1987 survey showed that 69% of women tested in antenatal clinics were anemic (IBRD 1989). Again, conditions were worst in the north of Ghana where 65% of pregnant and 45% of nonpregnant women showed symptoms of PEM compared with 43% and 30% in the south (IBRD 1989). Conditions were much worse in rural than in urban areas, owing to the heavy manual labor performed by the women (ROG-UNICEF 1990). Cultural factors add to the problem in those ethnic groups where a taboo denies eggs and meat to pregnant women (ROG-UNICEF 1990).

Micronutrient Deficiencies

Malnutrition is accompanied by micronutrient deficiencies that result from the lack of vitamins and essential minerals. This lack results from poor diet and increased intake required to handle the physical stress of infections, injuries and the disproportionate consumption of other nutrients.

1. Vitamin A deficiency: This results in night blindness and an increased mortality among young children. Although long known to be a public health problem in the north of Ghana, research in the Central Region of southern Ghana revealed that most children under five years of age suffered from it (NMIMR 1984). This problem could be overcome were (a) more of the foods rich in vitamin A provided to children and (b) more whole small fish, red palm oil, dark green leafy vegetables, colored vegetables and fruits available to households.

2. Iodine deficiency disorder (especially goiter): Goiter is a particular problem in the Upper Regions where 10.7% of the surveyed population is afflicted (ROG 1986). The deficiency is attributable to both natural and human factors. Among the latter is that iodine-rich vegetables are hardly consumed and that when eaten, the nutrients are washed and boiled out. Another likely cause is that soil erosion in the arid areas has stripped away the iodine content in soils, such that it cannot be absorbed by the crops (ROG-UNICEF 1990).

3. Iron deficiency anemia: This condition is common throughout the country and affects most pregnant women. The main cause is thought to be poor absorption from cereal-based diets (ROG-UNICEF 1990). But Watson (1971) commented that in the north of Ghana, iron levels in cereals were higher than expected. This is exacerbated by blood loss owing to malaria, bilharzia and hookworm (ROG-UNICEF 1990).

To summarize, malnutrition among resource-poor farm families in Ghana results basically from an insufficient staple and complementary crop production, thus the intake of either farm-produced or purchased nutrients are inadequate. This is exacerbated by labor demands, general ill health and cultural factors governing intrafamily food consumption. Food production both at the national level as well as on the majority of small farms does not meet demand.

Implications for Integrated Agriculture-Aquaculture Systems

Adding a vegetable field and pond to the farm-type models in the three ecological zones demonstrates that vegetable production and fish farming could both improve household nutrition as well as increase cash incomes dramatically.

However, it is important to note that vegetable production demonstrates much stronger nutritional and economic benefits than aquaculture. But it should also be noted that a pond has a much more important role on a farm than just fish farming (see below).

Hypothetical Nutritional Status

The graphs that follow are intended to demonstrate the relative roles of the various crops cultivated in satisfying the nutritional demand of a farm family. The scales of the "y-axes" have been varied for visual clarity and to accommodate the very large relative productivity of crops for some nutritional elements.

Deciduous Forest and Rainforest Zones

Maize-Cassava Cultivation (Fig. 11). In this case, the household demand for protein, iron, vitamin A and thiamine is more than satisfied by farm yields. But calorie, calcium, riboflavin and niacin yields are low and mostly below 50% of demand.

The important role of vegetable cultivation is immediately obvious in increasing vitamin A yields from just 50% of the demand to more than satisfying the demand. Similarly, herring consumption plays a vital role in the iron-fulfilling demand. Without herring, the inadequate provision of calcium and niacin would be even worse.

In this case, farmed fish mostly adds to animal protein intake and further increases the already satisfied protein demand. It also increases calorie and calcium availability minimally but not enough to satisfy demand totally.

Maize Cultivation (Fig. 12). Here the nutritional role of vegetables and farmed fish would be very important. The fish would double protein supply, such that it would just meet demand. It would also add a little to the low level of calcium supply.

Vegetable production would boost an already high output of vitamin A and would raise a critically low production of vitamin C to nearer satisfaction of the demand. But the overall situation would remain poor with respect to the intake of vitamins, calcium and calories. A much wider diversification of the staple crop assemblage is essential.

Maize-Plantain-Cassava Cultivation (Fig. 13). Calories, calcium, riboflavin and niacin are again poorly supplied.

Farmed fish would add quality to the protein supply as well as contribute marginally to improving a poor calorie and calcium supply. Vegetable production would add mainly to the already more than adequate supply of vitamin A.

