Technology — The Key to Increasing the Productivity of Microenterprises

GEMINI Working Paper No. 8

GEMINI

GROWTH and EQUITY through MICROENTERPRISE INVESTMENTS and INSTITUTIONS
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Technology — The Key to Increasing the Productivity of Microenterprises

by

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November 1990

Prepared by Growth and Equity through Microenterprise Investments and Institutions (GEMINI) Project, United States Agency for International Development contract number DHR-5448-C-00-9080-01.

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EXECUTIVE SUMMARY

Microenterprises involved in production and processing play a key role in the economies of less developed countries. As a basic source of goods and services, income, and employment, microenterprises are particularly important for low-income people, many of whom are women, who in many countries form the majority of microentrepreneurs. Sustainable improvements in the productivity and competitiveness of microenterprises are essential for their growth and for the creation of new wealth and opportunities for the people involved. Although credit can help expand the number of enterprises, inventories, and market share, credit alone is insufficient to generate the productivity increases needed for long-term economic growth and poverty alleviation.

Technology, a critical factor in this growth, includes equipment, tools, products, processes, materials, and skills, as well as the organization of production and marketing. Microentrepreneurs successful in production and processing are often involved in the innovation, adaptation, and dissemination of technologies; however, their efforts are limited by inadequate resources, poor communications, uncertain markets, and a non-supportive policy environment. Microentrepreneurs frequently lack information about technologies appropriate for their resources and skills. As a result, the full potential of technology to increase productivity in the microenterprise sector is not being achieved.

Technological change can enable microenterprises to reduce costs through faster production, labor time savings, substitution of cheaper materials, lower fuel costs (through savings or substitution), and increased process efficiency (including developing uses for by-products). Better informed selection and organization of equipment, tools, and labor can reduce the working and fixed capital requirements of entrepreneurs, and help them use credit more effectively. New technology can raise product output, quality, consistency, reliability, and packaging to open up new markets. New technology can also and raise the marketing power of micro-enterprises by diversifying their raw-material base and increasing product shelf-life.

Microenterprise support programs can assist the innovation, adaptation and dissemination of technologies by working with entrepreneurs, their suppliers, and their customers to identify resources and constraints for increasing productivity. A systems approach (such as subsector analysis) can help pinpoint where technological interventions will be most effective. Support should strengthen communication channels so that both entrepreneurs and donor agencies are aware of successful developments elsewhere (particularly technological developments within the informal sector).

Technological training can provide operation and maintenance skills necessary to sustain small-scale, decentralized workshops and can create new possibilities for local manufacturing. Training should be tailored to the particular needs and constraints of small producers, and be sensitive to those constraints facing entrepreneurs with responsibilities outside of the enterprise, such as cultivation of food crops and care of children. More attention should be paid to solving problems of marketing new products or locally produced items in competition with imports.

Practical demonstrations of the potential of small-scale production can provide an opportunity for sharing the risk with resource-poor producers and giving greater weight to the interest of microentrepreneurs in dialogue with government on policy and regulatory reform. The most effective technological changes for microenterprises have arisen from adaptation of tools, equipment, or production methods that have been traditionally in use, rather than the introduction of newer technologies developed in industrialized countries.

INTRODUCTION

Microenterprises are a basic source of goods and services, income, and employment in developing countries, particularly for low-income groups. Women form a majority of microentrepreneurs in many developing countries, and the flexible nature of microenterprise work enables them to combine business activities with other responsibilities. This paper discusses the importance of technologies to the survival, growth, and expansion of microenterprises. It emphasizes key issues in the identification of appropriate technologies for microenterprises, analysis of subsector linkages and related macro-policies, and methods of commercialization and dissemination of technologies. The paper analyzes constraints and opportunities for external assistance to support technology innovation and dissemination. It also examines the role of technological assistance in microenterprise programs, and ways in which development agencies can provide this assistance. The final section contains three case studies of recent experiences in the commercialization of technologies for microenterprises.

Technologies are the key to increasing the productivity of microenterprises and generating broad-based, sustainable economic growth. The upgrading of technologies can facilitate the establishment and growth of new types of manufacturing enterprises that allow more of the value added in the processing of raw commodities to be captured in rural areas. Unlike larger firms, which can often generate and adopt new technologies on their own, microenterprises may need assistance so that they can upgrade their production methods. Yet relatively little support has been provided for this purpose.

The potential for increasing the productivity of microenterprises is large. However, many factors constrain the innovation and dissemination of technology in this sector. One key constraint is the lack of access of microentrepreneurs to information on available technologies. Often, small-scale manufacturers and potential users are unaware of technologies that may be appropriate to their needs, despite the fact that such technologies are being widely used elsewhere. This lack of information precludes spontaneous dissemination and underscores the importance of assistance programs. In certain sectors, appropriate technologies for microenterprises do not exist or require modification. When that is the case, external agencies can facilitate efficient technological innovation, adaptation, and transfer.

One argument for strengthening the role of technology in microenterprise assistance stems from differences in the economic impact of manufacturing or processing versus trade activities. Manufacturing and processing enterprises are an important means for creating sustainable wealth for poor communities because of their backward linkages to agricultural production and forward linkages with downstream processing enterprises. Some manufacturing firms and workshops also enable other microenterprises to remain functioning by providing intermediate inputs and raw materials, as well as spare parts for repairs. Unlike trading operations, manufacturing and processing enterprises can generate a significant amount of value added locally. Micro-scale manufacturing enterprises provide consumer benefits by making products available for the low-income market (James 1982).

One-person cottage industries often provide the sole economic opportunity for economically disadvantaged groups. This is particularly true for many women, who may be prevented from taking part in trading activities outside the household or in formal sector employment, as a result of sociocultural constraints in certain societies. In Egypt, for example, as many as 80 percent of all household enterprises are owned by women; the share is 50 percent for the textile subsector and nearly 100 percent for dairy industry (Davies et al. 1984).

Technology plays a central role in the viability of manufacturing, processing, and service enterprises. Yet most of the assistance (especially credit) that has been provided to microenterprises has gone to trading and vending activities. Technology plays a lesser role in the viability of trading enterprises although technologies in market systems may open up opportunities for production. Some proponents of "minimalist credit" argue that entrepreneurs are perfectly capable of making their own choices on how to use loan proceeds, but this is true only for those entrepreneurs who already have the necessary skills and access to information and hardware for alternative technologies. For many of the women and men involved in microenterprises, this is not the case.

