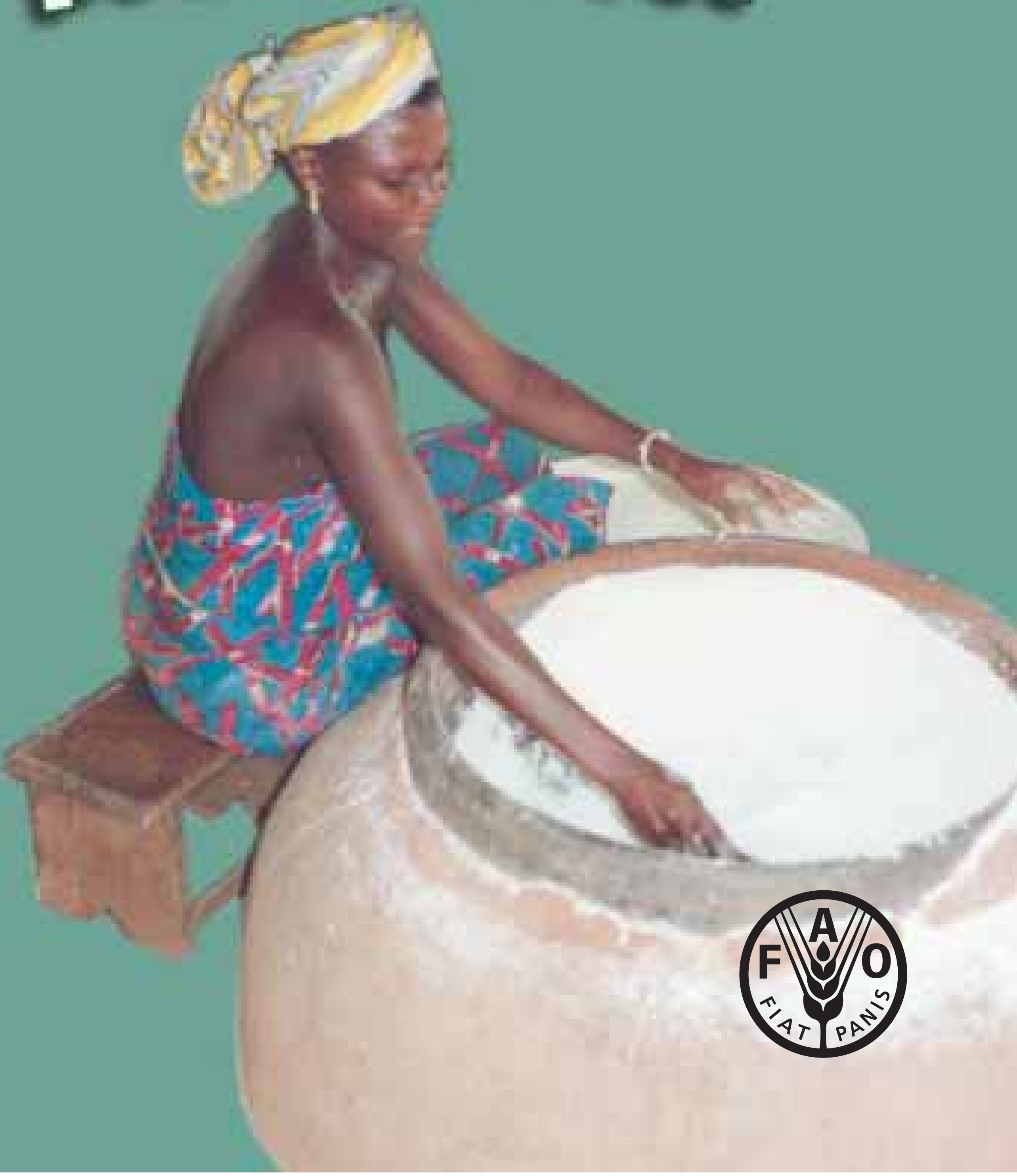
High hopes for post-harvest



FAO Diversification booklet 4

Diversification booklet 4

A new look at village-scale crop processing

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Preface

FAO Diversification booklets aim to raise awareness and provide information about opportunities at the farm and local community level to increase small-scale farmer income. Each booklet will focus on a specific farm or non-farm enterprise or technology that experience has shown can be integrated successfully into small farms or at a local community level. We explore the potential benefits associated with new activities and technologies, as well as appropriateness and viability in differing circumstances.

The main target audience for FAO Diversification booklets are people and organizations that provide advisory, business and technical support services to resource-poor small-scale farmers and local communities in low- and middle-income countries. We hope to provide enough information to help these support service providers consider new income-generating opportunities, and how they might enable small-scale farmers to take action. What are farmer requirements and constraints? What are critical "success factors"?

FAO Diversification booklets are also targeted to policy level people in government and non-governmental organizations. What actions might policy-makers take to create enabling environments for small-scale farmers to diversify into new income-generating activities?

It is important to point out that the Diversification booklets are not intended to be technical "how to do it" guidelines. In order to provide farmer advisory and support activities relating to introduction of new income-generating activities, most organizations will find it necessary to seek more information or technical support. For these organizations, each booklet identifies complementary sources of information and technical support.

If you find this booklet of value we would like to hear from you. Tell your

colleagues and friends about it. If you have any suggestions where we can make changes for the better in our next edition, or topics for other booklets – this is equally important. By sharing your views and ideas with us we can eventually provide better services to you.

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Foreword

Most of humankind's earliest tools – jars for storing grain or wine, grinding stones for making flour from cereals, threshing tools, winnowers and shellers – were designed to assist in processing and storing food. The nineteenth century saw great progress in the development of machines for processing and storage, which led to better hygiene and nutrition. In the twentieth century, vast improvements in materials and production skills and increased knowledge of crops should have meant there was little that could not be achieved in the effort to plant, harvest, process and store all the crops necessary for healthy, varied diets for most of the world's population. Unfortunately, the reality of the situation is very different: many people in the world live well below an acceptable level of nutrition, and many more face starvation.

This booklet presents an approach to improving the efficiency and productivity of crop processing at village level in developing countries. Village processing can lead to improved food security, greater prosperity and enhanced quality of life for the villagers. It requires improved tools and machines on a scale larger than that required for the immediate family.

