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The Design of Micro-Projects and Macro-Policies: Examples From Three of ATI's Projects in Africa

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June 27, 1988

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ABSTRACT

This paper presents three case studies of ATI's experience in Africa on the connection between macro-policies and micro-projects. The first example, palm oil extraction in Cameroon, shows how trade restrictions and a domestic price floor have supported this sector while inefficiencies in large-scale production by parastatals have left open opportunities for artisanal production. The second example, improved charcoal stoves in Kenya, illustrates how public sector R&D and a benevolent government attitude toward the informal sector can lead to rapid production and marketing of a simple new technology. The third example, ferrocement fishing boats in Malawi, was unsuccessful because of the low levels of investment and entrepreneurial capacity in the sector and the negative effects of controlled price ceilings on fish.

INTRODUCTION

Government policies and the socioeconomic environment at a macro-level have a significant effect on the success of micro-level demonstration projects and the potential for widespread dissemination of appropriate technologies as a result of the project as well as replication elsewhere. This paper describes three of ATI's projects in Africa and how macro-policies and the local context have affected their impacts.

These projects were carried out in different parts of the continent -- West, East, and Southern Africa. They involved different sectors: the processing of an agricultural product for food, use of mineral resources for production of a consumer durable (ceramics and metal), and equipment and supplies for small-scale primary producers (fishermen). The specific technologies discussed are palm oil extraction in Cameroon, charcoal stoves in Kenya, and ferrocement fishing boats in Malawi.

Palm Oil Extraction in Cameroon

The Local Context

Palm oil, an indigenous crop, is the principal cooking oil in West and Central Africa. It comprises four-fifths of edible oil production in Cameroon. As a concentrated source of calories and vitamin A, increased consumption of palm oil could reduce malnutrition problems. Improved varieties of oil palm can yield more oil per hectare than any oil crop.

Most large-scale industrial estates and contract smallholders in Cameroon grow the improved Tenera hybrid. A Tenera fruit contains about twice the oil of a Dura fruit and yields at least three times as much fruit per hectare. It takes 4-5 years for a Tenera plantation to begin bearing and 10 years to reach maximum production. The economic life of a plantation is 25-30 years.

Most of the artisanal production comes from the semi-wild Dura variety, which spread naturally from old plantations. These semi-wild groves receive little or no effort by farmers, except for harvesting. Dangerous climbing is required to harvest the tall Dura trees, unlike the dwarf Tenera. Because of harvesting and marketing difficulties, only one-quarter of the area of semi-wild oil palm in Cameroon is harvested.

Cameroon is the fourth largest producer of palm oil in Africa although its share of world production is very small. Total industrial production of crude palm oil was 95,000 t in 1986 and artisanal production has been estimated at another 28,000-32,000 tons.

Description of the Project

ATI's experience with palm oil extraction technologies is an example of the use of a for-profit workshop started by an NGO as the principal agent of dissemination of an appropriate technology. This workshop produces and markets the equipment. Marketing assistance and producer credit have been provided by the implementing organization ATI has worked with and these efforts have been expanded in Cameroon by a program of the Catholic mission.

The traditional process of palm oil extraction by foot stomping is laborious and yields a low percentage of the oil contained in the fruit. Upgrading the traditional technology through simple pressing equipment, rural incomes could be increased, labor drudgery reduced, and consumer benefits boosted from an increased supply of palm oil. The traditional process is still used in less prosperous parts of Cameroon and in much of the rest of West and Central Africa. However, most artisanal-scale commercial producers of palm oil in Cameroon have access to an old Colin press, a manually operated, horizontal expeller. Small farmers who do not have their own presses can purchase pressing services from others in exchange for an in-kind payment of one-fifth of the oil extracted and provision of the labor.

The Colin expeller was imported to Cameroon between the 1930s and 1973. As of 1982, approximately 400 Colin expellers remained in Cameroon. Most were over 30 years old and many were in disrepair, leading to poor productivity and frequent downtime Also, replacement parts were no longer available from the distributor. In 1972, the Speichim Co. bought out Colin and

stopped routine manufacturing of artisanal-scale presses. Due to the lack of affordable new equipment for replacement and expansion, increases in artisanal palm oil production have been limited.

With the support of Appropriate Technology International, an NGO in Cameroon, the Association Pour la Promotion des Initiatives Communautaires Africaines (APICA) sought to remedy this problem through a project on rehabilitation of existing Colin presses and production of auxiliary equipment such as cooking drums, bunch strippers, and clarifiers. APICA started its own subsidiary for the reconditioning work. In 1984, ATI provided APICA with a three-year grant of U.S. $304,324 for working capital, equipment, and a revolving loan fund.

The original goal of the project over 3 years was to purchase 75 used Colin presses for reconditioning and sell at least 68 units consisting of the press and the auxiliary equipment for stripping palm fruit bunches and clarifying the crude oil. It was expected that new groups of palm oil producers would be established, each with an average of 20 members.

A lease-purchase arrangement was established to finance the sale of 25 extraction units. This plan allows monthly payments over 36-48 months after a 3-month grace period. Group members would leave 25% of the oil pressed from their palm fruits in exchange for use of the press. This repayment method is similar to the prevailing arrangement for service pressing, but after the last payment, the borrower receives title to the equipment.

The original design of the project proved unworkable.

First, only 12 used Colin expellers were available for purchase at a feasible price because of the incorrect assumption that a large number of these units were in disrepair and idle. Even though many presses had the wrong parts and maintenance difficulties resulted in downtime, they were still usable much of the time. Also, it took up to 10 months to obtain imported replacement parts. Second, because of the high cost of repairs in small batches, the lease/purchase price was too expensive for potential buyers. At the same time, world market prices for palm oil declined, causing the large-scale firms to shift more production from exports to the domestic market where prices were higher. This adversely affected prices received by artisanal producers through competition.

Consequently, only 4 orders for reconditioned, manual Colin expellers were received in the first year, 3 from small groups and 1 from an individual. Some potential buyers expressed an interest in obtaining motorized expellers. Recognition of these problems led to a modification of the project. ATI and APICA decided that reconditioning an old press was too expensive and slow relative to production of a new press. Moreover, a simpler, less expensive model with fewer imported components was sought, so the horizontal Caltech was designed. This machine is a smaller version of the Colin, with one major change -- substitution of a reducer for the gearing that was subject to frequent breakdowns. Later, a far cheaper vertical axis Caltech was developed.