Technological assistance can increase the ability of microentrepreneurs to compete with larger firms in the quality and quantity of output and production costs. It can also enable them to form complementary linkages, such as subcontracting with larger enterprises. Technological assistance is important in expanding the number of microenterprises and the profitability of existing firms. By enabling the introduction of new products and production processes, technology can stimulate the economy of the informal sector.

IDENTIFICATION OF TECHNOLOGIES FOR MICROENTERPRISES

Technology encompasses knowledge of equipment, tools, products, processes, materials, and skills, as well as the organization of production and marketing. "Appropriate" technologies meet the needs and priorities of producers by using the skills and resources available to them, and should be compatible with market preferences, cultural attitudes, and infrastructure support. Microenterprises typically rely on small-scale equipment and processes (often locally made), and locally available raw materials. Compared with conventional technologies, appropriate technologies are typically less capital intensive; more labor intensive; less dependent on scarce foreign exchange for imported goods; and easier to operate, maintain, and repair. Yet appropriate technologies are usually labor saving in comparison to traditional methods of production (Hyman 1987a). The decline of large-scale industries dependent on foreign exchange for imported inputs also represents an opportunity to enhance the value added by microenterprises through technological innovations. There is increasing recognition by government officials in the Africa, Asia, and Latin America/Caribbean regions of the need for more appropriate technologies (Bagachwa 1988, Gomes-Lorenzo 1988, Mahmood 1988).

Types of Technologies

A range of different types of technology is usually available for a particular scale of operation. The choice of technology is often critical to the profitability and growth potential of microenterprises. Traditional technologies are those that have been used in production or consumption for at least 25 years. In some cases, they have been introduced from another developing country rather than being of indigenous origin. Traditional technologies usually rely on human or animal power, or renewable energy. Upgraded traditional technologies incorporate key elements of traditional technologies, but have been improved to take advantage of the potential for higher inherent efficiencies (such as thermodynamic properties or extraction rates) or economies of scale. Off-the-shelf modern technologies have been in use for a relatively short time, generally less than 25 years; they are often larger in scale than traditional technologies. Scaled-down modern technologies are versions of modern technologies that have been adapted for a smaller scale of production or consumption or to match the available resources. Innovative

replacement technologies are generated by application of new scientific and engineering knowledge (James 1984).

Each of these types may be appropriate for particular situations in developing countries, but the approach of upgrading traditional technologies is frequently the most effective way of increasing the productivity of microenterprises, especially those owned and operated by the rural and peri-urban poor. Upgraded traditional technologies often retain the accumulated environmental knowledge of local people and are more compatible with cultural values, local skills for operation as well as repair, and resources than are down-scaled modern technologies. The first step in upgrading traditional technologies is to identify the present technical capacity and constraints limiting the quantity or quality of their production. As Schumacher (1973) recommended "Find out what the people are doing and help them to do it better." However the resources devoted to research and development for upgrading traditional technologies are relatively low and it can sometimes take a substantial amount of time to modify a traditional technology.

In scaling down modern technologies, many of the economies of scale that make the technology efficient may be lost. Moreover, the products of down-scaled modern technologies may be less suited to the incomes and preferences of low-income or rural customers. Most off-the-shelf modern technologies and innovative replacement technologies tend to be less appropriate for microenterprises in developing countries because the research that produced these technologies was carried out in developed countries, where the relative costs of capital and labor are very different. However, some of the older modern technologies, innovative biotechnologies, or microelectronics may be appropriate for microenterprises in developing countries.

Choice of Scale and Labor Intensity

Although most developing countries have high rates of underemployment and unemployment, especially in urban areas, micro-level analyses of rural enterprises often reveal labor shortages in certain regions or during particular seasons. To be accepted by microenterprises, a technology has to conform to the local practices and gender-based divisions of labor. However, technologies do not need to be designed so that entrepreneurs can, and will, use the equipment themselves, except in one-person firms where no laborers are hired.

The scale of technology also has important implications for labor displacement. Poor people, in particular, are vulnerable to loss of jobs or casual employment from the introduction of new technologies. However, there will usually be less displacement than would occur with a more capital-intensive technology. In the short run, an upgraded traditional technology may reduce employment per unit of output. However, by increasing the quantity of output to meet an expanding market, the total employment in the industry may increase in the long run. Nevertheless, the social impacts of displacing hired labor can be serious because they fall on the unskilled or the landless poor, and may disproportionately affect women.

The sociocultural and economic environment of the firms will vary between, and even within, countries. Major factors affecting technology choice by enterprises include:

- **The needs and priorities of the entrepreneurs and workers**: Some microenterprises are part-time or seasonal activities, especially those operated by farmers. Maximization of profits through intensification of operations may not be a priority for some entrepreneurs, particularly for women who often have multiple social and economic responsibilities;

- **Access to technical resources**: Entrepreneurs have varying degrees of access to tools, skills, equipment, maintenance and repair facilities, power supply, training facilities, and information on products, processes, and techniques;

- **Access to other resources** such as cash, credit, labor, raw materials, markets, and transport;

- **Relative prices of factors of production and products**; and

- **Other factors such as government policies and local customs, practices, and beliefs.**

As an example, a manual press was developed to replace the arduous traditional process for processing shea nut butter, a major cooking fat in semi-arid parts of West Africa. This manual press is appropriate for service processing in small rural villages, where the supply of shea nuts is limited and small groups of women are involved in this activity. For another context in Mali, a motorized system was developed for shea butter extraction suited for a commercial enterprise in a larger village (Hyman in press).

TECHNOLOGY INNOVATION AND DISSEMINATION

Some important issues in technology innovation and dissemination include the sources of innovation, access to information on technologies, lack of technical expertise, business risks, linkages between users and manufacturers, the role of intermediaries, and the commodity sector approach.

Sources of Innovation

Incremental innovations in the microenterprise sector in developing countries often occur at the local level in response to entrepreneur's perceptions of local needs and conditions. However, indigenous inventors generally do not have the financial and technical resources needed to withstand the risks of new product development. This lack of resources inhibits the development and dissemination of local innovations and the identification or adaptation of technologies developed in other regions.

Access to Information on Technologies

The inadequate flow of information among developing countries is a critical constraint to the upgrading of technology by microenterprises. Microenterprises may be unaware of developments in other locations. For example, a low-cost treadle pump for small-scale irrigation can fill an important niche between use of a bucket and a motorized pump. The treadle pump was manufactured locally by microenterprises in Bangladesh and has been successfully disseminated to over 200,000 users since 1980. Yet this pump is unknown in most parts of Africa, Latin America, and many other parts of Asia.