Transition Zone

Maize-Cassava Cultivation (Fig. 14). In this case, farmed fish would play a very important role in doubling the supply of protein, such that the total demand would then be satisfied. It would also add marginally to a still deficient calorie and calcium supply. The main nutritional contribution of vegetable production would be to turn a seriously deficient supply of vitamin A into one where demand is met.

Yam-Peanut Cultivation (Fig. 15). In terms of farmed fish, the situation is essentially a repeat of the previous model. The role of vegetables in supplying vitamins A and C is also noteworthy.

Yam-Cassava Cultivation (Fig. 16). The situation is again similar to the preceding model. Farmed fish would ensure increased supply of protein both quantitatively and qualitatively such that the demand becomes satisfied. It would increase marginally the calories and calcium supplied, but both would remain deficient. Vegetables would have a vital role in supplying vitamin A.

Guinea Savanna Zone

Despite variations in detail, the nutritional situation is very similar for all the crop combinations modelled in the Guinea Savanna Zone. That being the case, only two examples of the models are given here.

Sorghum-Millet-Maize-Cassava (Fig. 17). Farmed fish would add quantity and quality to the protein supply, such that it would become satisfied. It would add marginally to the calorie, calcium and vitamin C supply, all of which, however, would remain below the demand. Vegetables would be critically important. They would double the vitamin A supply so that it would then exceed demand, and they would become the main supplier of vitamin C, although only about 75% of the demand would be satisfied.

Sorghum-Millet-Cowpea Cultivation (Fig. 18). The nutritional situation is basically poor. Farmed fish would increase the protein supply above the demand. It would also add marginally to the calorie, calcium and vitamin C supply, all of which, however, would remain below the demand. Vegetable production would again be important, although still insufficient, in increasing the supply of vitamins A and C.

Ponds and Vegetables and Improved Household Incomes

In all farm types modelled, the addition of pond and vegetable components would lead to a dramatic increase in household net incomes. Such an improvement would range from a "low" of 229% to a "high" of 697%. This, of course, reflects the net value of the original crop assemblage since a "low" of 229% occurs in the model where the crop-based cash income is highest at US$1,138·ha^{-1}) and a "high" of 697% occurs on a farm with a crop-based cash income of US$245·ha^{-1} (Fig. 19).

Whereas total economic improvement from the addition of a vegetable-crop component is excellent, it is important to analyze the relative role in this of vegetables and fish (Fig. 20).

To summarize, in none of the 13 models does the value from fish production based on a pond size of 0.01 ha (100 m^2) exceed 2% of the total production of the farm unit. In only four models did fish production yield as much as 2% of the income. Most (11 models) demonstrated that only 1% of the total on-farm income would be derived from fish.

Were the size of the pond component expanded to 0.06 ha, fish production would still contribute no more than 4% of total on-farm income. In other words, the bulk of the extra income generated would come from the production of vegetables. Further, in all models the value of vegetable production would far exceed that of the staple crops: vegetables contributing from 55 to 84% of the value of total farm economic output compared with staples that would contribute 14 to 43% (Table 1).

Potential Role of Integrated Agriculture-Aquaculture at the National Level

The following extrapolation is based on a 5% adoption rate among the 2.3 million national population of small-scale farmers. This 5% rate, which is conservative, is based on a site and water supply feasibility reconnaissance survey of Mampong Valley, Akuapem, combined with an informal farmer attitudinal survey regarding adoption of aquaculture.

Extrapolation is also based on a vegetable field of 0.04 ha and a pond size of 0.01 ha. The vegetable plot size is double that at Mampong (M. Prein and J.K. Ofori, pers. comm.). It is important to realize that although a 100 m^2 pond is extremely small, and its contribution to farm cash incomes is minimal, its nutritional importance, demonstrated above, is considerable. For comparative purposes, projections have also been made based on a 0.06-ha pond, using a 1-ha pond.

The rates assumed are based on those being achieved now at Mampong and extrapolated.

If these figures are multiplied by 5% of the 2.3 million small-scale farmers in Ghana, there would be a total of 115,000 adopters of vegetable cultivation and fish farming.