With the shift toward manufacturing and a more realistic view of the effective demand for new extraction equipment, the

production target was reduced to a total of 35 units including 9 manual Colin expellers, 12 motorized Colin expellers, 6 manual Caltechs, and 8 motorized Caltechs. The revised target for auxiliary equipment is 23 sets of the bunch stripper and clarifier. Repair services and motorization also were initiated, with a target of 51 minor and 15 major repairs to Colin expellers.

After the reorientation, the project became more successful. By the end of 1987, the workshop had sold 8 manual Colin expellers, reconditioned 3 more, and reconditioned 1 and converted it to a motorized model. It had sold 38 horizontal Caltechs and 10 more were in production. Also, 7 vertical Caltechs had been produced. Only 10 clarifiers and 11 bunch strippers were sold. Financing played an important role in encouraging sales.

The idea of purchaser groups proved unpopular, particularly in Otele where the market has been largest. This area is dominated by the individualistic Bassa tribe. Considerable interest in artisanal-scale presses exists in Otele because farmers there are too far from the parastatal oil mills to market their palm fruits. In addition, a program of the Catholic mission has made progress in establishing smallholder plantations of improved palm varieties there.

The horizontal Caltech is a modification of an accepted technology that is well-proven in Cameroon. The modifications make it more appropriate for a smaller scale of palm oil production and allow local manufacture. The manual and motorized versions of the horizontal Caltech have been working well and the

estimated demand for these expellers in Cameroon is 24 per year. In fact, that is well above the dissemination rate of 11-12 per year when the original Colin was being sold at a time when the price of palm oil was higher relative to the cost of the press. The vertical Caltech has a much larger potential market since its cost is only 39% of that of the manual, horizontal Caltech. The marketability of the vertical Caltech depends on whether workers will accept the form of labor -- turning a pole while walking in a circle -- or if animal power is feasible.

By expanding to serve neighboring countries, the workshop in Cameroon could sell as many as 50-60 horizontal Caltechs per year. It has already received an order for 5 horizontal Caltechs from the World Bank-financed ITURI project in Zaire. It is completing a market study in Benin, Togo, Ivory Coast, and Guinea-Conakry. A firm in France involved in the design work has also fabricated a motorized Caltech for an organization in Guinea. ATI is also considering a replication project in Zaire.

The Effect of Macro-Policies

Two parastatals account for over 80% of the industrial production in Cameroon, but there is some competition from a handful of private firms. The capacity use rate for the large-scale firms is only 24% because their exports are uncompetitive and there are difficulties in transportation and sale on the domestic market. Local production costs greatly exceed the delivered sale price of palm oil from Southeast Asia, mainly due to the relatively low yields in Cameroon.

Since 1975, government policy in Cameroon has set a domestic price floor for palm oil above the world market price and maintained it through a ban on imports. However, large-scale producers may not charge a higher price than this fixed level. This pricing and trade policy allows continued operation of the relatively inefficient domestic producers. It also keeps the farmgate price for palm fruit above what it would be in an open market, but below the level that would prevail under continued protectionism in the absence of the price ceiling. In the areas where artisanal producers compete with large-scale firms, small-scale enterprises are indirectly affected by the controlled price. However, artisanal palm oil is sold at a much higher price in remote areas that are not served by distribution systems from large-scale industry although most of the excess profits accrue to middlemen rather than the producers. Also, government regulation has not been able to control the large retail price increases that occur during times of scarcity, such as droughts.

The estimated growth in output from large-scale industry through the year 2000 is only 1.5%, well below the expected increase in domestic demand from population and income growth. The reason for this is stagnating production of palm fruits on aging industrial plantations. The main policy alternatives for increasing industrial production are (1) establishment of new plantations of contract growers, (2) clearing of forest for larger blocks of small plantations, (3) creation of medium-scale enterprises for intensive management of new plantations, and (4) expansion of intensive, large-scale plantations.

Intensive plantations are expensive and there is a long time

lag before any new plantings become productive. Companies can minimize their capital costs by relying on smallholders, but at current prices and yields the financial returns to contract growers from new plantations are marginal. At a low production rate, the complementary investments incurred by the companies in equipment, transport, and quality control have proved burdensome. Also, the distance between participating smallholdings and political pressures to expand participation beyond the economic radius has made transport costs high for the companies. In fact, an FAO/IBRD mission suggested that the companies eliminate contractual arrangements with the more distant smallholders.

Artisanal production is the fastest and cheapest way to increase palm oil output as the gap between industrial production and demand grows. The large area of semi-wild trees could support expanded production if harvesting difficulties can be overcome. Seedlings of improved varieties could be distributed for enrichment planting of semi-wild stands.

The artisanal sector also offers important advantages in meeting the rural demand. First, rural consumers prefer the sharp taste of local oil with a high free fatty acids content over industrial-quality oil. Second, production costs are low because of the relatively inexpensive source of palm fruits and low equipment costs. Unskilled labor, often from unpaid household sources is the main input. Third, artisanal production has been more stable than industrial-scale production from year to year. Fourth and most importantly, the industrial product often does not reach remote rural areas. When it is available, the industrial product sells for a higher retail price in rural

areas than in urban areas because of high transportation costs and a lower volume of purchases.

Removal of the import ban on palm oil would be another way of meeting the expected future shortfall, but it is unlikely that the government will change this policy. Palm oil production is too important as an economic activity generating income and employment in rural areas to do so. Policies to encourage artisanal-scale production of palm oil within the country can also be justified by the foreign exchange savings. In any case, the domestic product is better matched to local tastes than the refined imported oil. In return, it is the consumer who bears the costs of the current protectionist policy.

To effectively expand their operations, artisanal producers will need to adopt improved, small-scale technologies for oil extraction. Purchases by smallholders whose contract growing arrangements are terminated also could stimulate the demand for small-scale, low-cost pressing equipment. However, as long as the contracts are available, many farmers will resist giving up the security of these arrangements, even if they could earn a higher income processing and marketing their own palm oil.