Lack of Technical Expertise

The transfer of technologies to diverse locations often requires adaptation to local conditions and skills. For example, animal-traction plow implements made by local blacksmiths need to be adapted to the type of draft animal, local soil conditions, climate, and available materials (Carruthers 1985). Such

adaptation often requires technical skills not commonly found among microentrepreneurs. Universities, government agencies, and nongovernmental organizations (NGOs) can play an important role in overcoming these constraints if they can effectively reach microenterprises at the grassroots level.

The introduction of a new technology can have a dramatic effect on labor allocation, prices, and the demand for inputs. An innovation can break through one constraint only to bring another to the surface that could render the innovation useless. For example, small-scale irrigation equipment may allow a farmer to increase vegetable production, but if the market cannot absorb the additional fresh produce, food preservation technologies such as dehydration become important. Similarly, steps may have to be taken to secure sufficient supplies of inputs such as seeds and fertilizers to allow farmers to take full advantage of the increased potential offered by the irrigation equipment.

Business Risks Associated with New Products

Low-income innovators face substantial difficulties in successfully commercializing a new product, particularly given the low profit margins of most microentrepreneurs. To recoup the costs of research and development, entrepreneurs may need to sell an innovation in large volumes, which can be difficult in thin and fragmented markets. Moreover, if the product is cheap and easy to manufacture, competition is likely to be high and profit margins low. The manufacturing of new products in developing countries is often risky due to characteristics of the market, such as the low purchasing power of consumers, the risk-averse nature of low-income people, the need to adapt innovations to local circumstances, and an uncertain demand affecting the ability to recover the costs of developing the innovation and generate profits.

Manufacturers will not be interested in producing a new product unless they are convinced that a sufficiently profitable market exists. Introducing a new product to the market can be difficult, risky, and expensive. Efforts by governments and NGOs to promote new products have often failed because of insufficient attention to the needs of manufacturers. In particular, attempts to keep the prices of products artificially low may reduce incentives for commercial production.

Microentrepreneurs need to be convinced of the relative costs, benefits, and reliability of a new technology. The process of convincing low-income producers or consumers to adopt new technology can be slow, although they are usually willing to accept innovations since they have been shown to meet microentreprenuers' needs.

Cultural preferences are vital to the adoption of a new product. Users should be included in design, extension, and promotional efforts so that the most appropriate technologies can be selected. For example, efforts to disseminate more fuel-efficient stoves in India demonstrated that, unless women consumers have significant input in stove design, new technologies will not be adopted.

Some producers face different constraints than others in purchasing and using a new technology. For example, the ability of women to maintain control of the income generated is an important influence on their willingness to adopt an innovation. If development projects affecting activities that are traditionally the responsibility of women are geared toward technologies more likely to be used by men, women may withdraw their labor, causing the project to fail.

Linkages Between Users and Manufacturers

Communication linkages between users and manufacturers is critical in ensuring that technologies are designed to meet the needs of the users. In some cases, reliance on informal sector manufacturers can promote spontaneous linkages. Large- and medium-scale enterprises can play an important role in the development of a healthy microenterprise sector. Many microenterprises are service-oriented operations such as grain milling or oilseed processing. The equipment used by these microenterprises is often produced by larger manufacturers. In addition, microenterprises can be providers of intermediate goods for larger enterprises.

The Role of Intermediaries

A variety of institutions can help overcome the constraints of manufacturers and user enterprises in adopting, operating, and maintaining new technologies. This can be done through extension services, demonstration, training, follow-up technical assistance, and credit for purchasing technologies or new products. Constraints can also be overcome by facilitating linkages between users and manufacturers. Without support and follow-up, users can become frustrated by problems that could have been easily solved by an external agent and this frustration can make further dissemination of the technology difficult.

The development of new products and processes for microenterprises deserves increased support from governments, research institutes, and development organizations that can work closely with manufacturers and users. This is especially true in the following areas: identification of the needs and opportunities for technological interventions in close collaboration with the producers themselves, identification of innovations developed locally and those developed in other countries, adaptation of innovations to local circumstances, market testing, and product promotion.

The Commodity Sector Approach

Development projects have often been compartmentalized by sponsoring agencies with little concern for the other requirements of a viable commodity system. A commodity sector approach would provide a better understanding of the growth and dynamics of microenterprises. This approach focuses on a particular set of goods that are important to low-income people and examines interrelationships among raw material suppliers, primary producers, processing firms, the distribution system, and markets. A site-specific needs assessment by an interdisciplinary team is a good way to select commodity sectors that offer the best prospects for significant gains for the intended beneficiaries. Special attention should be paid to the resources and constraints facing small-scale producers and processors.

A commodity sector approach makes it possible to design technological interventions that are more likely to have a significant impact than provision of credit alone (Rhyne 1988). This analysis can point out strategic locations where a technological change at any level in the system might have a significant impact on microenterprises so that more effective interventions in production and distribution systems can be made at several levels within that commodity sector. The commodity sector approach can also be used as a vehicle for demonstration or replication of several technologies at different levels in the sector.

The commodity sector approach also offers good opportunities for reaching women. Often, economic activities within a sector are characterized by a division of responsibilities by gender. Careful

choice of technologies along the chain from primary production through processing and marketing can help ensure that women and other disadvantaged groups will be active participants. The approach also reveals strategic intervention points at which an investment to upgrade production technologies could strengthen the competitiveness of women entrepreneurs within a subsector, or enable them to cooperate with complementary firms that serve high-return markets.

WHAT TECHNOLOGICAL ASSISTANCE TO MICROENTERPRISES CAN ACHIEVE

Technology limits production by microenterprises in many sectors. Entrepreneurs often know that markets exist, but do not know how they can produce goods to meet these markets. Technological assistance can remove these barriers to entry by allowing local manufacturing of a product that previously had to be produced in large cities or overseas, raising production quality to serve a different market niche, and increasing output to levels required to serve new markets.

Microenterprises often depend on an insecure supply or distribution system that is controlled by a small number of firms. Poor communities may suffer when their sole source of essential products is a large producer serving many markets, especially if they are located in remote areas. New technologies can make microenterprises more secure and poor communities more self-reliant.

For growth or increased competitiveness in a sector, an improvement in production technology is often essential. The examples outlined below show how technological change can help micro-enterprises increase productivity, improve product quality, increase local self-sufficiency, and develop local skills. These improvements can lead to further innovation and can make existing production more profitable, secure, and sustainable.

Faster Production

Technological change can reduce costs by allowing more of a product to be made in a given amount of time. For example, carpenters can use rebate planes to make window frames more quickly and accurately than can be done with chisels. Few African carpenters possess this tool, yet they could make their own using available skills and tools (Moore 1986, 1987).