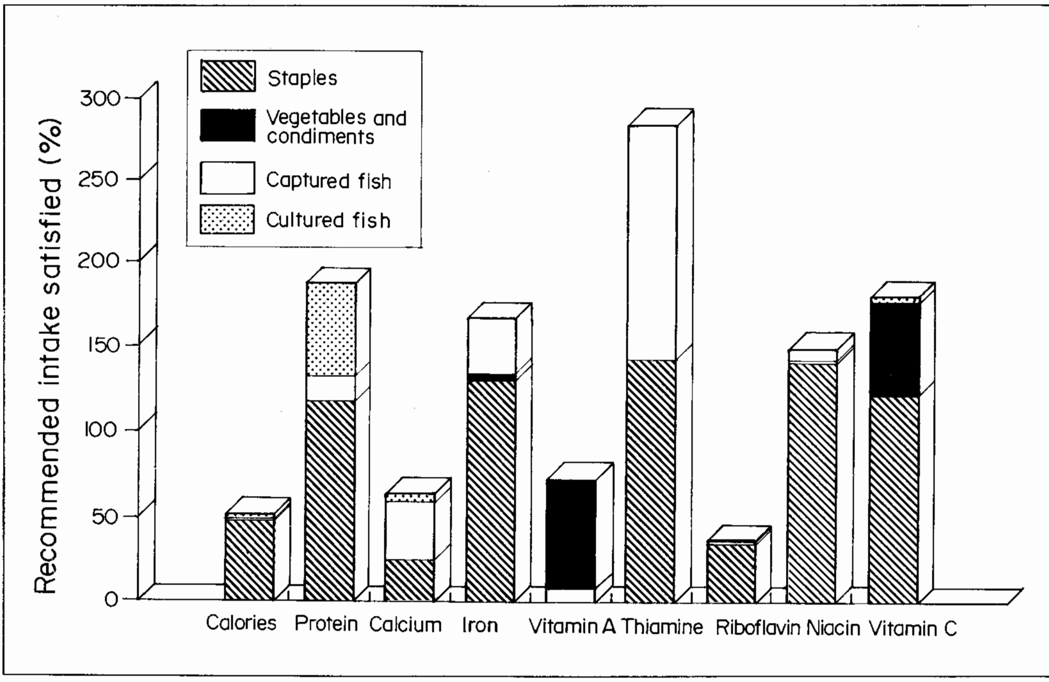

Fig. 15. Hypothetical nutritional status: transition zone (first year, yam; second, peanut; third, no crop).

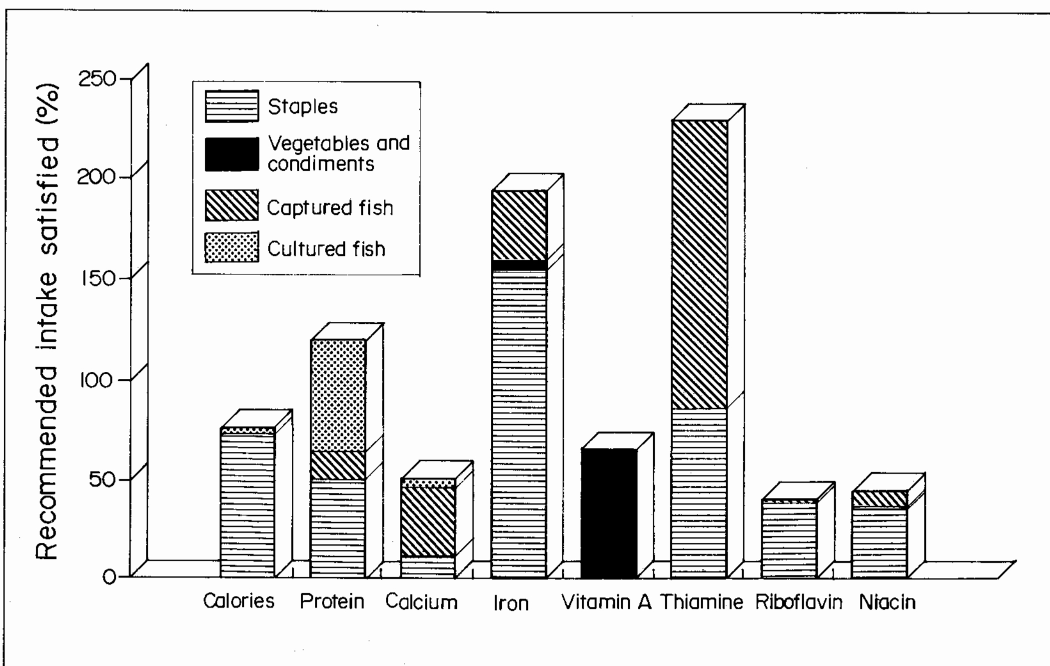

Fig. 16. Hypothetical nutritional status: transition zone (first year, yam; second, cassava; third, no crop).