Similar undertakings in the past were often too large or too optimistic. That is why this booklet highlights some of the requirements and dangers of developing a village enterprise and includes steps to secure funding and create simple business plans that offer a good chance of early repayment of loans. Village processing should not make abrupt changes to lifestyles or cultures; it should gradually eliminate some of the more inefficient practices and so improve the overall standard of living for all those affected by change. This may be sufficient to generate household incomes that will enable children to go to school and provide local people with more food. Simple machines can make it possible to grow a wider range of crops, including those that would be difficult to process manually.

These proposed village operations are best suited for products that need to be processed in large volume. They often need cooperation or input by several farmers or perhaps an entire village. Individual family operations, on the other hand, are often limited to traditional techniques that rely on manual operation. Finished food

FIGURE 1 Gari production at a village in Benin.

products for retail are often successfully produced using traditional techniques.

To be able to help, communities, planners and policy-makers need to know the potential for any crops that may be grown in identified areas. In the long term, infrastructures may need to be developed to take advantage of world market demand for suitable crops. Account has to be taken of prevailing socio-economic factors and local customs and culture. An adequate support system will reduce the risk of failure for a farmer who must often rely on guidance from a local

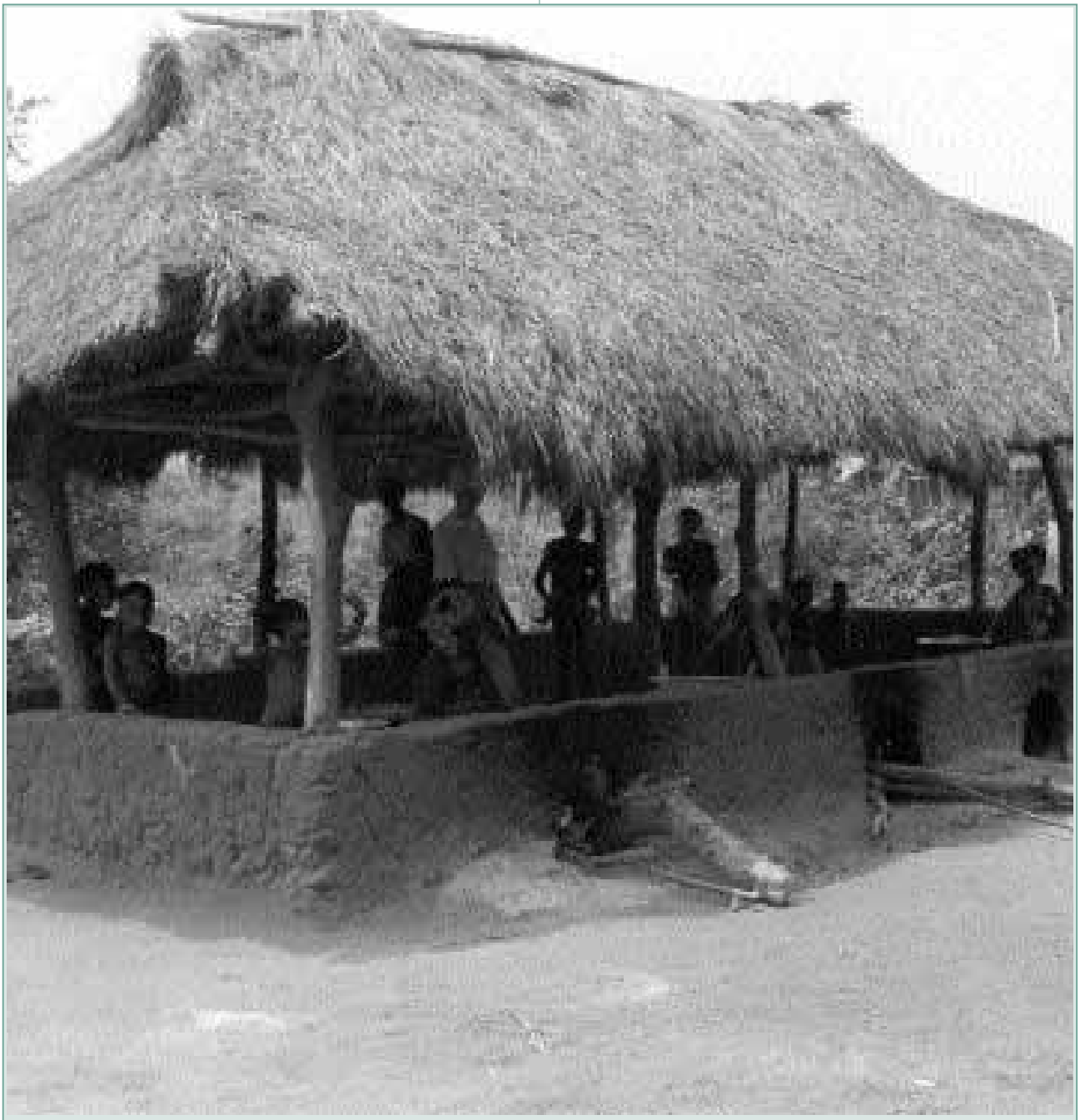

FIGURE 2 A simple covered building for gari production in Benin, adequate for keeping the rain off.

shopkeeper who is only looking for a quick sale. By identifying the criteria for successful village processing, it becomes possible to extend those good practices and their benefits to villages anywhere in the world.

Processing at village level, even in developing countries, has been practised for many years and certainly for the past 150 years, as settlers from industrialized societies took their skills, tools and machines with them as they moved into agrarian societies. Local manufacturing has developed in countries of Africa, Asia and Latin America only in the last 50 years. Little progress had been made in those countries to utilize wind, water or steam power, despite widespread use in industrial countries. In modern times, with the introduction of the diesel engine and the electric motor, a wide range of processing machines can be found in most countries, but for various reasons they still are not available to a vast number of people who could benefit enormously. Many people are trapped in poverty because they lack the knowledge, opportunity, capital or outlets to process and sell their produce.

Community members must decide together whether they want to take on the added responsibilities necessary to develop into a more prosperous, secure society. A village's primary resource is its crops; adding value to the crops makes it possible to generate funds. This first step could lead to changes in centuries-old techniques and traditions, setting up systems for better food production, income generation and vastly improved quality of life. Villagers must take a hard look ahead. They must decide how they want their communities to develop and look at the possibilities for producing viable goods that will help them to achieve their aims.