Increasing the price received by artisanal producers of palm oil could boost the demand for improved, small-scale presses. Although artisanal producers could take advantage of seasonal price variations by storing palm oil for 6-12 months, few do so because of their immediate needs for cash. another way to increase the rural producer's share is to reduce inefficiencies in distribution by organizing marketing and transport and improving market access in poorly served areas. Elsewhere

in the region such as in Zaire, Benin, Togo, Ivory Coast, and Guinea-Conakry, the traditional process for palm oil extraction is more prevalent. There, the potential gains in productivity from simple, upgraded technologies are large, but it may be difficult to convince artisanal producers to adopt an improved press. Also, the profitability of an improved press might not be the same as in Cameroon. Palm oil prices are higher in some other countries, which increases the profitability of an improved press. On the other hand, smallholder planting programs for the improved variety of palm fruit may be less far along.

Charcoal Stoves in Kenya

The Local Context

Charcoal comprises almost two-thirds of the energy used by lower- and middle-income households in urban areas of Kenya. In addition, higher income households use charcoal for one-third of their domestic energy. Unlike wood, charcoal takes little storage space, is ready to use without chopping, and burns cleanly. Many rural households cannot afford marketed cooking fuels and may have access to wood or crop residuals for free, but urban households have to pay cash for wood.

In 1980, 637,000 tonnes of charcoal were consumed in Kenya and it took 5.3 million tonnes of wood to make this charcoal in traditional earth pit kilns. By comparison, 12.9 million tonnes of wood were burned directly as fuel. With expected changes in population, household size, urbanization, and per capita incomes, charcoal consumption may increase 6.7% per year between 1980 and

2000 in the absence of policy changes. The predicted mean annual increment of wood in the year 2000 could only meet 35% of the annual consumption. Part of the shortfall could be eliminated if households adopted more fuel efficient stoves.

Practically all of the charcoal stoves (jikos) in use in Kenya before 1980 were of the traditional design. That design was introduced into Kenya in the early 1900s by Indian laborers and it took about 50 years for this stove to replace the three-stone stove in Kenya through market forces. The traditional jiko is made of scrap metal and is assembled by local tinsmiths on a cottage industry scale. Since it is uninsulated, this stove radiates heat to the air as well as the cooking pot. An average household in Nairobi using a traditional jiko and having a single wage earner spends between one-fifth and one-quarter of cash income on charcoal. Although the average rural user consumes a smaller quantity of charcoal and pays a lower price, rural incomes are lower.

Description of the Projects

ATI became involved in replication of prior work on improved household charcoal stoves ("jikos") in Kenya. The technology was an outgrowth of one that proved successful in another LDC (Thailand). Work on improving charcoal stoves in Kenya began in 1977 at Kenyatta University College and later at Egerton College. Interest expanded after a locally organized exhibition tested charcoal stoves for the U.N. Conference on New and Renewable Sources of Energy in Nairobi in 1981.

Improved stove designs have proceeded in two directions -- (1) all-metal stoves and (2) ceramic-lined versions of the

traditional jiko. All-metal stove designs were developed by the Bellerive Foundation in 1979 and UNICEF in 1980-81. It is the ceramic-lined jikos developed later that are being adopted in significant numbers. Table 1 compares these improved stoves to the traditional jiko.

UNICEF developed two charcoal stove designs -- the Umeme and the Haraka. The Umeme is a double-walled, all-metal stove with an insulating layer between the two walls. The Haraka is a variant of the Umeme with a single wall and a handle that can be swung for air circulation to make lighting the stove faster.

An average-sized pot sits on the prongs inside the Umeme , rather than resting on top of the stove. This stove has a high fuel efficiency due to the enclosed combustion chamber, good convective heat transfer to the inserted pot, the insulated chamber wall, and the regulated air flow. The Umeme remains hot for a long time, cooks fast, and is durable. The large firebox diameter provides stability. It only takes one type of artisan, a metalworker, to make this stove and this avoids the quality control problems that have been experienced with ceramic liners.

The Umeme has several disadvantages. It requires a lot of metal, which makes it expensive, and the metal work is more time-consuming than for a ceramic-lined stove. It is also more difficult to use than the traditional stove or the ceramic-lined stoves and is perceived to be a greater risk for burns. The Haraka requires less metal.

About 4,000 Umeme stoves have been produced in Kenya through mid-1985. Although production was subsidized, less than 50 per month were being made. The Haraka was not made in commercial

Table 1. Comparison of Kenyan Traditional and Improved Charcoal Stoves

	Traditional Jiko	Bell-Bottom Stove	Umeme Stove	Haraka Stove
Retail price in Nairobi (K.S.)[a]	40	65-85	85[b]	70[a]
Parts needing replacement	Metal grate	Ceramic liner/ grate and insulation	Metal grate	Metal grate
Price of replacement parts in Nairobi (K.S.)	10	30[c]	15-20	20
Frequency of replacement of parts (Months)	3	8-12	6-12	6-12
Expected lifetime at full use (Months)	12	24	48	24
Efficiency in laboratory tests (%)[d]	20-22	29-39	33-36	28-31

[a] There are approximately 16 Kenyan Shillings (K.S.) per U.S. dollar.

[b] The artisans receive scrap metal through UNICEF at a reduced price. At market prices for scrap metal, the Umeme stove might cost K.S. 120 and the Haraka stove might cost K.S. 100.

[c] Including labor.

[d] PHU_2--Percent of charcoal's heat utilized in boiling and evaporating 2.0 liters of water for 60 minutes.

Sources: Joseph, Shanahan and Young, 1982; Sambali and Schneiders 1984; Stewart 1984; Allen 1985; Claassen 1985; Kinyanjui 1985; Schneiders and Mkallata 1985.

quantities. Demand was limited because UNICEF did not carry out an extensive promotional program for these stoves.