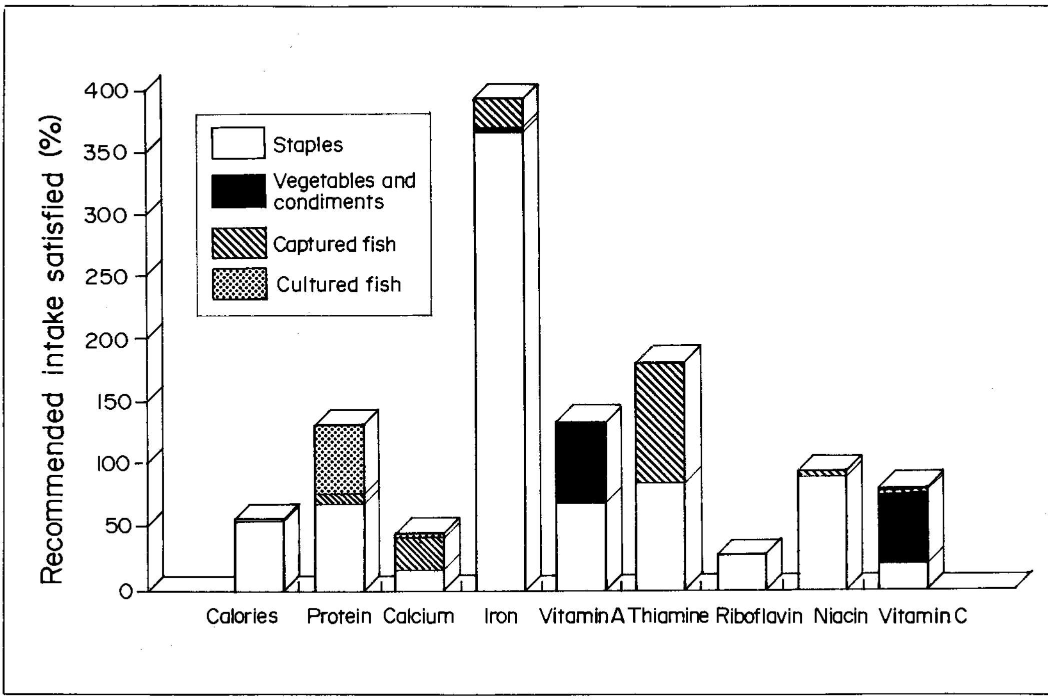

Fig. 17. Hypothetical nutritional status: guinea savanna zone (first and second year, sorghum, millet and maize; third, sorghum, millet, maize and cassava).

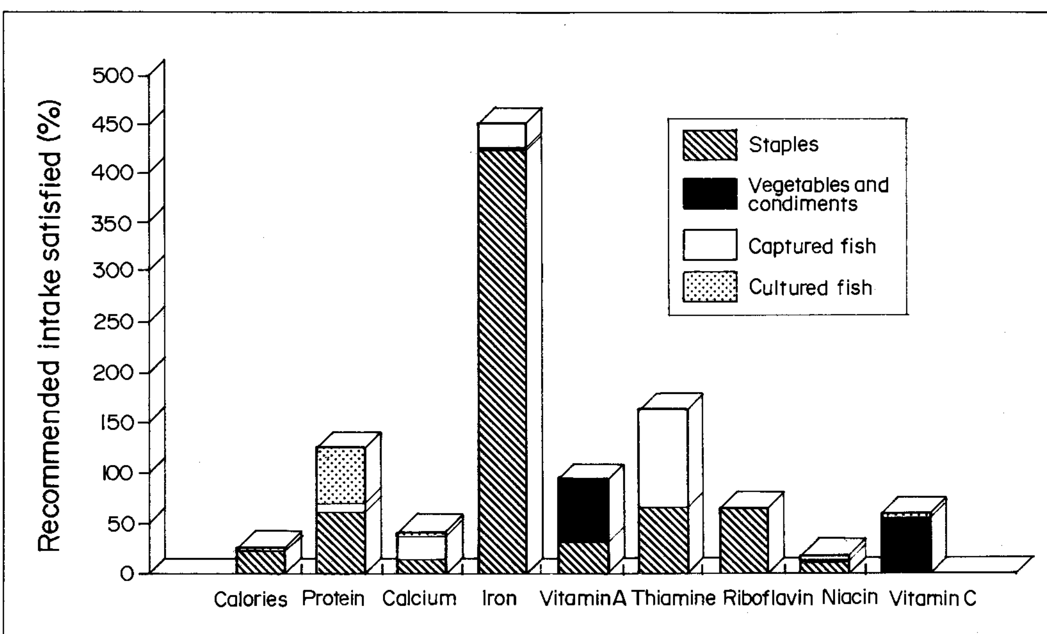

Fig. 18. Hypothetical nutritional status: guinea savanna zone (first, second and third year, sorghum, millet and cowpea).