Some basic facts about village processing

As much as 50 percent of food is lost between harvest and consumption, often because of poor storage facilities that allow moisture, fungus, rodents and insects to take their toll. Improved storage and early processing such as drying can greatly reduce these losses. The increased food supplies can then be sold, or the land can be used for an alternative cash or food crop. Much of the labour involved in food production and processing is done by women and children, labour that brings few rewards when losses are high. Finding ways to improve production decreases labour demands, saves food and time and can help to improve family living conditions and cultural development. Children can focus more on education and play, instead of having to take on family responsibilities at an early age.

All crops differ physically and biologically, and so require specialized processing. Cassava, for example, deteriorates within a few days after harvest unless it is dried or made into gari. Yams are a similar crop, but can last much longer in a fresh state. A chipper, which is a simple processing machine, can help to expose cassava for rapid, easy drying in the sun.

Oil is highly valued throughout the world for cooking and as a source of energy and flavour. Manual or motor-driven machines are well suited to extract it: manually operated bridge presses for groundnuts and ram presses for sunflower and copra extract higher-quality oils with less effort and a higher percentage of oil extraction. Where they are used, these machines are very popular because they save effort and increase production and because the availability of oil improves diets and leads to improved health. There are many villages, however, with no knowledge of these machines or no opportunity to use them.

It is often wealthier farmers with the ability to raise purchase capital who can own and manage these machines. They become even wealthier if other farmers pay to use their machines. They can then buy other machines and process other crops, which puts them in very powerful positions. But if a group such as a farmers' organization or cooperative invests in a machine, the standard of living of the entire group can be improved; lenders may be more willing to make a loan if a group of farmers is sharing responsibility for repayment. For those

without land or other resources, machinery can mean new opportunities for employment. This will in turn discourage people from migrating to larger towns or cities in search of employment and provide greater security to the entire rural community.

Training can often be made available through local extension services. As the community is strengthened, management skills, machinery workshops, dealerships and communication networks can be introduced as appropriate. As the village becomes more secure, schools, medical facilities and other services can follow. In order to begin the process, however, a wide range of factors needs to be checked, because shortfalls in any one of these could lead to failure.

This booklet shows that if certain methods are followed, it is not too difficult to establish a viable business that operates efficiently and enjoys reasonable stability. National institutions favour small- and medium-scale enterprises for good reason: they have the potential to improve the overall prosperity of the country, eventually improving the balance of payments, increasing export potential and improving food security for the growing urban populations.

Loan and aid schemes can support the introduction of small-scale technology into poor areas, which often operate under traditional barter economies and where cash crops have not been available. The schemes exist in the tropics and in temperate climates in countries where agricultural patterns are changing, partly as a result of political changes. In such countries, there is often a growing need to become self-sufficient in food and to attain a higher level of internal security and economic prosperity.

The water pump and the grain mill are the two machines that usually offer the greatest benefit to a village. In many villages, women spend up to two hours every day grinding food, usually grain, using a traditional method such as a quern consisting of two circular stones. In Africa, an estimated 50 percent of all villages still pound grain in hollowed out logs or tree stumps. Imagine the time and effort that could be saved with a mechanized operation.

Before seeking funding and advice to initiate a mechanized operation, however, a wide range of factors must be considered. The first is the market for the produce. This might simply be the local community, or there may be commercial markets to consider if the village is within reasonable travelling distance of a town by bus or collection truck. If a farmer needs to grind 2 kg of grain each day for home use, and the smallest machine is capable of grinding 80 kg per day, the farmer would be able to process enough

grain for 39 other families. In order to take advantage of this spare capacity, many machines are operated as a business with a manager or entrepreneur employed on a full or part-time basis. Because a machine may cost up to US$3 000 and the means must be found to pay for it, the business must be linked to a cash economy at some stage. Machines can be paid for with grain or flour, but a system has to be put in place to organize this. When a machine is simply given as a form of aid, it does not foster independence as it would when there is some form of organized payback system.

Socio-economic factors must be considered too. When women use machines, they save as much as two hours of work each day. They might miss the social aspects of being together to pound their grain, although the time could be spent in further processing. In the case of cassava, for example, there is the incentive of adding value to the product by making the fermented and roasted product known as gari or farina, rather than the raw roots. Most crops lend themselves to further treatment or processing, leading to a higher and more consistent quality and fewer losses.

Benefits of using appropriate processing technologies for creating sustainable livelihoods

There are three common scales or levels of processing: domestic, village and factory. Before looking at village-scale processing, it is worth considering some of the limitations of domestic and factory-scale processing.

Domestic processing is limited to small-scale production and can be of variable quality. It is suitable for the immediate family with a little extra capacity for local market or roadside sales. Because domestic processing cannot take advantage of powered machinery, except where an electrical supply is available, it cannot have much influence on the community.

Factory processing and production has the potential to transform a society from mainly subsistence farmers to factory labourers. The community as a whole often does not share the profits, however, and the traditional lifestyle is lost. The labourers must spend the money they earn on food and clothing and housing is often poor. The attractions of the factory approach are that large amounts of food can be produced and processed and the national economy can be improved by sales on the world market of such products as coffee and cocoa. If factories are too big or not well planned, massive investments may be lost and local lifestyles, cultures and traditions can be badly and often irretrievably affected.

Village processing is the alternative approach. At village level, the addition of machines for production offers many advantages:

- reduced post-harvest losses;
- food supplies throughout the year;
- opportunities to produce a cash crop;
- possibilities of growing and processing alternative crops;
- added value to crops before sale;
- less tedious processing tasks;
- increased leisure or opportunity time;
- reduced danger in some processes.

With production at village level, local communities can be made more prosperous without substantially changing their cultures.

Machines reduce the danger as well as the tedium of processing tasks, often providing much higher quality products. Rice is easily husked by machine, while a hand-operated tool requires very hard work and often results in high losses be-

cause of the number of broken grains. Without powered machines or tools, it probably would not be worth growing rice in many areas. The same is true for such crops as coffee, cashew and tea. Cleaning crops with a sieve is another difficult process to carry out by hand, whereas a cheap mass-produced sieve that is either shaken by hand or driven gives a precisely sized product every time.