The addition of a ceramic liner to a traditional jiko was inspired by the Thai bucket stoves and was suggested in 1981 by a researcher with the Beijer Institute. Around the same time a local energy planner was investigating cement/vermiculite mixes as a material for stoves. One component of the Kenya Renewable Energy Development Project (KREDP) supported the development of liner stoves between September 1981 and June 1985. The KREDP was funded by U.S. AID through the Ministry of Energy and Regional Development (MOE).

The liner stoves have (1) a metal cladding, (2) a fired ceramic liner and grate, and (3) an insulating layer of cement/vermiculite that binds the liner to the cladding and covers the bottom of the ash box. The liner stove designs have evolved a great deal since 1982.

The current type, the bell-bottom jiko, was developed in late 1983 and refined in 1984. The one-piece ceramic liner has a perforated floor which serves as a grate. The cladding is narrowest in the middle like a waist. This shape allows gravity to hold the liner in place firmly so that it is less prone to cracking from differential expansion in heating. Because the liner only extends halfway down the height, this stove (1) is more portable because it weighs less, (2) is cheaper to produce, and (3) has a smaller firebox, reducing charcoal waste from overloading.

The goal of the KREDP was the manufacture and sale of 5,000 improved jikos in 2 1/2 years. In fact, private workshops

produced 13,000 ceramic-lined stoves by the end of 1983, 66,000 by the end of 1984, and 125,000 through mid-1986. Since then, the production rate has been 3,000-5,000 per month, so total output is at least 200,000 stoves. Liner fabrication is the limiting factor in production.

The KREDP also set a goal of creating at least 20 enterprises producing improved jikos. Over 15 enterprises were making liners in early 1985. However, most of the liners have been made by 3 relatively large enterprises in the Nairobi area: Clayworks, Ltd. (which has since ceased production), Jerri International, and Miaki Jikos. Metal claddings for the bell-bottom jiko are made by about 100 "fundis" (informal sector metal artisans). Jikos are assembled by the metal artisans or liner manufacturers. The jikos component of the KREDP included (1) applied research and prototype development; (2) training, extension, and demonstration; and (3) development of productive enterprises.

Energy/Development International (E/DI) was the contractor for the KREDP and it hired Kinyanjui as director of the jikos component. Following the suggestion of the National Christian Council of Kenya, E/DI decided to rely on informal sector artisans rather than consumers to build the stoves. Since the Thai designs showed promise, the KREDP sponsored a 4-week study tour of the stoves industry in Thailand.

The original project's approach was based on three assumptions. First, it was assumed that the efforts of government and NGOs could be most effective if they built on Kenya's strong private sector and maintained profit incentives

for production and distribution. Second, it was assumed that households would pay the higher price of the improved stove if they could be shown the benefits of doing so. Third, it was assumed that households would maintain their regular cooking practices and cultural preferences.

The original project provided training to artisans, trainers, and managers. Little direct production assistance was provided under the KREDP. The KREDP mostly confined its demonstration activities to displays at exhibitions because management was concerned about creating a potential demand that could not be met before production had expanded sufficiently.

Improved jikos are available at a wide variety of outlets. In early 1985, at least 22 wholesalers distributed the jikos; 40% of them were in Nairobi. There were over 73 retail distribution points including workshops, open air markets, the Kenyan Grain Growers Union cooperative stores, food stores, hardware and appliance stores, and churches (Opole 1985). Since the technology is affordable and benefits can be captured by consumers, consumer subsidies were not needed.

After the KREDP had been completed, ATI supported a stronger demonstration and marketing program and provided assistance to small-scale producers outside of the Nairobi area in a follow-on project. This was important in extending the benefits to peri-urban areas throughout the country, which had not benefited much from the original project.

Informal sector artisans often make changes in the recommended designs and some of these changes can reduce a stove's fuel efficiency or durability. Some inferior liner

stoves have been sold as improved jikos by artisans who were not trained properly or were trying to cut corners in construction.

One approach to resolving quality control problems and increasing productivity is to change the production technology. An engineer on the staff of ATI designed a jolly. This machine, a simple motorized jig for molding liners, was introduced in Kenya in mid-1986. Hand-formed liners have a cracking rate of about 30% because too much air is left inside the clay, compared to only 5% for the liners molded by the jolly. It takes 10 minutes to mold a liner completely by hand, compared with 1-2 minutes on the jolly.

Effects of Macro-Policies

The pricing of alternative fuels has a major effect on the incentives for adopting an improved charcoal stove. In Kenya, kerosene and LPG consumption are not subsidized. Electricity costs in Nairobi are higher than either of these two fuels. The capital costs of stoves for fossil fuels are much higher than those for wood or charcoal.

Some of the charcoal used in Kenya comes from natural forest stands managed by the Forest Department; stumpage prices for this wood are below its replacement costs. Hardly any of the charcoal is produced from wood grown on managed stands or plantations. Most is taken from high-potential agricultural land and fringe areas.

Although the financial savings from adoption of a more efficient charcoal stove is significant, government pricing policy for charcoal has reduced the incentive below what it would otherwise be. The maximum price of a sack of charcoal for a

wholesaler or consumer is controlled, varying by location. Since the ceiling prices have not risen in proportion to increasing scarcity, sellers have circumvented them by reducing the weight of charcoal in a sack from 40 to about 30 kilograms and sometimes deliberately adding pulverized charcoal fines, twigs, and even stones. The price controls are not vigorously enforced and are ineffective at the retail level at which most poor consumers by charcoal -- in small tins or piles containing 1 to 4 kilograms.

Programs for the conservation of charcoal can also be justified on environmental grounds as well as economic ones. Charcoal production has more serious environmental impacts than fuelwood collection. First, it takes twice as much wood to obtain a given amount of energy from charcoal produced in traditional earth pit kilns, than by burning the wood directly. Second, fuelwood often consists of twigs and fallen branches, while whole trees are often felled for charcoal conversion.

Thus, policies should not encourage existing users of fuelwood from switching to charcoal consumption, even with an improved stove. The target group is urban and peri-urban consumers who are already using charcoal because of its more convenient storage and combustion characteristics. Beyond a certain distance, transport costs may make charcoal more economically feasible than marketed fuelwood. In East Africa, fuelwood is rarely transported more than 80 kilometers, while much of the charcoal consumed in Kenyan cities comes from farther distances. The Kenyan experience has considerable replication potential because charcoal use is widespread in urban households and traditional stoves are relatively inefficient in many

developing countries. The same traditional stove is common in Tanzania, Uganda, Burundi, and Rwanda and to a lesser extent in Malawi.