Use of a simple, hand-operated brick press and an improved kiln can produce a larger quantity of bricks that are also cheaper and more durable than those made through slop molding and firing in field clamp. However, the upgraded technology may lead to some labor displacement because it does not employ as many unskilled workers.

Where the traditional industry is declining due to foreign competition or substitution of other domestic products, productivity increases may be necessary just to preserve existing jobs. An example of this is in Costa Rica where the traditional process of making lime is being upgraded to increase the quantity and quality of production and reduce labor costs. It has become difficult to recruit labor for the arduous task of lime processing because of the proximity of the lime deposits to the capital, where alternative employment opportunities are available. The changes in technology have also reduced occupational health and safety problems from exposure to high temperatures and lime dust.

Labor Time Savings

In areas of labor surplus, small-scale, labor-intensive technologies can generate needed employment opportunities and consumption linkages that can benefit large numbers of micro-scale producers. Where there are labor shortages, capital investments can be used to reduce labor constraints. For example, investments in labor-saving technologies can release women from the arduousness of household tasks such as food preparation and allow them to use scarce time for more productive activities.

Improved technologies can reduce the time required to make the same amount of product. This is very important for the many producers who only work part-time to supplement their incomes from agriculture. They may not wish to maximize their off-farm output, but to use the time served in other productive or leisure activities. For instance, the introduction of hydro-powered oil mills in Nepal as a replacement for manual expelling has greatly reduced extraction times for mustard seed oil by rural women. Similarly, more fuel-efficient cookstoves can release some of the time spent in gathering fuelwood and reduce negative environmental impacts.

Substitution of Cheaper Materials

Entrepreneurs can use new technology to reduce their costs of materials by substituting cheaper materials or making more efficient use of existing materials. For example, low-cost roofing tiles made of local materials are being made in many countries as a substitute for galvanized iron roofing sheets.

Increased Process Efficiency

Raw material costs can be reduced by increasing the process efficiency in the enterprise, or they can be offset by the selection of technologies that yield valuable byproducts. For instance, improved presses for edible oil extraction in Africa can yield more product per unit input than the traditional manual process. The machines also produce a byproduct — oilseed cake that can be used for animal feeds or fuel.

Reduced Fuel Costs

Fuel is often a major component of production costs for micro-producers, and many of them depend on biomass fuels. Significant savings are possible by increasing the efficiency of energy use in micro-scale industries. Conservation of more valuable energy resources can be achieved through combustion of waste products such as bagasse, wood chips, or crop residues. Wood or charcoal fuel costs can make some enterprises economically marginal and environmentally destructive (Hyman in press b). One example where higher capital costs are accepted in return for low energy costs is micro-hydro power, which is being used for cassava milling in Zaire.

Other technologies offer savings in both capital and operating costs over conventional alternatives and can operate when traditional alternatives are ineffective or relatively unproductive. For example, total installed costs for an animal traction mill for sorghum and millet in Senegal would be $1,100, compared with $4,500 for a domestically produced diesel-powered hammermill. Use of animal traction could also save $1,300 per year in fuel and repair costs of the diesel alternative, if both were operated at a high

capacity use rate. Although the animal traction mill has only half the capacity of the diesel mill, it could be more profitable in small or poor villages (Hyman 1989a).

Reduced Working Capital Requirements

Technological assistance can improve the organization and management of production lines, decrease waste rates, and reduce working capital requirements, which are a major constraint on expansion for small producers. Thus, blanket producers in Peru have reduced production time from 23 days to 14 days by adding a pedal spinner and manual carder to their system. The same amount of wool is still required per blanket, but by selling the product nine days earlier, they reduce loan interest costs and the capital required to maintain raw materials supplies.

Reduced Fixed Capital Requirements

Appropriate technologies can reduce fixed capital requirements through the selection of cheaper equipment, tools, or processes. For example, diesel-powered grain mills that are locally made are being purchased now in Senegal instead of more expensive, imported equipment.

Improved Product Quality

A change in production technology can increase the quality of products so that microenterprises can compete better with large-scale industry and imports. It can also open up new, higher value markets for their products. Using improved reeling technology, small-scale silk enterprises in India can produce a more valuable higher grade of cottage basin yarn.

Better-quality lime commands a much higher price than low-grade agricultural lime produced in traditional kilns. Improved lime-processing techniques have been demonstrated in Costa Rica. Improving the quality of the lime could boost the demand because the domestic product would become suitable for other nonagricultural uses such as construction, sugar milling, and leather tanning, which previously had to rely on imported lime because of the poor quality of the domestic supplies (Lola 1988).

Many of the colorants and essential oils used by communities in rainforest environments can be produced for export sale. In Peru, Amazon communities now produce calendula (a pigment derived from a flower) and other products at or above the state marketing standards.

Improved Product Consistency and Reliability

Technological assistance can make the products of microenterprises more consistent and reliable. Rural blacksmiths cannot easily obtain hard steels for tool production, but a process of hardening and tempering allows them to make tougher, more durable tools from the mild steels that are readily available. In Malawi, trained blacksmiths now make hardened and tempered tea-pruning knives that smallholder farmers can purchase in place of imported ones. The introduction of jigs and templates can improve the consistency of fabrication of metal products.

Better Packaging Technology for Bulk Markets

Poor-quality packaging often limits the market that microentrepreneurs can serve. The development of small-scale paper pulp packaging technology in Zambia gave egg producers the means to expand output and serve a wider market. Colorful bags and labels used for confectionery products and snack foods in Asia can raise the status of these products and help them compete in markets served by large enterprises and imports.

Greater Self-Sufficiency in Supply of Raw Materials

Simple wheel-making jigs enable African cart manufacturers in Africa to produce wheels from a wide range of metal sections. This frees them from dependence on automobile scrapyards and from competition with auto repair shops. In addition, the jigs enable them to custom design wheels to fit the available sizes of tires. This avoids complex and time-consuming welding to adjust wheels to tire sizes and consumers obtain better fitted, more easily serviceable carts.

Increased Marketing Independence

Farmers frequently lose potential income from their crops because of the need to market them soon after the harvest to avoid spoilage. By establishing their own enterprises for drying or processing, farmers can stabilize their products, giving them more time and a stronger bargaining position with distributors.

Another way to improve the marketing position of microenterprises is through better organizational channels. For instance, women coir workers in Sri Lanka share information on marketing arrangements to enable them to resist pressures from middlemen to sell at relatively lower prices.