There are many situations where post-harvest losses can be reduced. A properly dried and stored product such as grain in a steel silo can last for years with little deterioration, whereas a damp, exposed heap of grain will usually deteriorate within a few days. Machines that save time and produce extra food for those who use them can also provide the opportunity to grow cash crops.

Choices and the factors that influence them

There are many areas in the world where there are no machines but very real needs. This booklet addresses those situations where there is still ample scope for village development.

Business choices

In setting up any business, it is first necessary to establish the potential for the sale or use of the product. Although a major advantage of a processing business is avoiding the drudgery of daily tasks such as shelling, grinding or cleaning, there is no way to pay for machinery if the produce is only for personal consumption. That is why it is important to be aware of following alternative ownership scenarios and outlets.

Owner

The owner or owners may be:

- a single farmer in a village;
- a group of farmers in the same village;
- a manager or entrepreneur;
- an outside investor.

Sales/outlets for products

These may be:

- the inhabitants of a village;
- the inhabitants of other villages;
- the inhabitants of nearby towns and cities;
- transport entrepreneurs;
- national merchants.

A simple business plan must be made, even if it is not on paper. The security of the business for several years is essential. If a machine has to be paid for within a certain period, then the markets for the produce plus the likely profits must be clearly identified. Market research sounds complicated, but it is essential to determine potential sales of the products and to be aware of any factors that may influence these projections. Discussions with other farmers, neighbours or tribal elders can raise awareness of the plans and objectives of other farmers or groups in the area. This is a way to avoid being in competition rather than cooperation with others, so that profit margins do not suffer as each tries to remain profitable.

If only one person in the community owns a machine, it places others at a disadvantage. Their unprocessed produce may not be able to compete with processed goods and may remain unsold. Other villages may suffer in the same way, and suddenly a whole area may actually be destabilized

rather than secured. It is better to share the risks and benefits rather than focus on a single farmer. One way of achieving success is to include as many people as possible in the decision to invest in machinery and share the risks. This leads to a wider sense of ownership and responsibility and, with luck, to a larger customer base. Investigation may show that the markets are wider than anticipated and that local townships may be in need of particular kinds of food, especially with the growth of urbanization. Knowing this in advance means that a bigger machine could be bought, leading to more efficient operation and more opportunities for employment in the business. This may often need outside help from non-governmental organizations (NGOs), donor agencies or local government officers. Once sufficient development has taken place, roads, telephones, electrical power supplies, improved water supplies, drains and agricultural supply facilities can become part of the overall plan for the area.

Funding for new technology may come from a variety of sources. Aid agencies have funded numerous ventures in the past. Banks have always been ready to make safe loans, but often at high interest rates that increase the risk to the farmer. Government loan schemes may be safer, but they are not always easy to obtain. Dealers will often be prepared to set up a scheme, but their interests are purely commercial, so the buyer's best interest is not always served. Inappropriate machines are often sold in this way. Farmers without education or training who live in an unstable environment are not good risks for loans. Even when they can pay in cash from their savings, they must identify a reliable dealer who will give them the best advice. Local extension services can be very useful in making farmers aware of issues such as competition, availability of loans, recommended dealers in the area and technical advice.

Commercial development can stimulate the local economy. Large companies may select an area as suitable for growing a particular crop such as coconut or groundnut and make advances to the local community with a view to buying the primary processed product. They may even be prepared to provide the initial investment for village processing machinery. Commercial crops are often grown on a larger scale, but certain crops lend themselves to local production. The presence of a large investor can help significantly in the provision of machinery, high quality seeds, fertilizer, growing information and market opportunities. The success of such developments depends on the degree of the community's dependence on the investor. Each party

has to protect its own interests, which can create difficulties. It is usually better for the community to retain its independence without being restricted to a single crop. Quality standards have to be maintained: for example, farmers who process their maize on their farms may spoil it with low-quality processing, while processing by a central store or trader may result in a higher-quality product. Traditional crops should still be grown and processed, so that lives are changed as little as possible. Introducing new crops and processing facilities, however, increases the chances of greater employment, greater security and sustainable futures.

Machinery choices

Even if the choice of machine seems straightforward, it is still necessary to gather as much information as possible. It is preferable to see machines in operation elsewhere and discuss them with the owners. Dealers may have a range of types and sizes to offer and should be able to give guidance, but extension officers and current owners will probably be able to give the best advice. The money available and the potential of the machine will obviously be major influences.

Machines should ideally last at least ten years; some might give good service for more than 20 years, while others will have shorter lives for a variety of reasons. Regular maintenance is a key factor, requiring the availability of spare parts and repair skills. Many processing machines are like the proverbial axe: it will last forever as long as new heads and handles are available and the cost is not prohibitive. A reliable supply of raw materials and fuel is needed to keep the machines working and retain people's trust in the system. As soon as confidence wanes, the business will be under threat, especially if there are alternatives.

Crop choices

Research and consultation into all alternatives should be conducted before deciding on a new cash crop. Processing staple foods does not require as much information, except in the choice of machine. Crop choice should be decided right from the start, based on full discussions to determine local needs and preferences. It can take time to introduce new crops and foods. Maize and cassava, for example, were not grown in Africa until relatively recently, yet now they are well established staples.

Hybrid varieties of sunflower have high oil yields and will grow in most parts of the tropics. New varieties of cassava and maize are being developed for improved disease resistance, flavour and yield. Although oil from groundnuts, seeds or fruitlets can be readily extracted by machine and usu-

ally finds a ready market, it is traditionally a slow, tedious process, which makes the oil relatively expensive.

Communities are often undernourished. As part of their development, new crops may be suggested that will diversify their diets, along with the machinery to process them.

Many enterprises fail because the supply of raw crops fails. Failure may result from a bad harvest caused by diseases or adverse weather conditions, or because alternative markets for produce are opened. Studying the experience and history of a locality can help to give a reasonable guarantee of material supply. Confidence in supply is greater if farmers buy machines to process their own crops and if their crops are sufficient. If not, other sources of crops for their machines to process should be investigated before launching into new enterprises. The prior agreement of the village as a whole to support or use the new technology adds greatly to the security of any business.

Energy and power choices

If a farmer or group does not want to invest in motor power, or there is no infrastructure to support it, energy can be supplied by water, wind, animals, the sun or hands and feet.