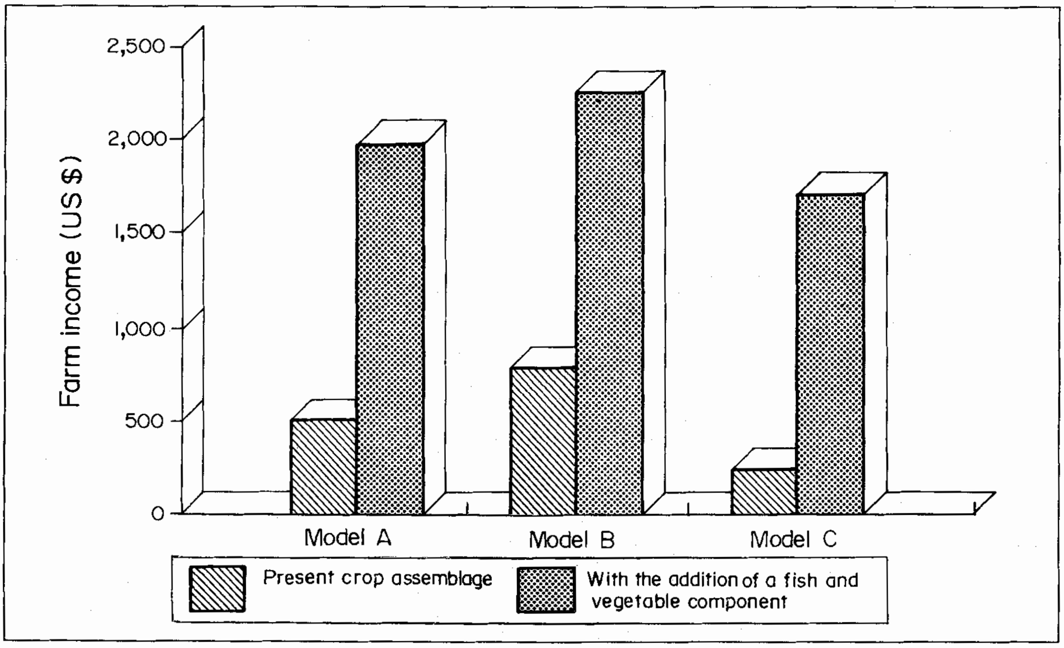

Fig. 19. Change in net farm income with the adoption of an IAA system: examples from the transition forest zone.