Broader lessons about how to disseminate a simple, new technology can also be gleaned from the Kenyan experience. The idea was local and the traditional technology was used as the starting point in the design work. Users were not expected to make any major changes in the way they used the stove. Yet, the improved stove had a readily observable difference so that consumers could recognize it easily. Improvements in the technology were made after adapting the experience from other LDCs.

After laboratory tests narrowed the range of alternative technologies, field tests were conducted to obtain feedback from potential users. Following the field tests, further sorting out of the technologies was left to the market.

The active efforts of international organizations, the government, local NGOs and private sector artisans and distributors have spread improved stove technology faster than the original rate of dissemination of the traditional jiko. Many stove projects elsewhere have not taken off because the private sector was not given a role in the design or implementation of the projects. Although the informal sector lacks the capacity for R & D or testing of a new technology, it has the ability to adapt rapidly to introduced designs if they are appropriate. It can produce and market simple consumer goods in large numbers at a relatively low cost. Reliance on existing artisans avoids the need to establish a whole new infrastructure and completely train

inexperienced workers. Unlike many other countries where the informal sector is illegal and often harassed by the authorities, the government of Kenya has encouraged small-scale artisans. National political figures have visited Shauri Moyo, the large open air market and workshops where the jikos and other products are made and sold. In many parts of Kenya, the use of public land for similar market/workshops has been authorized and in some cases, simple sheds have been constructed for shared use by the artisans.

Ferrocement Fishing Boats in Malawi

The Local Context

The government of Malawi places a high priority on development of the relatively undeveloped fishing industry on the northern part of Lake Malawi. Since sea conditions are significantly different in the north, it was thought that larger fishing craft would be needed to tap the relatively unexploited resources there. The government also was concerned about the availability of high-quality timber for plank boats. Canoe makers also began experiencing difficulties in obtaining hardwood boles for large canoes. The government decided to investigate ferrocement as a boat-building material since cement is domestically produced.

Lake Malawi has few natural harbors along the northern lakeshore and deep water is close offshore. Protein consumption in Malawi is low and fish comprises 53-70% of the animal protein. Per capita fish consumption in the north is only 5.2 kg, one-third the national average, due to lower availability.

Although the north contains 50% of the area of Lake Malawi,

it only provides 14% of the lake's total fish catch. The northern waters are less productive because they are deeper. Limited data indicate a significant potential for increasing the catch through use of large-scale deepwater bottom trawling; near-shore resources beyond the range of traditional craft; extension of the traditional fishery; and trapping crabs and catfish. Even if only half of this increment could be tapped, that would amount to a 30% increase over the current catch. An increased catch would require improvements in marketing and transport.

Fishing is an important occupation around Lake Malawi, with 90% of the total fish catch by traditional fishermen and 10% by commercial enterprises. In 1984 there were 5,100 fishermen (full- and part-time) in the north using 1,900 operable fishing craft. Only 38% of fishermen owned their craft and gear. Dugout canoes comprised 99% of the craft and the rest were mostly plank boats without engines.

Dugout canoes are scooped out of a single tree trunk; previously most were 5.0 - 3.0 m long. Due to the increasing shortage of long tree boles, new canoes only average 2.5 - 3.0 m in length and are often misshapen. Dugout canoes are built by specialized artisans. It takes four times as much prime wood to build a dugout canoe than a plank boat of similar capacity. Hardwood canoes are best, but more softwood canoes are being built now because of the increasing scarcity of hardwoods along the lake. The price of a canoe varies with its size and quality and the location of sale. In 1985, a 2.4 m canoe made of low-grade softwood cost MK 30, while one made of better softwood or hardwood cost MK 55 (the exchange rate at the time was 1 Malawi

Kwatcha = $U.S. 0.57). A 4.6 m canoe cost MK 45 in low-grade wood or MK 75-200 in high-grade wood. Many canoes are bought by businessmen who rent them to small-scale fishermen for a share of the catch or, less frequently, a fixed monthly rent in cash.

A small number of wooden plank boats are in use in the north. These open boats without a deck were introduced in Malawi in the 1940s, but production did not take off until FAO provided design and construction assistance in the early 1960s. Most plank boats in Malawi are 5.2 - 5.8 m in length, but there are a few 7.6 m plank boats on the southern lake where the waters are relatively calm. Two types of plank boats are made in Malawi. V-bottomed plank boats can travel faster than flat-bottomed plank boats to escape rising winds. Flat-bottomed plank boats are more stable under calm lake or shallow river conditions, and offer more working space. Two government boatyards make plank boats in Malawi. A small number of cheaper plank boats are made by private individuals along the central and southern lakeshores.

Wood is the traditional material for plank boats and the preferred species in Malawi is Mulanje cedar (Widdringtonia nodiflora). This softwood is durable, relatively resistant to rot and termites, and easy to work because it has a straight grain with few knots. Only dead Mulanje cedar trees may be cut legally from natural stands and it takes 75-150 years for this tree to reach maturity. Plantation cedar on lower elevations grows faster, but its wood is softer and has a lower specific gravity and more knots.

The scarcity of Mulanje cedar is reflected in its increasing wholesale price per cubic foot. Because of its higher cost,

government boatyards only use Mulanje cedar now for planks rather than as main timber. Less-desirable hardwood species have been substitutes, but rot more rapidly and are more susceptible to insect damage. Wholesale prices of hardwoods have also increased substantially. The Forestry Department expects to raise the price of timber more frequently in the future to reflect its replacement cost.

Canoes and plank boats have a range of less than 1.0 km from the shore of the lake, compared to 8.0 km for ferrocement boats, Their range is limited because fishermen must paddle to safety if the weather turns bad. A canoe can only fish in waters shallower than 100 m on Lake Malawi even though commercial stocks of fish are available at twice that depth.