Water power, once widely used in developed countries, is only an option where there is a suitable water supply; mountainous countries are often well supplied with water. Designs are available for a range of high- and low-speed machines powered by turbines or waterwheels. If there is a reliable supply of water, it should be the first option considered, because water can provide high power at high speed if it is available at sufficient height and quantity. Minimum water requirements for small slow-moving waterwheels are about 0.5m^3 per minute at a height of 3 m. A medium-sized pair of grinding stones 0.6 m in diameter will use about 0.5 kW.

Wind power has been used successfully in many countries. The windmill is a typical example of a grain-grinding machine. Winds are often unreliable and light in the tropics, however. Unless a region – perhaps an island – is known to have a reliable source of wind power, it is rarely a viable option for driving processing machinery.

Animal power is a choice in communities where animals are traditionally used for work. Donkeys, buffaloes, camels and oxen can all be used for processing crops; the machines have to be designed to suit the animal. The power is clearly provided at very slow speeds of about 1 rev/min, but at relatively high torque. Threshing, oil extraction and grinding are suited to animal power, provided the machine is designed to

FIGURE 3 Solar drying rice in Sri Lanka.

run in this way. In contrast, a machine driven by a motor has an input speed of at least 500 rev/min.

Solar power is abundant in the tropics and should be utilized where possible for drying operations. Rain protection, simple solar collectors and aids to air flow can transform a risky, inefficient process into a reliable and efficient operation with little investment. Cassava, yams, spices, fruits and vegetables can all be preserved with solar dryers and stored for seasons of food shortage. Ventilated polythene covers on an A-frame can make a simple, inexpensive drier. More sophisticated types are available.

Biomass is a by-product of such crops as oil palm, rice, maize and sugar cane and can be used as a fuel for drying if it is available in sufficient quantities. Careful planning is required, however, to make sure that the system is sustainable and reliable. There is, for example, sufficient energy available in rice husk to drive a complete rice process plant if the means is provided to convert the energy into rotary power. Biomass has been used in the past to drive steam engines, but this is an unusual option these days.

Methane is a product of wet waste organic material. It is the natural gas that is produced in enclosed containers and makes an excellent fuel for diesel and petrol engines. By-products from fruit and vegetable processing plants and any other green trimmings can be used for methane production, as discussed later.

Hand or foot power can be used for a wide range of machines and tools that are available for small-scale processing. In the earliest stages of development, especially in remote regions, it is often wisest to start with manual or animal-driven machines; in peri-urban areas, electric or motor-driven machines are often more appropriate.

Diesel and petrol engines can range from 3 kW up to about 25 kW for village-scale operations. Diesel engines are more reliable than petrol engines. They cost more initially but are cheaper to run. Many diesel engines in developing countries have run for decades. Diesel engines are often used to drive generators, which, supply power to electric motors, lights and office equipment. A manual worker can sustain an output of about 75 W for some time, but a diesel engine can produce its power rating, say 3 kW, continuously. This gives up to 40 times the output and saves the expense of the worker's wages. Engines do not require breaks or holidays, but they do require a substantial cash investment and a reliable supply of fuel.

Training in the care and maintenance of engines is essential. The first choice of motor and fuel would usually be diesel, provided diesel fuel is readily available. This fuel is also suited to tractors and many transport vehicles. If the enterprise has access to electricity, however, this would be the immediate choice because it is cheaper and simpler and more reliable in every way to operate. Electric motors are quiet, easy to start and cleaner; they produce no fumes and are available in a wide range of sizes. The main object of this booklet, however, is to address the needs of regions where there is no electricity.

FIGURE 4 Hammer mill in the Congo driven by a diesel engine.

Some factors that affect choices

It is impossible in this small booklet to cover in depth all the issues that can influence the choice of crops, machinery and power. The following are the more important issues:

- potential local and regional markets for products;
- prospects for growth in the market;
- availability of a reliable and appropriate energy or fuel supply;
- crops that grow reliably in the area;
- availability of machines and maintenance;
- availability of cash from savings or loans;
- awareness of who will be affected by the introduction of a new machine;
- opportunities for cooperation with other potential buyers;
- understanding of the current labour situation;
- appraisal of personal preferences and wishes.

How to do it: equipment and methods for village operation

Grain storage

It is important to choose a watertight, rat-proof, insect-free container in which crops can be stored for at least nine months. Galvanized steel makes very good silos, but it usually needs to be imported, which requires significant investment. The resulting savings may permit rapid repayment, however, if surplus grain can be sold. Surpluses thereafter are for profit. Most societies have devised some method of storage, but rats and other pests often cause significant losses. In India, losses are estimated at up to 50 percent. Such figures are hard to substantiate, but the author has seen complete stores with every grain lost. The benefits of good storage are overwhelming. Even the use of improved, locally made stores with rat guards made from chicken wire plastered with mud or, preferably, cement would be a major improvement in preserving crops.

Small stores can be made from used 200-litre oil drums. They can be especially useful for storing sufficient seed grain for sowing the following year. A tight-fitting lid keeps out water and insects. Other stores can be made entirely from local materials. Sun-baked mud over pliable sticks woven to make a grain store can be very effective and can be made to a wide variety of local designs. Some are better than others, however, and sharing knowledge of the best techniques pays good dividends.

FIGURE 5 An improved grain-storage silo made from local materials in Malawi.

Oil extraction

In recent years, major advances have

FIGURE 6 A Bielenberg lever press extracting oil from hybrid sunflower seeds in Zimbabwe.

FIGURE 7 Traditional kneading of oil-palm fruitlets after steaming to make oil to be used in a village in Benin.

been made in extracting oil from the fruitlets of groundnuts, sunflowers and palms. The traditional ways of processing these crops – pounding, roasting or kneading – are tedious and inefficient. The Bielenberg lever press, designed to operate manually and replace many of these operations, offers an alternative. With it, one operator can produce 2-3 litres of oil per hour from sunflower, copra, sesame and several other types of oilseed. Significantly, this machine is manufactured in developing countries and has proved successful in East Africa and other regions. On a slightly larger village scale, a group of farmers might be able to afford, supply and

FIGURE 8 Traditional washing out of the oil after kneading.