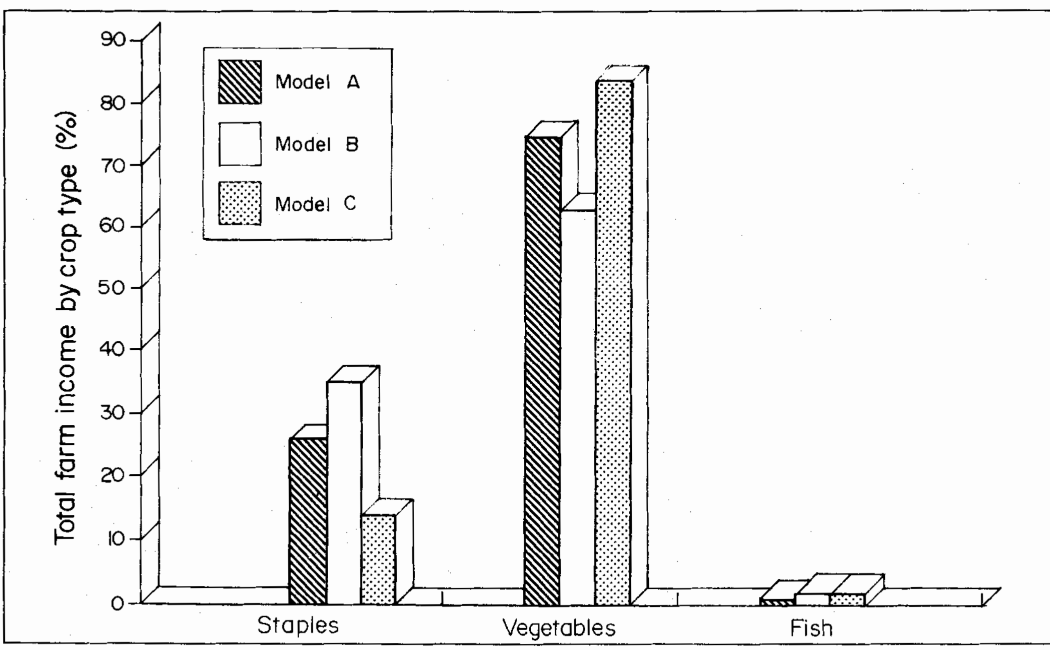

Fig. 20. Economic impact of pond-vegetable component: examples from the transition forest zone.

Table 1. Projected yields of vegetables and fish on vegetable plots of 0.04 ha and 1.0 ha and in ponds of 0.06 ha and 1.0 ha.

	0.04-ha plot			1-ha plot		
Crop	Yield (t)	Value (cedis)	Value (US$)	Yield (t)	Value (cedis)	Value (US$)
Okra	0.180	23,400	37.44	4.50	585,000	936
Tomato	0.710	30,000	48.00	17.77	75,000	1,200
Onion	0.024	10,000	16.00	0.60	250,000	400
Eggplant	1.008	19,200	30.72	25.20	480,000	768
Pepper	0.104	30,000	48.00	2.60	750,000	1,200
Cabbage	1.070	800,000	1,280.00	26.67	20,000,000	32,000
Total	-	912,600	1,460.16	-	22,140,000	36,504
	0.06-ha pond			1-ha pond		
Fish	0.260	102,948	164.70	4.40	1,715,800	2,745.30

The projected national levels of production are shown in Table 2.

Projected Protein Demand in 2020 and the Capacity of Farmed Fish to Fulfill It

As mentioned above, a projected 405,412 t·year^{-1} of animal protein will be the demand of the population of Ghana in the year 2020. Holding fish landings constant, this will result in a deficit of 236,962 t·year^{-1} of animal protein.

Since sun-dried tilapia contains 72% protein compared with 68% for smoked tilapia (the fuelwood crisis could preclude that), it would require 305,680 t of tilapia to meet this demand.

This demand could be met using ponds of different sizes. But each pond size has different implications at the national level. Among these are:

1. If the current average pond size of 0.01 ha (100 m^2) were adopted nationwide, to produce 305,680 t of tilapia would require 6.9 million ponds. This implies 6.9 million adopters or roughly three times the present number of small-scale farmers. This is ludicrous! But even more ludicrous is that it would require - at 30 farmers per extension agent - 230,000 extension agents. Clearly, this is not an option.

2. A national total production of 305,680 t tilapia could also be achieved using 1,157,883 ponds of 0.06 ha. This would require the efforts of about 1.2 million adopters or 50% of the existing number of small-scale farmers. Again, this is not a viable option.

3. However, when ponds or a set of ponds of 0.24 ha are used, the total number of ponds required nationwide becomes 289,470. This would represent a 12.5% adoption rate among the existing population of small-scale farmers.

Table 2. Vegetable and farmed fish production projections for 0.04 ha and 1.00 ha of vegetables and 0.01 ha and 0.06 ha of ponds (yield in t).

	0.04-ha plot	1.00-ha plot
Okra	20,700	517,000
Tomato	81,650	2,043,550
Onion	2,760	69,000
Eggplant	115,920	2,898,000
Pepper	11,960	299,000
Cabbage	123,050	3,067,050
	0.01-ha pond	0.06-ha pond
Fish	5,060	29,900

This becomes an option worthy of further consideration. Obvious implications are the need for a reliable water supply. That will mean tying into community projects to reafforest denuded watersheds to ensure formerly perennial springs become so again. This would have the additional merits of decreasing the rate of soil erosion, and providing locally accessible fuelwood, and depending on the species, materials for direct human consumption or other uses, like fodder, fish feed or manure.

Extension demand would not be exorbitant. It would require some 9,600 extension personnel (at 30 farmers per extensionist). This could be achieved in a variety of ways: using NGOs, for example, training local master farmers or using the "farmer-teaches-farmer" approach as used by the Ghana Rural Reconstruction Movement in Mampong Valley.