Development of Skills and Fostering of Innovation

By improving basic production skills through technological training, microenterprises can develop a greater capacity for further innovation. Not only do artisans who learn to make their own tools improve their established products, but they become able to expand into new product lines. Assistance in acquiring technologies can enable poor producers to move into new product markets with higher returns. This is often the case for women whose traditional skills in garment making, horticulture, food processing, and handicrafts usually yield low incomes.

Training in machinery repair and maintenance can increase output and allow producers to ensure regular supplies of their products, as required by larger buyers. Producers with toolmaking and repair skills can develop new tools and machinery. The experience of the South India Federation of Fishworkers Societies has shown the benefits that can ensue from stronger local communication and organization. These artisanal fishermen have developed new boat designs and construction enterprises to cope with hardwood scarcity and artificial reef designs to restore marine environments damaged by large-scale trawling. This group developed its own outboard motor repair service to reduce dependence on motor suppliers. They now use their new skills to produce a diesel engine more suited to off-shore fishing.

Creation of New Possibilities for Local Manufacturing

Cooking oil is a scarce commodity in many rural communities in Africa. Oil produced by large-scale urban manufacturers is expensive and often is not well distributed to rural areas. Yet the oilseeds used in making the product come from rural areas and a range of production technologies appropriate for rural microenterprises involved in oil extraction are available. Small-scale oilseed presses allow farmers to process their own sunflower seeds in Tanzania, and palm fruits in Cameroon, instead of selling to marketing boards or large processors (Hyman 1990a, 1990b). Annatto, a food colorant derived from the seeds of the tree Bixa orellana, is being processed closer to its rural sources. This reduces loss of the pigment in transport and enables the value added to be captured locally instead of in the capital city (Hyman 1990b).

Electricity can often be produced competitively by small, decentralized power stations. Water mill owners in Nepal sell electricity to many households in areas that the national electricity authority cannot serve.

Increased Output to Open Up Bulk Markets

Mechanized peanut butter production in Zimbabwe gives rural producers the opportunity to sell to large retail outlets, which were unwilling to establish purchase and distribution arrangements at the previous low levels of output. Another example is the association formed by carpenters in Malawi to improve their production facilities and increase production so that they can compete for government tenders. This association has built a workshop, obtained electricity, and won a government order for bulk supply of school furniture.

Greater Effectiveness of Financial Assistance

Some firms are oversaturated with credit that they cannot use effectively because of lack of access to information on alternative technologies. Technological assistance can help microenterprises use credit more effectively by enabling them to identify new production or marketing opportunities. When technical assistance is available, credit institutions may be more willing to provide loans to microenterprises. Formal credit, when available, is often tied to specific uses, mainly fixed capital, and with inflexible repayment schedules. Microenterprises need frequent small loans for working capital, which are usually not available from formal financial institutions. Much of the credit available for this purpose is from informal sources at high interest costs, and only a limited amount can be obtained through special development programs. Technological assistance may provide an alternative by reducing requirements for working capital, hence ending the cycle of perpetual debt.

HOW TO PROVIDE TECHNOLOGICAL ASSISTANCE TO MICROENTERPRISES

Access to appropriate equipment and technical assistance is essential for successful formation or transformation of manufacturing and processing enterprises, even though this boosts the costs over programs that provide credit alone. Without organized assistance to provide other missing ingredients, potential opportunities for microenterprises might not be exploited (Grindle, Mann, and Shipton 1987;

Bowman 1988). Strategies for technology promotion must recognize the differing needs of women and men as entrepreneurs and workers in microenterprises.

Many research institutions develop productive technologies and conduct laboratory and field tests. However, the next step of encouraging the commercial manufacturing and use of these technologies is often lacking. One reason for the lack of success of research and development institutions in this regard is the failure to involve microenterprises throughout the process of research and development and technology dissemination. The private sector is frequently unwilling to take the initial risk of investing in adaptation or acquisition of a technology before its benefits have been well demonstrated. One way to bridge this gap is through demonstration projects by the public sector or development assistance organizations. Yet the public sector in developing countries rarely gets involved in commercialization of new technologies appropriate for micro-scale industries. NGOs and producer associations can have an important role in providing assistance in technology transfer at the grassroots level.

The first step in efforts by government agencies, NGOs, and donors should be to work with the microenterprises in identifying their capacities and their constraints on increasing their productivity. Demonstration projects can be influential by stimulating the interest of producers, users, other donors, NGOs, and government; however, this does not happen automatically. Demonstration projects provide a way to obtain grassroots-level information on the local business environment and assess the impact of constraints imposed by government policies.

In developing demonstration projects, some of the factors to be considered are potential number of beneficiaries and the costs of reaching them; magnitude of income gains for low-income producers and processors; benefits from employment gains or time savings of unpaid labor of the poor; magnitude of consumer benefits; impact on sociocultural development; an emphasis on production rather than vending; sociocultural compatibility with skills, attitudes, and values; minimal policy constraints that would affect commercialization; the amount of new learning expected; and the degree of innovation and high-replication potential outside the project area, ideally in more than one country.

Project Design Issues

Even when technology dissemination projects involve interventions at only one or two points in a commodity sector, a systems approach should be taken in project identification and planning. Consideration needs to be given to raw material supply, product markets, backward and forward linkages, related policy issues, local benefits, and environmental quality.

Entrepreneurs obtain information on technologies from other producers, suppliers, and customers. In selecting the forms of technical assistance that are most likely to produce substantial long-term benefits to a particular group of producers, it is important to have an understanding of the commodity subsector and the resources and constraints of microenterprises.

An effective way to provide more complete assistance to enterprises in different socioeconomic categories is to link technological support with financing and business support programs. This does not mean that the same institution needs to provide all these forms of assistance. Indeed, it is often more effective to have several institutions specializing in the various functions, providing there is adequate coordination among them.

Strengthening Communication Channels

Technological assistance can strengthen communications channels to help transfer knowledge about technologies used in other countries. One way to take advantage of resources for technology dissemination is to encourage regional sharing of information and lessons learned through formal or informal networks. Also, helping to forge stronger links between micro-producers can increase access to information within developing countries. For technologies with good replication potential elsewhere, testing and adaptation might need to be done only in one location if the conditions of the testing sites are sufficiently representative of other places.

Many projects have focused on providing development assistance for a particular area. With area- or beneficiary-focused projects, there is typically an inadequate base of technologies and technical support to increase productivity in the wide variety of economic activities involved. The pitfalls of spreading resources too thinly across too many commodity sectors and having limited technical expertise can be avoided by concentrating on a selective range of related productive activities and technologies in a sector.