FIGURE 9 Larger-scale palm oil extraction in Benin at fruitlet selection stage.

FIGURE 10 Larger-scale palm oil extraction in Benin using a screw press.

operate a motorized screw press with the same crops, yielding 15 litres per hour with very little manual labour. With careful filtration, there is even the possibility of using the oil that has been pressed to run the diesel engine. Palm oil is traditionally produced by boiling, kneading and washing. Steaming and pressing in a manual screw press is a simpler alternative. Many such machines are available and made in rural workshops in many parts of the wet tropics. Ground nuts are probably processed best with a bridge press after the nuts have been coarsely ground, wetted and roasted. It is a simple machine that produces up to 3 litres of oil per hour.

Rice milling

Rice, the staple of Asia, can be stored unmilled until it is required for eating. At that point, a rice mill can remove the hard husk and polish the kernel. This system makes it possible to keep the mill working throughout the year, as long as stocks of unmilled rice remain. Traditional rice processing does not really compete with machine milling, so mill owners will not disturb the local labour balance, although eating habits may be affected. Different types of rice mills are available. National preferences may dic-

FIGURE 11 Parboiling rice in concrete tanks in Sri Lanka.

tate whether an under-runner disc, a rubber-roll or an Engelberg mill would be the best. This often depends on the ability to share existing knowledge and experience, and the knowledge that support can be obtained quickly if trouble arises. The under-runner disc mill is very popular on the Indian subcontinent, for example, but virtually unheard of in Africa; there is, however, some pressure to adopt the rubber-roll mill, which produces fewer broken grains. If there were no such preferences or constraints, the author would suggest the Engelberg as the best village-scale mill. It is relatively inexpensive, robust and readily repaired. It has few moving parts to wear out and provides an acceptable quality of rice. The skills to operate and maintain this machine can be learned quickly. On the other hand, only the small domestic machines are manually operated; others are driven by diesel motor, which may be too much for some villages. Because a new engine and mill cost about US$3 000, a large sum of money to a subsistence farmer, careful planning is needed.

Farmers have in general been the most likely people to buy rice mills. They have the raw, unmilled rice, can see the added value that comes from

FIGURE 12 Rubber–roll rice mill in Liberia.

milling the grain and can easily install the equipment on their farms. They can set up a small building and may have access to labour or a family member to operate the mill. They may transfer some of their existing tasks in order to concentrate on the milling, which requires skill in operation and management. Most farmers would wish to keep an item representing such considerable investment under their personal control.

Eventually, facilities for parboiling, drying, cleaning or polishing the milled rice can be linked to the enterprise and will add value to the finished product. At this level, the rice can be sold directly into the retail market; unmilled rice is mainly bought by traders.

Maize milling

The maize mill for producing fine flour has been probably the most widely accepted processing machine in Africa because of its obvious advantages over pounding or scrubbing stones. Grain mills can be hand-operated, but can easily be readily motorized, saving a good deal of physical effort. The most efficient manual systems are the plate mill or stone quern, but these are still laborious methods yielding about 5 kg of coarse flour

FIGURE 13 Locally made plate mill in Nigeria, used for wet and dry products.

per hour or 1 kg of fine flour. The smallest hammer mill with a 3 kW diesel engine will produce about 150 kg of similar coarse flour per hour or 50 kg of fine flour. The savings in labour are dramatic. The meal is ground through a sieve of fixed size, so the quality is always the same; manually prepared flour can be quite variable. The main choice of machine is between the plate mill and the hammer mill. The hammer mill is the more popular of the two and can be supplied in larger sizes if required; an inexpensive, locally made version is often available with easily fitted spare parts, although certain parts have to be imported. The plate mill is usually only available up to about 7 kW. The whole machine is usually imported, and even the spare parts are difficult to make. The choice of mill often comes down to availability and local preferences. The plate mill can grind both wet and dry products; the hammer mill is confined to dry products. Both machines are capable of grinding a wide range of materials, which may be a means of widening the scope of a business.

Crop cleaners

Crops can be cleaned more easily by machine than by hand. Perforated-plate or wire-mesh sieves cannot be constructed locally, but they are imported fairly inexpensively and are designed to give a guaranteed product size. Nuts, seeds, grains, coffee, spices and various types of chipped or extruded foods are suited to cleaning by mechanical sieving machines. Many models incorporate a winnowing fan that cleans light material such as chaff or dust from the product by air blast during the sieving process. The output of even the smallest 3 kW motorized cleaner is about 5 tonnes per hour.

Cassava processing equipment

Cassava processing lends itself to mechanization for several products,

such as dried chips, starch and *gari*. *Gari* is a popular food in West Africa and in South America, where it is known as *farinha de mandioca.* Chips are made by a chipping machine, which usually consists of a large, vertical wheel with coarse serrations or blades on the surface against which the cassava root is held in order to cut off suitably sized pieces ready for drying. This is a simple machine, often locally made, which can be operated by hand, pedal or motor.

Machines are also made for *gari* production. The crop is washed, peeled, grated, fermented, pressed to remove water, roasted, sieved and packaged. A range of simple tools and equipment can multiply output considerably. Soil particles are washed off in concrete tanks with running water. The roots are still cleaned by hand, even at quite large factory scale. Attention should always be paid to good seating, correct worktable heights and ensuring regular supply and removal of the peeled roots.

The knife used to peel the roots should be sharp and of medium length with a good handle, sturdy enough to withstand the constant twisting necessary to lever off the thick peel. The peeled roots can be washed again, in order to remove any soiling from peeling, although this is not always done. The peeled roots can be grated, using one of a range of techniques that yield a good-quality mash. These include the common motor-driven hammer mill, locally made drum graters or even manual graters. The resulting mash is left to ferment for three to five days in non-corroding containers such as polypropylene sacks, fibreglass drums, wooden boxes or stainless steel tanks; the choice affects the investment cost significantly, although the final product is not so different.

FIGURE 14 Locally made cassava grater in Nigeria.

The mash is then pressed to remove the water. At village level, this can be done inexpensively with a

FIGURE 15 Large, flatbed gari-making machine in village production in Nigeria.

simple lever system of ropes and wooden beams, or with a more elegant screw or hydraulic press. The latter are usually based on lorry jacks and are therefore readily available and cheap to buy. The cassava mash that comes from the pressing stage is in the form of a cake, which has about 50 percent moisture content and needs to be broken up. Screens, sticks or simple scrapers can be used to do this before it is placed in a roasting pan for preparing and drying the *gari*. In this process, the starch gelatinizes into a hard, dry powder, which can be stored for up to a year.