However, labor demands could be a constraint. Based on a labor demand of 14 days to construct a 0.01-ha (100 m^2) pond at Mampong, a 0.24-ha pond would require an input of 336 person days. This would cost 154,560 cedis at the current official minimum wage of 460 cedis·day^{-1}, and 672,000 cedis at the rate of 2,000 cedis·day^{-1} plus lunch currently demanded by agricultural laborers.

For smallholder farmers, this option is not feasible owing to land access and labor costs. Additionally, the ensuing management requirements of such large ponds (i.e., availability and cost of fingerlings, required nutrient inputs, necessary harvest facilities, etc.) also prohibit this option. Unfortunately, this option has been the one followed by most development initiatives and has failed (Prein and Ofori, this vol.).

But the main point is that the year 2020 population will not be reached for another 27 years, so there is ample time for farmers to progressively expand their pond area as their income increases particularly from the associated vegetable field.

Capital can be raised in a variety of ways. The obvious way is from the production of the vegetable field. Other obvious sources would be the "fish mammies" (such entrepreneurial women have offered to purchase the entire output of the Mampong ponds) and other rural entrepreneurs.

It is important to reiterate the multiple roles of the pond as well as the symbiotic relationship between pond and vegetable field. Notice that the term "fishpond" has not been used. This term is both misleading and limiting because farm ponds play a variety of roles simultaneously, as follows:

1. They are the "container" in which fish can be raised.

2. When they gradually become sealed against seepage, they are a small reservoir for irrigating high-value field crops (especially vegetables) during the dry season. This role is enhanced if the pond is manured and the fish are properly fed, such that the pond water becomes nutrient-rich.

3. If the pond is manured and the fish are fed, the pond is a source of fertilizer for crops from the organically enriched pond mud that is periodically removed from the pond's bottom and spread over the vegetable field.

4. They act as a sediment trap to catch friable soils eroded from upstream during the wet season.

5. And, if well-constructed, they serve as a "buffer" to reduce wet season rainfall runoff and the likelihood of flooding in lowlands and valley bottoms.

The two main symbiotic pathways between vegetable field and pond are: (1) as mentioned above, the nutrient-rich pond mud and water delivered to the field; and (2) the use of vegetable waste, such as outer cabbage leaves, as fish food.

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Appendix I. Policy towards Fisheries Development in Ghana

Fisheries Department
Ministry of Agriculture
Accra, Ghana

The existing policy (ROG-MOA)[a] towards aquaculture and fisheries development in Ghana is designed to:

1. increase fish production for local consumption and for export;
2. alleviate poverty in the fishing communities;
3. assist in the development of a resource management plan for the entire fishery;
4. integrate fishery into the farming systems through the promotion of aquaculture; and
5. strengthen the Fisheries Department to carry out all these assignments.

[a]ROG-MOA (Republic of Ghana, Ministry of Agriculture). 1990. Medium-term Agricultural Development Plan (MTADP). Vols. 1 and 2. Ministry of Agriculture, Accra.

Appendix II. Workshop Program

Research for the Future Development of Aquaculture in Ghana
Institute of Aquatic Biology
Council for Scientific and Industrial Research
Accra, Ghana
11-13 March 1993

Wednesday, 10 March

Arrival of international participants and registration
Opening ceremony (combined with the adjoined Workshop on Tilapia Genetic Resources of Ghana)
M.A. Odei (Acting Director General, CSIR). Welcome and introduction
Hon. Ibrahim Adam (Minister of Food and Agriculture), *J.J. Meijer* (FAO Regional Representative), *M. Bilio* (GTZ Representative) and *R.S.V. Pullin* (Director, Inland Aquatic Resource Systems Program, ICLARM). Welcoming address
Navy Captain K.A. Buta Rtd. (Minister of Science and Technology). Keynote address and opening

Evening reception

Thursday, 11 March

Welcoming session

M.A. Odei. Welcoming remarks and schedule presentation
R.S.V. Pullin. Outline of project rationale and objectives
M. Bilio. Scope of GTZ support for research and development of aquaculture in Africa

Coffee break
Group photograph

M. Prein and *J.K. Ofori.* Past initiatives for promoting aquaculture in Ghana
C. Lightfoot, M. Prein and *J.K. Ofori.* Analytical framework for rethinking aquaculture development for smallholder farmers