Canoes are usually paddled with a wooden oar or pole. Most plank boats on the northern lake are propelled by oars or paddles

economical for commercial fishing of scattered, high-value species for subsistence fishing. Areas in the north where commercial gillnetting would be viable are not large and if more than a few enterprises were developed there, the stocks of fish could decline making them unprofitable.

Longline fishing is less common than gillnetting in the north although it may have commercial potential over a wide area, including deep waters. Longlines can be used at the same time as gillnets. The speed of setting and hauling rather than storage space limits the number of hooks used.

A purse seine (ring net) can catch pelagic fish in deeper water than can gillnets and would probably have a higher valued catch per unit effort. However, commercial-scale purse seines are not in use in the north because they require a large boat.

Description of the Project

In 1981, the Fisheries Department began a demonstration project with funding of $75,083 from Appropriate Technology International. The objectives were to establish a ferrocement boat-building capacity in the north and sell these boats on credit arranged though other programs. Although results were mixed, useful lessons were learned about the technology and its relationship to policy issues.

Ferrocement is a mortar of cement, sand, and water that is densely reinforced throughout with steel mesh wire and formed into a thin shell. Layers of steel mesh comprise 2-10% of the material by volume. The wire mesh increases the resistance to impact and prevents complete collapse of the structure if it cracks from the load.

Ferrocement offers many advantages as a boatbuilding material. Unlike wood, it can be formed into complex curves that improve boat performance. Ferrocement is best suited to the construction of round bilged boats, where the curvature of the hull provides strength without internal ribs or stingers. As a shell structure, ferrocement accommodates stresses from imposed loads, and cycles of heating and cooling or wetting and drying.

Ferrocement boats are said to be low cost and easy to build. Ferrocement construction is labor-intensive; yet, it requires less skilled labor than wooden boat construction. Little new training is needed because cement construction is widely known. The inputs needed are readily available in most LDCs -- chicken wire for the mesh (preferably galvanized) and building-grade cement. Large investments in plant and machinery are not needed for a ferrocement boatyard, but electricity is desirable.

Ferrocement boats can be turned out faster than wooden boats and could be mass-produced in LDCs. It is easy to experiment with different hull designs by altering the molds for a ferrocement boat. By contrast, building a new wooden hull design is more time-consuming and requires more engineering work and skilled labor.

Ferrocement is a durable material that increases in strength with age. It can have a long life because it is rot-proof and immune from attack by termites or shipworms, unlike wood. A ferrocement boat only needs to be painted for aesthetic reasons. It also resists corrosion by freshwater or seawater and can withstand a major fire without damage. Ferrocement boats that have been wrecked on reefs and pounded can survive. The damage

is often localized and repairs are easy to make by chipping of the damaged area, fixing the mesh if necessary, and replastering.

Ferrocement boats have some real and perceived disadvantages. Extensive demonstration and marketing may be necessary to sell these boats because small- or medium-scale fishermen are not familiar with this material. However, the weight of a ferrocement boat is a false concern. A heavier boat provides a good working platform for fishing and can be more stable on rough waters. A lighter boat has the advantage that it can be pulled up on the beach in calm weather. A single-hulled wooden boat of the same displacement as a medium-sized ferrocement boat would probably require a concrete slab on the keel for ballast. Most fishermen in Malawi are not familiar with the handling of a ballasted boat, and might perceive that a ferrocement boat feels heavy. The motion of a ferrocement boat should be more comfortable in choppy water because the weight is distributed evenly through the hull instead of being concentrated in ballast. However, this weight cannot be varied to keep the keel low relative to the center of buoyancy for maximum stability.

Ferrocement has a minimum thickness of 17 mm, which does not need to change much as the boat's length and width increase. As a result, large ferrocement boats are proportionally lighter than small ones because the thickness is spread over a larger surface area. A ferrocement boat longer than 16 m is lighter than a steel boat of the same size. The extra weight of a small ferrocement boat compared to a wooden boat may be a problem at high speeds. Before this project, it was thought that a

ferrocement boat had to be at least 9-10 m long to be of acceptable weight. An innovative construction method tested through this project allowed ferrocement boats to be as small as 5.6 m in length.

Quality control is important in construction of a ferrocement boat. If the mortar mix contains too much water, the cement will be weak. Poor mixing will result in shrinkage of the material. Plastering is also critical because exposed mesh can rust. If the mortar has not been cured properly, the compressive strength will be low and cracking will occur. Small hairline cracks that do not penetrate beyond the outermost layer of mesh are not significant.

Ferrocement is very susceptible to punching damage from the localized impact of collisions with sharp or hard, protruding objects. Even after one punching, the mesh and broken concrete is usually intact, preventing uncontrolled flooding of the hull. Diesel oil can damage ferrocement so the area around an inboard engine should have a protective coating. Faulty grounding of engines and equipment can lead to rusting of the hulls through electrolysis. Ferrocement is resistant to the impact of storm waves if the hull curvature is adequate. It also has fairly good resistance to a force applied evenly across the surface (e.g. being run up on a beach). Watertightness is not a problem for a ferrocement hull.

Canoes and plank boats have a short fishing season because they cannot be used when waves are high. The waves on Lake Malawi are highest during the dry season, when fish processing and trading are easiest. The low center of gravity of a canoe

makes it easily water-logged and prone to sinking. Only 120 days per year are fishable with a dugout canoe. A ferrocement boat can also carry a larger catch per fishable day because it has more working space than a canoe or plank boat of the same length. A 4.6 m canoe or plank boat holds a crew of 4-6 fishermen, compared to 8-12 in a 5.2 m plank boat, and 20 or more in a 5.6 m ferrocement boat. It can also carry more fishing gear.

Under the Karonga project, two sizes of ferrocement boats were built. The smaller boat has a length of 5.6 m, displacement of 1,500 kg, and fishhold capacity of 500 kg boxed. The larger boat has a length of 7.2 m, displacement of 2,800 kg, and a fishhold capacity of 1,000 kg boxed. Both sizes have a watertight deck and riggings for sails. There is good potential for combining sails with motors on plank or ferrocement boats. Using a sail as the sole propulsion method, a ferrocement boat could fish 200 days a year. The motor could be used alone during periods of insufficient wind, allowing another 100 days of fishing a year. Or, sail power could be used with a motor to increase the speed or decrease fuel consumption at a particular speed. A sail also makes a boat steadier in the wind and less prone to rolling.