Roasting can be done in a small bowl or pan for domestic use, but larger bowls are easily managed. At village scale, large flat pans 2-3 m long can be mounted on concrete blocks over a fire, which creates a large, easily managed *gari* processor. The drying can be done in the same large pan by raking the powder to a cooler part of the pan. These large flat pans can be used to produce up to 500 kg of *gari* per day.

Cashew shellers

A cashew nut crop is high in value and lends itself to village-scale operation, although there are some constraints in processing rates. In India, most of the manual processing market is controlled. The skill and speed of the Indian processors and the low cost of labour make it a difficult market to break into; some nuts grown in Africa are exported raw to India for shelling. Cashew nuts are thick-shelled and contain a rather nasty, sticky liquid that is itself of some value. There are small manual tools for decorticating the nuts. After roasting in the shell liquid, the nuts can be cracked open. Small mallets are commonly used and can be operated at the rate of about 10 nuts per minute. About 75 percent of the nuts will remain whole, which makes them more valuable than the broken nuts. In addition to the mallet method, tools

have been developed that feed the nuts into a chain system, where they are clamped and a specially designed knife cuts and twists the shell off the kernel; other options exist but are not yet commercially available. Cashew nuts offer the opportunity to introduce a valuable cash crop at village level with very little investment. The supply of raw cashew nuts can be somewhat unreliable, which would not affect a village greatly, but a bad crop could spell the end of a factory that depends on sophisticated automatic equipment and must pay a regular labour force.

Supporting technologies required for village processing

Some supporting features should be in place before a new technology is adopted. Adequate supply of raw material, for example, is essential and probably represents the most frequent source of failure of village enterprises. These features and technologies are listed below and then discussed individually:

- machinery sales office or dealership;
- rural machine-repair shops;
- training and skills acquisition;
- structures;
- water;
- packaging materials;
- marketing;
- transport;
- disposal of waste.

Machinery sales office or dealership

Many machinery companies have only one office in a country, and it may be difficult for a potential buyer to make a trip there or even to find it. Buyers are often not clear about what they require in the way of a machine.

FIGURE 16 Rural workshop in Nigeria making cassava graters.

It is up to the company to market its machines properly, to set up public demonstrations and field days and publish posters. A buyer who has a local sales office is fortunate indeed, because advice, training and maintenance support can be given.

Rural machine-repair shops

Most machines need maintenance at regular intervals, which can be provided most easily by local machine shops. If the dealer who sold the machine is nearby, maintenance can be provided from that source. Spare parts will inevitably be needed. Maintenance needs can range from a simple weld to a new screen for a hammer mill or a rotor for a rice mill. Many components have to be imported, such as belts, bearings, chains and engine parts. Owners can make simple replacements, but ordering of parts and machining activities are the responsibility of the shop. Easy access to this facility is very useful though not essential and may only be needed once a year. These shops tend to grow up where they are needed.

Training and skills acquisition

Training is vital for the success of village enterprises. An owner or manager has to have a basic understanding of the business aspects as well as the technical implications. These are not natural skills, and they can be difficult to learn. Advice on such aspects as bookkeeping, future planning and payback periods is necessary to build a secure business with a good chance of success. The extension service in most countries is well positioned to provide these services.

Practical techniques and skills are more easily learned. Sales offices should be able to offer all the advice that is needed. Maintenance schedules, likely running costs and all other implications should be made very clear. Advice can also come from aid agencies, missionaries and governments.

Structures

Many small enterprises need at least a roof, if not a fully enclosed building. Most engines, for example, are designed to operate under cover. Tropical storms can cause damage, so engines should be mounted firmly and level on a concrete base. The roof can be made from local materials and should protect both operator and machine. Hand-operated equipment can of course be used wherever it is convenient; a special place for storage is all that is required. Dryers, threshers, cookers and roasters are often set up with a roof but without walls, allowing fumes and smoke to escape and letting the process continue even if there is rain. Rice mills, hammer mills and oil extractors are usually

FIGURE 17 Galvanized-steel building for village hammer mill in Kenya.

kept in locked buildings because of the need to protect valuable items such as bowls, sacks, tools, spare parts, raw material and finished products. Materials used for the building depend on the locality. Concrete blocks are the best choice if they are available, but in some villages a wooden or mud structure with a roof of banana leaves or palm branches may be the best option. If no concrete is available, the machine should be provided with a steel-bed frame and levelled as accurately as possible.

Water

Many processes depend on potable water, especially those that entail washing root crops and fruit with field dirt on them. If a well is nearby, then this problem is solved and the location of the process may be determined by the location of the well. River water is not usually as clean as well water, and if either well or river water is dirty, some form of filtration is required. Normally, 1 m depth of sand with a grain size of 0.3-0.8 mm would provide an adequate filtration bed, but further calculations and tests would have to be made to ensure that sufficient water could be filtered. A small cassava washing plant, for example, may need up to $4m^3$ of water per day, which calls for $4m^2$ of sand bed with $4m^3$ of sand and a suitable

FIGURE 18 Locally made basket for taking produce to market in Thailand.

holding tank. The rate of filtration depends on the physical properties of the sand and its natural filtration rate. Tanks and elevated support structures would then need to be constructed, usually of galvanized steel or concrete. In some villages, this type of facility might need an engine-powered pump to provide the necessary water, as hand operation might be too laborious.

Packaging materials

Packaging materials depend on the market. Local markets use traditional packaging materials such as woven bags, baskets and wrapping leaves. For selling to larger markets, however, or to markets in towns and cities, there may be a need for factory-made cartons, bags or plastic trays. Wrapping material can be of help, whether natural leaves and twine or factory-made paper. Factory-made cartons also help in determining the package size. Consistency of price per unit of weight helps give a buyer confidence. A well marketed product should be packaged for protection and preservation, and well presented, so that it will command a higher price. Some people will always prefer the local market type of presentation, even in the largest cities, but with the growth of shops and supermarkets, standards have risen all over the world and good marketing usually pays off.