Training

The training of local manufacturers of equipment and tools suitable for small-scale production can have a significant impact on microenterprises using these products. This was the case in Nepal where a training course enabled local manufacturers to produce a wide range of turbines for different applications by microenterprises. It may be possible to introduce women to new enterprise opportunities through training so that they can expand their economic activities beyond traditional gender roles. However, as one case showed, a program to train women as carpenters will not succeed if the resistance of men excludes them from practicing this trade. Training can also increase two-way communication between microentrepreneurs and assistance agencies so that extension services, banks, NGOs, and government agencies can become more aware of the needs of microenterprises.

Where training on manufacturing and processing technologies is available in developing countries, it has mostly been designed to meet the needs of large- and medium-scale producers. Often the content of these courses is not relevant for microenterprises and the teaching techniques used are not effective for people with limited formal education. A learning-by-doing approach is generally best for micro-producers. Training methods developed in response to specific local producer interests and using producers as trainers wherever possible has proven far more effective. This kind of training may require innovative participatory methods.

Microentrepreneurs cannot afford to take much time off or travel far for long training courses. Short courses that provide specific skills in locations near their businesses are generally more useful. In some areas, microentrepreneurs may need training in literacy and numeracy before learning more specific skills. It may be necessary to provide child care services so that women entrepreneurs can attend training classes.

Much of the training in business management for microenterprises has been concerned with simple bookkeeping techniques. Other management skills such as the way to organize a production line, handle raw material inventories, and maintain quality control have not generally been addressed in training for microenterprises. Yet these skills are essential for effective production enterprises. In addition to technical training of microentrepreneurs and the manufacturers of the tools and equipment they use, training for business advisors of institutions such as NGOs, training institutes, and banks, to raise awareness of the

particular needs of micro-producers can enable them to provide relevant and effective support to the microenterprise sector.

Training is generally most useful when tailored to the immediate business needs of enterprises and delivered on a fee basis (McKean and Binnendijk 1988). Simple methods that build on locally available knowledge work best (USAID 1988). Since training is expensive and difficult to deliver, it is usually available only to a small proportion of firms (Ashe 1985; Harper 1988). More should be done to develop materials for trainers and assess the strategies and impacts of training programs. New approaches based on links between microenterprises and large firms or between microenterprises and their suppliers may be promising (Bigelow 1987).

Marketing Assistance

More attention should be paid to the problems that microenterprises face in marketing new products or locally produced items that compete with imported substitutes. Successful production depends on convincing customers of the value, reliability, and acceptability of the new product over the traditional or large industry alternatives. Marketing assistance can help create new linkages to broaden marketing options among producers or between providers and distributors through tenders, subcontracts, cooperative arrangements, or trade associations.

Products manufactured by microenterprises in developing countries often have problems of poor market image because consumers are frequently skeptical about the quality of the local products compared to imports. Governments can help establish the credibility of local products by making purchases early on, as the Government of Kenya did by ordering fiber-concrete tiles for the Homa Rock public housing project. Government purchases of local products can be of greater and more lasting value to producers than cash subsidies. Another way to reduce the risk of new products is through pilot or demonstration projects supporting manufacturers, users of intermediate goods, or consumers. In this way, assistance agencies share the risks and help to establish the credibility of local producers.

Policy and Regulatory Support

Both the survival and growth of microenterprises are strongly affected by the macroeconomic policies and regulations of governments and practices of financial institutions. In many cases, import duties, taxes, credit regulations, differential foreign exchange rates, and price controls cause distortions in the economy that favor large-scale industries over microenterprises and capital-intensive production methods over more appropriate technologies (Haggblade, Liedholm, and Mead 1986).

Some donor policy reforms could increase the use of new technologies by microenterprises. These reforms include substituting sectoral aid for project aid, supporting smaller projects and enterprises, implementing projects through NGOs, eliminating tied aid, obtaining technical assistance and equipment from other developing countries, financing recurrent costs and local currency costs rather than just capital and foreign exchange costs, and supporting more research and development for appropriate technologies.

Assistance agencies can use the experience from improving microenterprise production quality and reliability to lobby governments and regulatory bodies to create a more positive environment for the growth of small-scale production. Assistance agencies can also make efforts toward bringing micro-producers and technical advisers into contact with government agencies and larger industries so

that policies will be more likely to take the interests of microenterprises into account. In a notable case, the growth of the micro-hydro industry in Nepal has been accelerated by close collaboration between the National Electricity Authority, the Agricultural Development Bank, and the small firms that design and install the equipment and civil works. The National Electricity Authority changed its regulations to allow private power generation in units with capacity of less than 100 kilowatts. The Agricultural Development Bank opened a special loan window for rural electrification projects.

It may be necessary for microentrepreneurs to organize for policy reforms to be achieved. By helping to forge stronger links among producers, an international organization enabled a group of artisanal fishermen in Kerala, India, to lobby successfully for new legislation to regulate the exploitation of near-shore fishing resources.

CONCLUSIONS

Technology upgrading is often essential in achieving a sustainable productivity increase in businesses, rather than just shifting employment and income from one producer or seller to another. Rural entrepreneurs may be unaware of the existence or availability of the most appropriate technologies. When new technologies have not yet been commercialized in a particular area, little information may be available on their costs and benefits.

Technology projects for microenterprises can be most effective and will have the fewest unintended, negative impacts when low-income people can own and operate profitable enterprises that match their skills and resources. These projects may be designed to increase their access to goods and services, raw materials, financing, technical information, and markets. This strategy also increases the participation of the poor in the development decisions that affect them. Such opportunities are neglected by commercial sources of capital because they are relatively risky, small-scale, and may not be located in the largest cities.

In disseminating technologies to microenterprises, it is important to adopt a needs-oriented approach that emphasizes working directly with the producers, building on their own resources and skills. Without organized assistance to share the risk and provide critical missing ingredients such as technology extension services or finance, potential opportunities in this sector will not be exploited.

A variety of strategies are available for providing assistance to microenterprises so that they can successfully adopt improved technologies: working with microenterprises to identify potential areas for changes in the technology they are using, identification of technologies used by microenterprises in other areas, research and development and technology adaptation for local conditions, analysis of commercial viability, demonstration and market testing, training of microentrepreneurs, training the manufacturers of tools/equipment used by microentrepreneurs, upgrading the capacity of training institutions, production of manuals and/or drawings for users/manufacturers, marketing assessment and product promotion, lobbying for policy and regulatory reform, coordination with credit institutions, and strengthening those institutions providing microenterprise support.