Lunch break

M. Prein and *J.K. Ofori.* Mapping of aquatic resource systems with areas of potential for aquaculture in Ghana
A.L. Dassah, F. Ulzen-Appiah and *H.N.N. Bulley.* Social and economic characteristics of small-scale farmers in Ghana
B. Fiawatsror, A.L. Dassah, F. Ulzen-Appiah and *H.N.N. Bulley.* Gender issues in resource-poor farm households in Ghana
S. Sefa-Dedeh and *J. Nketsia-Tabiri.* Post-production issues and aquaculture development in Ghana
J.K. Ofori and *M. Prein.* Rapid appraisal of low-input aquaculture systems
K. Ruddle. Aspects of the human ecological context of resource-poor farmers in Ghana
S. Hem. Coastal lagoon aquaculture in Côte d'Ivoire as example for application in Ghana

Friday, 12 March

Field visits

Departure for Mampong Valley, Akuapem, Eastern Region

Visit to the Yensi Centre, Ghana Rural Reconstruction Movement: farmer cooperators, new entrants to integrated agriculture-aquaculture, farm visits and demonstrations

Saturday, 13 March

J.K. Ofori, A. Asamoah and *M. Prein.* Experiments for integrated agriculture-aquaculture systems design
D. Kumah, D. Bagbara and J.K. Ofori. Rice-fish culture experiments in the Tono irrigation scheme
A. Fastenau. Strategic considerations for aquaculture development in northern Ghana
C. Lightfoot, M. Prein and *J.K. Ofori.* The potential impact of integrated agriculture-aquaculture systems on sustainable farming
K. Ruddle. The potential role of integrated management of natural resourcesin improving the nutritional and economic status of resource-poor farm households in Ghana

Lunch break

Discussion of presentations

Closing remarks

Appendix III. List of Participants

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Mr. J.A. Ampofo, Research Officer
Mr. O. Ansa-Asare, Research Officer
Ms. V. Vanderpuye, Research Officer
Mr. M. Owusu-Frimpong, Research Officer
Mr. J.N. Padi, Research Officer
Ms. M. Entsua-Mensah, Research Officer
Mr. K. Agbogah, Scientific Secretary
Mr. A. Asamoah, Assistant Research Officer
Ms. R. Hammond, Assistant Research Officer
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Mr. S. Hem, Senior Scientist

Participants in the ICLARM/IAB Workshop on Research for the Future Development of Aquaculture in Ghana, 11-13 March 1993, Accra, Ghana. (Photo by Mark Prein.)

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

GTZ is owned by the Government of the Federal Republic of Germany. It is commissioned to undertake specialist technical planning and implementation of measures for technical cooperation with developing countries. This takes place on the basis of a General Agreement with the Federal Government. Development policy is formulated by the German Ministry for Economic Cooperation and Development (BMZ). GTZ draws on the facilities available in both the public and private sectors as far as this is expedient and cost-effective.

Institute of Aquatic Biology

IAB was established by the Council for Scientific and Industrial Research (CSIR) of Ghana in 1965. It has the mandate to conduct research in all aspects of the resources of the inland, estuarine, lagoonal and the immediate coastal inshore water systems of Ghana and to provide needed information for the proper utilization, exploitation, development and management of the resources (abiotic and biotic, fauna and flora). The institute operates through five interactive scientific divisions, namely, Limnochemistry, Hydrobiology, Aquatic Plants and River Basin Management, Fisheries, and Parasitology/Entomology/ Microbiology. The institute undertakes special training in relevant areas for user agencies and is a government-subvented organization.

International Center for Living Aquatic Resources Management

ICLARM is an autonomous, nongovernmental, nonprofit, international scientific and technical center which has been organized to conduct, stimulate and accelerate research on all aspects of fisheries and other living aquatic resources. It was incorporated in Manila in 1977. It became a member of the Consultative Group on International Agricultural Research (CGIAR) in 1992.

ICLARM is an operational organization, not a granting entity. Its program of work is aimed to resolve critical, technical and socioeconomic constraints to increased production, improved resource management and equitable distribution of benefits in economically developing countries. The center's work focuses on tropical developing countries in both marine and freshwater areas. Research is carried out on the population dynamics, on alternative management schemes and on improving the productivity of key species. The work includes cooperative research with institutions in developing countries and supporting activities in information and training. The programs of ICLARM are supported by a number of private foundations and governments.

Policies are set by a Board of Trustees with members drawn from the international community. Direction of ICLARM, under the policies set by the Board, is the responsibility of the Director General.