Despite the potential, few small-scale fishermen in Malawi use sails since there is little tradition of the technique there. Although it would only cost MK 50 to add an outrigger for sailing to a dugout canoe, most fisherman on Lake Malawi cannot even afford to buy their own canoes, and need additional fishing gear more. Traditional fishermen also lack sailing skills, which would require 2 months of training to develop. Imported sailcloth

should last for 3 years; but it is expensive The major textile mill in Malawi makes a cotton drill cloth that could be substituted. Although the drill cloth might only last 1 year, it is readily available at one-seventh the cost of imported sailcloth. Even with frequent replacement, it is cheaper.

An outboard motor costs one-fifth as much as an inboard motor. It leaves more space on the boat for storing fish or gear and the position of the hold space has a better center of gravity for the cargo. The sail performance is also improved. Since an outboard motor is light, it can be lifted easily out of shallow water. It is also easier to repair than an inboard motor, using less skilled labor.

An inboard diesel motor consumes only one-quarter the fuel an outboard motor for an equivalent propeller thrust, and diesel fuel costs less than the 25:1 gasoline/lubricating oil mixture used for an outboard motor. An inboard motor has a longer life, needs fewer replacement parts, and is more durable than an outboard motor. It is also less of a fire hazard and the absence of an electric ignition increases the reliability of operation. However, the fuel savings do not justify the higher capital costs of an inboard motor for the 5.6 m ferrocement boat. Due to its larger size, the 7.2 m ferrocement boat requires an inboard engine.

Including the motor, but not gear and working capital, an investment of MK 4,600 is needed for a 5.6 m boat and MK 16,400 for the 7.2 m boat. The difference in capital costs is mainly due to the inboard motor required by the larger boat. In comparing production costs, note that the ferrocement boats are

larger than wooden plank boats of the same length.

Production costs for a 5.6 m ferrocement boat are 124% higher that a motorized plank boat of equivalent size and quality. However, the 7.2 m ferrocement boat would be 5% cheaper than the equivalent plank boat. The smaller ferrocement boat could be cheaper than the wooden boat in the long run if it lasts longer.

A softwood canoe lasts 2-3 years, while a hardwood canoe lasts 4-6 years. The lifetime of a canoe is often extended by patching it with pieces of wood and sometimes metal. Some fishermen who can afford a plank boat prefer a hardwood canoe because of lower repair costs. Plank boats made from local hardwoods at the government boatyards can last 15-25 years. However, they may need minor repairs after 3 years and major repairs after 8-10 years. A ferrocement hull should last at least 25 years if properly handled. Fuel and engine maintenance costs for a ferrocement boat are similar to those for a plank boat with the same kind and size of motor operating for the same length of time. If a sail were used for supplementary power, these costs would be lower for a ferrocement boat.

A fishing entrepreneur with an outboard-powered plank boat would bear costs of MK 2,000 - 5,000 and net MK 500 - 1,200 per year. An entrepreneur with a locally produced, non-motorized plank boat might gross MK 600 and net MK 300 per year. Hired fishermen earn MK 10 per month in cash, a ration of 1-4 fish per day, and a bonus if the catch is large. A gillnetting enterprise using a 5.6 m ferrocement boat with sail and outboard motor would have an internal rate of return of 84%, without financing. With

financing, the net present value would be MK 17,335 at a 15% discount rate. The net present value would be lower, but still positive for most other propulsion methods; however, it would be marginal if an inboard motor were used without a sail. The 7.2 m ferrocement boat would be better suited for an enterprise combining purse seining and longlining.

In fishing trials with ferrocement boats, the Fisheries Department had a lot of trouble with boat accidents due to staff inexperience and poor labor supervision. About 10 incidents occurred over a 2-year period due to ignorance of the basic rules of sailing and mooring, not from any inherent problem with the design of the boats. A significant amount of damage to the boats occurred, but was repaired without much difficulty although it caused delays and extra cost. Several things could have been done to reduce the damage, including adding fenders made of old tires and building a heavier skeg.

The Effects of Macro-Policies

The lessons learned from this project have implications for regional development policy, price regulation, financing of boat sales, and the promotion and demonstration strategy. A demand for these medium-sized boats by commercial-scale enterprises did not materialize due to the limited fishery resource base, fish pricing policies, and poor infrastructure in the area. Traditional fishermen were not interested in the additional risk or lacked the managerial capacity needed for a larger scale enterprise.

Infrastructure for the fishing industry in the north is poor. Thus, fresh fish must be sold on the day they are caught

for lack of cold storage facilities or ice on boats, beach landings, transport, and markets. The beach demand for fish is roughly stable, but since the daily supply is variable, any excess must be sold at a low price or dried. Variations in the catch rate among traditional fishermen are large, depending on the type and condition of their boats and gear, their access to better fishing grounds, and available labor.

Although the markets are closer to the beach landings in the north, transport costs per kilometer are higher because of poorer roads and access to vehicles. Small amounts of fish are carried by hand, bicycle, or on small vehicles where sanitation and quality standards are low. Fresh fish is available at few inland locations in the north. About 90% of the catch is consumed within 10 km of the shore and 62% by the families of the fishermen. The marketed share of the fish catch is lower than in other parts of the country because of the smaller catch, more difficult transport, and local government pricing policies.

The retail price of fresh fish is higher in the north due to larger markups between the beach and lakeshore communities. Traders charge a high retail markup on fresh fish because they bear the risk of spoilage. Despite higher retail prices, the fishermen receive a lower beach price due to local government price controls.

Because of the difficulties in handling fresh fish in the north, 85% of the catch is dried or smoked. Fish are dried at the landing by women from fishing households and much of the profit is in drying and transport. In the south, fishermen often sell fresh fish to male traders who resell it in bulk or process

it. Dried fish cost twice as much in the north as in the rest of the country.