The recent trend toward the provision of credit alone in microenterprise programs does not necessary help overcome technological bottlenecks. Credit may allow only a marginal increase in the size or profitability of an existing business if technologies are unchanged, unless the enterprise is primarily for vending rather than production. The Grameen Bank, one of the most cited examples of minimalist

credit, now includes marketing and technical assistance to enable client firms to grow (Hossain 1988, Yunus 1989).

A "needs-oriented approach" to technical assistance begins with identification of the main constraints facing entrepreneurs. In particular cases, these problems may be limited access to fixed capital for plant, equipment, and machines; lack of working capital for raw materials; too few clients or irregular sales; competition from large or small enterprises and imports; absence of legal status that results in harassment by the authorities; and lack of land tenure rights. Government policies and the socio-economic environment have a significant effect on the success of micro-enterprise assistance programs and the potential for widespread dissemination of new technologies for these firms.

A common cause of failures in technology assistance is lack of compatibility with the economic, social, or natural environment. Such failures can frequently be avoided if a thorough assessment of the likely impacts is done before project design. Field testing of the technology before widespread replication can lead to important design modifications for technologies. Although external assistance in the development or adaptation of technologies and in early promotional efforts is often necessary, technologies with a large replication potential may eventually spread on their own if the market and policy incentives are satisfactory. Ex post analysis of impacts and documentation of the lessons learned from successful and unsuccessful cases can provide critical information for decisions about replication of the technology in other areas.

APPENDIX

CASE STUDIES

MICRO-HYDRO POWER IN NEPAL

The vertical axis waterwheel has been used in Nepal for centuries in Nepal for grinding grain. An estimated 20,000 such mills are in use today. During the 1930s, diesel mills began appearing in rural communities, initially near towns and alongside rural roads. From the 1970s on, loans on favorable terms from the Agricultural Development Bank of Nepal (ADBN) allowed installation of diesel mills in more remote locations. Several thousand diesel mills are now in operation. These milling enterprises provide both grain hulling and milling services as well as crushing of mustard seed for oil, which was traditionally done by hand laboriously. Diesel engines have the disadvantages that they can only drive one end-use at a time, they require regular and reliable supplies of fuel, and they are complex to maintain and repair.

In view of the enormous hydro-power potential in Nepal, the development and introduction of alternative hydro-powered mills was initiated during the late 1960s and early 1970s. The United Missions to Nepal (UMN), a private voluntary organization, and Balaju Yantra Shala (BYS), established as a joint venture between the Nepali and Swiss Governments, were the two key institutions engaged in the development of the now widespread cross-flow turbines.

At about the same time, the private sector in the form of Kathmandu Metal Industries developed the Multi-Purpose Power Unit (MPPU), a lower cost hydro-powered milling unit. This unit has a much lower capital cost, $2,000 per installation (compared with over $4,000 for a more powerful cross-flow turbine) and it is also simpler to manufacture. The disadvantages of the MPPU are its low power output (4 hp) and the need for frequent repairs. The MPPU was quickly adopted by a significant number of mills, many with financial assistance from UNICEF.

The first commercial cross-flow turbine installations were completed in the late 1970s. It soon became clear that without credit the dissemination of the technology would be severely limited. Following an evaluation of the UMN and BYS cross-flow installations, the ADBN ended its loan scheme for diesel mills and switched to hydro-mills. Since 1977, the ADBN has provided loans for over 600 hydro-mills. The vast majority of these are used only for agro-processing, but 114 of them are also being used to generate electricity and over 20 are used for saw-milling or other productive activities. Most are operated as privately owned small enterprises.

The number of micro-hydro installations funded by ADBN increased rapidly from 4 in 1977 to over 80 in 1985. As a result, the need for technological assistance from UMN and external agencies such as ITDG, the program's emphasis changed from development of the turbine equipment to assistance to manufacturers, the design of complete installations, and end uses. The deregulation of electricity generation (up to 100 kW) in 1984 increased the demand for technical support on the electrical side, particularly for control systems and end uses. More recently, this has included the training of manufacturers and introduction of another type of turbine, the Pelton wheel.

The widespread dissemination of improved micro-hydro installations has been made possible by the provision of credit from the ADBN. Although bolstered since 1988 with subsidies from the Government of Nepal, the implementation of the individual schemes has been undertaken by indigenous private manufacturing enterprises. About a dozen small enterprises are now engaged in the design, manufacturing, and installation of micro-hydro units.

The micro-hydro technology has helped the rural population of Nepal by reducing the labor time and arduousness of women's work in rice hulling and mustard seed crushing. The many small entrepreneurs who have invested in mills have on the whole earned good financial returns, while providing valuable services to rural communities. Where electrification has occurred, rural people have been able to gain social benefits.

The development and dissemination of improved micro-hydro power technologies in Nepal illustrates several important issues in technology transfer to micro-enterprises. First, dissemination did not occur until the ADBN and the government recognized the value of the technology and changed their policies. The policy change did not occur until several years after work on cross-flow turbines had been initiated, which illustrates the time scale that is often necessary before significant impacts can be achieved. Dissemination was only made possible by the capability developed in small engineering enterprises, through technical assistance, to supply, install, and maintain the equipment. Micro-entrepreneurs who invest in the technology can earn good profits, while generating benefits for the consumers of the milling services.

PALM OIL EXPELLERS IN CENTRAL AND WEST AFRICA

In Central and West Africa, the traditional process of palm oil extraction by foot stomping is laborious and yields a low percentage of the oil contained in the fruit. By upgrading the traditional technology through simple pressing equipment, rural incomes can be increased in micro-enterprises, 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 West and Central Africa. However, most artisanal-scale commercial producers of palm oil in Cameroon have access to an old Colin press, a horizontal expeller. Small farmers who do not have their own presses can purchase pressing services from others in exchange for an in-kind payment, usually of one-fifth of the oil extracted. In addition, the client provides the labor for a manual press or the fuel cost for a motorized press.

The Colin expeller was imported to Cameroon between the 1930s and 1973. Most are now over 30 years old and many were in disrepair, leading to poor productivity and frequent downtime. The French company stopped routine manufacturing of artisanal-scale presses and replacement parts are no longer available. 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 ATI, an NGO in Cameroon, APICA, began a project to recondition 75 existing Colin expellers and produce auxiliary equipment such as cooking drums, bunch strippers, and clarifiers.

The original design of the project had to be modified in implementation. First, only 12 used Colin expellers were available for purchase at a reasonable price since even though many expellers had the wrong parts and maintenance difficulties resulted in downtime, they were still usable much of the time. Second, it took up to 10 months to obtain imported replacement parts to recondition. Third, because of the high cost of repairs in small batches, the price of a reconditioned unit 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 competition adversely affected the prices received by artisanal producers.

As a result, ATI and APICA decided that it would be cheaper and faster to manufacture a new press. A simpler, less expensive version with fewer imported components was designed, the horizontal Caltech. In 1990, excluding the 10% sale tax, the manual horizontal Caltech cost $3,920, the gasoline-powered version cost $6,590, and an electric one cost $6,080. Later, a much less expensive vertical axis Caltech was developed, which does not need the imported gear reducer. The vertical Caltech, which can only be operated manually, cost $1,450.

After the reorientation, the project exceeded its targets for production and sales. Financing played an important role in encouraging sales. By mid-1990, the workshop had sold 72 Caltech expellers in addition to the 12 reconditioned Colins. However, the idea of group enterprises proved unpopular because the area with the largest market is dominated by the individualistic Bassa tribe. Considerable interest in individually owned oil pressing enterprises exists there because farmers 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 in this area.

The horizontal Caltech is a modification of an accepted technology that is well-proven in Cameroon. The modifications make it more appropriate for a micro-enterprise to use and allow local manufacture. The manual and motorized versions of the horizontal Caltech have been working well. The vertical Caltech has a much larger potential market due to its lower cost. 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 alternatively, the feasibility of using animal power. This has not been a problem in Cameroon where there is little tradition of animal power because of the tsetse fly (Hyman 1990a).

ATI has developed a regional palm oil extraction project based in Zaire that builds on the experience in Cameroon. ATI is assisting in the transfer of this technology to Zaire by working with a local NGO, FOCIDI. The following strategy is being used: preparation of a manual containing engineering drawings and a description of the steps in manufacturing the press; working with local manufacturers to produce the Caltech presses; preparation of a simple guide book for training farmers in how to use and maintain the press; and implementation of a program to publicize the press, including demonstrations of its use

The project will also carry out field research on alternative technologies and examine related issues in the commodity subsector, such as agricultural extension, clarification of oil, and use of byproducts. In addition, ATI is providing support to enable the NGO in Zaire to provide technical assistance to organizations in other countries, including assessing small-scale palm oil extraction technologies in use; identifying individuals and organizations interested in this subsector; setting up field demonstrations to compare alternative technologies and to document their economic and technical performance; providing hands-on training in Zaire for potential manufacturers and NGOs in other countries interested in promoting the technology; and establishment of an international network of organizations in small-scale extraction of palm oil, including publication of a newsletter. This approach of relying on a core project in one location and providing information and training support elsewhere is a cost-effective way to facilitate the spread of a technology from one country to another.

CHARCOAL STOVES IN KENYA

The traditional charcoal stove in Kenya is produced by informal sector metal artisans. A more fuel-efficient design has been developed, which requires the collaboration of the metal artisans and ceramics enterprises. The upgrading of this traditional technology allowed the producers to increase their profits while benefiting consumers.

An average household in Nairobi using a traditional jiko and having a single wage earner may spend one-fifth to one-quarter of its cash income on charcoal. Practically all of the charcoal stoves ("jikos") in use in Kenya before 1980 were of the traditional, all-metal design, introduced in the early 1900s by Indian laborers. It took about 50 years for this stove to replace the three-stone stove through market forces. This uninsulated stove radiates heat to the air as well as the cooking pot.

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. USAID supported the development of the improved charcoal stove from 1981 to 1985. The project was implemented by Energy/Development International and the Ministry of Energy. The liner stove designs have evolved a great deal since 1982.

The current type, the bell-bottom jiko, was developed in 1983-1984. The one-piece ceramic liner has a perforated floor which serves as a grate. The cladding is narrowest in the middle like a waist. An insulating layer of cement/vermiculite binds the liner to the cladding and covers the bottom of the ash box. Because the liner only extend halfway down the height, this stove is more portable because it weighs less; is cheaper to produce; and has a smaller firebox, reducing charcoal waste due to overloading.

As of 1989, over 250,000 of the improved jikos had been produced. Liner fabrication is the limiting factor in production. Over 15 enterprises were making liners in early 1985; however, most of the liners have been made by 3-4 medium-scale enterprises in the Nairobi area. Metal claddings for the bell-bottom jiko are made by about 100 informal sector micro-enterprises. The project provided training to artisans, trainers and managers, and some demonstrations for consumers, but little direct production assistance. Since the technology is affordable and benefits can be captured by consumers, consumer subsidies were not needed.

Once competition was established among producers, the improved stove cost about $4.00, compared to $2.50 for the traditional stove. However, the traditional stove only lasts one year and requires replacement grates every three months. The bell-bottom stove lasts for 2 years, but may need a replacement liner after one year. The fuel efficiency in lab tests was approximately 21% for the traditional stove and 34% for the improved stove (Hyman 1986).

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 properly trained or were trying to cut corners in construction. A change was made in the production technology to resolve the quality control problems and increase productivity. An ATI engineer designed a simple motorized jigger jolley for molding liners, which was introduced in mid-1986. Hand-formed liners have a higher cracking rate, about 30%, because too much air is left inside the clay, compared to a cracking rate of 5% for liners molded by the jolley. It takes 10 minutes to mold a liner completely by hand, compared to 1-2 minutes on the jolley.

Charcoal use has more serious environmental impacts than fuelwood use because it takes twice as much wood to obtain a given amount of energy from charcoal than from burning wood directly. Also whole, live trees are often felled for charcoal conversion, while fuelwood is usually taken from twigs and fallen branches. Thus, policies should not encourage existing users of fuelwood to switch to charcoal consumption, even with an improved stove. 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 and electricity is even more expensive.

Broader lessons about how to disseminate a new technology can also be gleaned from the Kenyan experience. Improvements in the technology were made by adapting the traditional technology and incorporate features from the technology in another developing country. After laboratory testing, field tests were conducted to obtain feedback from potential users. Then, further sorting out of the technologies was left to the market. Users were not expected to make any major changes in the way they used the stove. Yet the improved stove has a readily observable difference in shape so that consumers could recognize it easily.

The active efforts of international organizations, the government, local NGOs, and private sector artisans and distributors spread the improved stove technology faster than the original rate of dissemination of the original jiko. Many stove projects elsewhere have not taken off because the private sector was not given a leading role. Informal sector micro-enterprises can be subcontracted by larger firms to 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 (Hyman 1987a).

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