There have been four types of prices for fish in Malawi: (1) beach prices; (2) controlled prices at government landings, (3) wholesale prices, and (4) retail prices. Beach prices are paid to fishermen by middlemen where the catch is landed. Certain district councils or tribal chiefs in the north maintain particularly rigid price controls. For example, the controlled beach price at Likoma was only one-sixth the average for the north. Maximum prices at government landings were controlled by the Treasury Department until November of 1985. Beach prices had averaged 35% of the retail prices, and wholesale prices received by middlemen had been about 60% of retail prices. Prices tend to be higher in the dry season, reflecting the reduced supply.

Due to price controls, many fishermen in the north do not sell fish at the beach. Instead, they barter fish with the community or smoke or dry fish for inland wholesale markets. Price controls might reduce the cost to consumers, but would be harder to monitor and would still adversely affect the profitability of fishermen and the quantity of fish on the market.

The gillnetting enterprise with a 5.6 m ferrocement boat that was shown to be potentially profitable at expected lakeshore wholesale prices would lose money at the controlled prices for government landings. The price controls would decrease annual gross revenues by MK 5,952, making the net present value at a 15% discount rate (-MK2,600) and the internal rate of return -0.4%. The elimination of these price controls should have a

positive effect on the fishing industry in Malawi.

Although a ferrocement boat could be commercially viable, few fishing entrepreneurs in Malawi can afford the higher initial capital costs without financing. The National Bank of Malawi agreed to make one loan of up to MK 12,000 available to cover the costs of a 5.6 m ferrocement boat, motor, gear and working capital. It also agreed that repayments from this loan would be reloaned to a similar enterprise. Other sources of financing would have become available had the commercial viability of such an enterprise been demonstrated.

No loan was made. Because the prospects for dissemination of the technology in Malawi rested so heavily on the success of a single loan, the Fisheries Department was cautious in recommending a loan applicant. Many of the applicants lacked experience in managing a commercial fishing venture. Yet, the prospects for success might have been better for an entrepreneurial type than for a traditional fisherman. The Fisheries Department's insistence that the selected applicant be from the north may have been counterproductive. The main reason for lack of demand among fishermen in the north was the selection of an inappropriate scale of boat for the area.

The appropriateness of a boat design depends on the abundance and location of fishery resources, entrepreneurial capacity, fishing methods and skills of the crew, transport and distribution facilities, market conditions, and the policy environment. In small- to medium-scale fishing, fishermen gradually upgrade the types and sizes of boats used. Since almost all fishermen on the northern lake use canoes, a plank

boat would be the next step up. Some fishermen who could afford a bigger boat resist buying one because they can make more money by purchasing more fishing gear or another canoe that can be rented out. Consequently, the demand for a medium or large fishing boat in the project area is very low at present. A 5.6 m boat is at the lower limit of the size that is practical for ferrocement although some work has been done on a ferrocement canoe.

If a fishing enterprise of sufficient scale were properly managed, a ferrocement boat could have discounted life-cycle costs lower than those of a plank boat of comparable size because of reduced replacement costs. However, the fishing entrepreneurs who might want a medium-size boat prefer to keep capital costs low despite higher total life-cycle costs. Since capital is short and the risks are high in the fishery sector in Malawi, entrepreneurs are not looking for large loan obligation even if the boat can last 25 years.

Successful operation of a ferrocement boat requires an enterprise with a relatively high level of organization, which would have to fish nearly every day that conditions permit. It would also need an adequate amount of gear and sufficient access to marketing channels for fish. Commercial fishing enterprises like that are rare in Malawi, but could be profitable. At that scale, an absentee owner whose only role is to provide a boat and take half of the catch is not likely to be successful. The prospects may be better for an entrepreneur who understands the fishing business and hires a good crew than for a traditional fisherman.

The experience also raises questions about the likelihood of proper handling of a ferrocement boat. A good manager who has a financial stake and trains his crew well could have more success in this regard than poorly motivated and supervised government fishing crews. Nevertheless, a ferrocement boat would not be ideal for a large purse seining or stern trawling operation because of the risk of impact damage when several boats are used in tandem.

The ferrocement boats project was premature in Malawi because a critical enough level of wood scarcity has not yet been reached. While suitable timber stocks last, wood will remain the principal material for small and medium-sized fishing boats. In the future, the relative attractiveness of ferrocement may increase as the price of timber rises and government regulations on wood cutting become more stringent.

The well-intentioned regional development objective of creating a new boatyard in the north proved to be misguided. Production costs would have been lower if the facility had not been located at a remote site. Transport costs and labor waste caused by raw material shortages would have been lower at an existing boatyard. A facility that only makes ferrocement boats is unlikely to be commercially viable in Malawi and rural development objectives are not served by an idle project. Since ferrocement construction does not require large equipment, it would be easy to move to one of the existing boatyards better positioned to meet the possible demand on the central and southern lakeshores. Combining the boatyards would give potential buyers of a plank boat the chance to see a ferrocement

boat.

This project was also adversely affected by the bad reputation of a defunct ferrocement boats project on the southern lakeshore. The earlier Malindi project built poorly constructed boats of different design. Since Malawi is a small country, the experience of the Malindi ferrocement boats was well known among medium-scale fishermen. Nevertheless, despite the problems experienced in the northern part of Lake Malawi, ferrocement boats have proven to be appropriate in other LDCs.

The dissemination of any new technology requires thorough promotion and demonstration. Entrepreneurs want to be reasonably sure they can earn more profits from a ferrocement fishing boat than from an investment in a different type of craft, more gear, or an alternative outside of fishing. Moreover, hired crews would have to accept the boats as being relatively safe and convenient to use.

The project did show the merits of sails as a propulsion method for small and medium-scale fishing boats. As a supplemental source of power in motorized wooden plank fishing boats, sailing can significantly reduce fuel costs. A sail can also improve the performance of a canoe. Consideration should be given to promotion and training on sailing techniques for small-scale fishermen.

The project has several lessons for technology transfer. First, a technology dissemination effort should not be begun soon after the failure of a similar attempt nearby. Second, the appropriateness of any technology is location specific and varies within a country. Third, one of the main determinants of

appropriateness is the potential for spontaneous adoption of the technology by the private sector. Thus, governments and donors should select technologies that have characteristics conducive to widespread dissemination.

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