Produce can be sold through entrepreneurs who own vehicles to take goods to market and provide the appropriate sacks and boxes. They are in a good position to reclaim containers from nearby towns and re-use them. When a farmer sells a product in a container, it is difficult to reclaim it or it may be non-returnable. This reduces the quality of container that the farmer can afford to lose, and so prices have to be increased to cover the cost of packaging. Used containers such as bottles for oil, juice and other liquids, sacks for rice and flour and baskets and boxes for dried spices are quite acceptable.

FIGURE 19 Returnable crates used for packaging produce to take to market in Thailand.

The main problems of returnable containers are as follows.

- Who should own them?
- Is a deposit system workable?
- How can theft be prevented?
- How can a large number of bags or boxes be identified?

In the case of retail, the solution is often clear: buyers can either bring their own containers or set up a deposit system. A ready supply of second-hand or new containers can be a serious problem and needs to be addressed at an early stage.

Marketing

Any business depends on its markets. Unless there is an existing demand, the market has to be created by persuasion. If no market exists for pineapple juice, for example, customers have to be persuaded of its virtues. The easiest approach is to build from a small business with each investment in new machinery fully justified by demand. In this case, one should simply make sure that the market is not oversupplied, or the producer will have to find new markets, requiring expansion and travel to other towns or villages.

Most produce is traditionally sold at the nearest market. Larger urban areas also attract street vendors and provide an opportunity for sales to shops. Sales of processed goods are

most successful, however, if a regular outlet can be found. Information spreads quickly by word of mouth in most developing countries; if goods are satisfactory, there is less of a problem with marketing. A barter system may be necessary if a cash economy has not developed; goods may be exchanged in return for other goods or services. In some cases, customers bring their raw produce to a service machine and it is processed in return for a proportion of the goods. Maize or rice, for example, may be milled in return for 10 percent of the initial weight of the crop, and the milled product is returned in its original package. In some instances, customers receive their own crop back again; in others, they simply receive the appropriate weight of milled crop.

Marketing on a wider basis usually includes a packaging strategy. Cartons and bags may show the origin, weight and type of the contents. As a general principle, good packaging promotes the goods and provides enhanced protection and preservation. For sales in towns and cities this is a good approach, because the original processor is likely to lose contact with the final customer. If processors wish to build up a regular customer base, they must identify their produce clearly.

The first rule for a successful business is to know the market. The best product in the world will not sell if nobody knows about it. It is always easier to start a business with a product that is in demand. Once that part of the business is successful, other products can be launched on the back of a good reputation. A minimum level of business expertise is necessary for success, even at village level. At some stage, knowledge of office procedures, records, accounts and sales forecasting must be applied if the business is to grow. Other implications of a successful enterprise must be considered. If the introduction of a large new hammer mill, for example, puts all the other smaller millers out of business, it not a success for the village. It is important to know the potential for immediate sales in the village as well as for wider sales outside. This situation can often be helped by entrepreneurs who buy local produce with no intention of further processing: they will simply transport it to a bigger market for sale.

As a business grows, there is always the opportunity for widespread advertising through outlets such as radio, TV, roadside posters, portable exhibitions and field days. Extension services offer courses and help in these matters in most countries.

The start-up and growth of any business requires investment and risk. Success is not guaranteed, and worst-case scenarios must be considered before

taking the plunge. Thousands of small processing plants and businesses thrive in developing countries, however, and make significant contributions to the quality of village life. There is room for many thousands more.

Transport

As markets grow, products tend to travel farther and farther. Many farmers transport their produce to market by bus. They will either stay at the market until the produce is sold or go home and return the next day. This approach has severe limitations for perishable items but not for processed goods, which do not suffer the same losses that fresh fruits and vegetables with poor packaging suffer on poor roads. Taxis, transporters and middlemen of various sorts can all play vital roles. Local markets can act as gathering points where transporters will gather goods and take them by truck to main markets. In this case, the transporter may be prepared to travel more than 100 km, which would be out of the question for a small producer.

When farmers can justify buying their own vehicles, however humble and whether as sole owners or in a cooperative, it heralds an independence that is a new stage in

FIGURE 20 Horse used for transporting produce to market in the Philippines.

their development. This assumes the existence of roads that are passable for most of the year, although everyone will be aware of the danger periods. The need for transport has to come first, and the road will follow. Businesses tend to grow up along roads, so the presence of a road encourages further development; the initial stimulus, however, is often the availability of agricultural items from a productive area.

Bicycles are popular in many countries. Bags of produce can be strapped to a bicycle or loaded into its trailer, and distances about three times longer than with hand-carried loads can be covered. This extends the market considerably. Most countries have workshops that can service bicycles, so this is an attractive option, especially for low-volume processed goods such as spices.

For fully preserved items such as spices, dried fruit and possibly jams or high-valued items, animal transport may be satisfactory. Donkeys, oxen, camels and horses are all used to pull trailers or carry saddlebags, depending on the size of the load. Trailers can have spoked wheels for lighter loads or old motor-vehicle wheels for heavier loads up to 1 000 kg. Animals can cover distances up to 25 km, and in some cases will travel many days with a high-value commodity.

Disposal of waste

In developing countries, disposal of waste is not usually a high priority compared to obtaining sufficient food and earning sufficient income. Waste should, however, be turned into a by-product whenever possible. Almost all agricultural waste material can be used in some way: peel, cores and any green waste from a plant used for making juice, puree or pulp can usually be fed to animals or composted to be put back on the land; similarly, waste from cereal plants such as husk, bran or germ can be fed to animals. Rice husk is probably the most inedible grain residue, although chickens and goats do pick over it. There are occasionally special uses that can be made of waste, such as selling the liquid that exudes from the shells of cashew nuts. Even dirty washing water can often be re-used after filtration to wash down floors and then as irrigation water.

For drying processes, burning waste as fuel is a practical way of enhancing the value of materials that may require disposal. Excess combustible biomass can be used for fuel, as has been widely practised by large-scale sugar producers, who burn the cane residue known as *bagasse* to dry sugar after it has been washed from the cane. In the same way, small-scale sugar expellers amass piles of mangled cane that can be burnt to dry the

sugar. Rice husk can be used to dry parboiled rice and even to fuel the initial steaming. Residues from palm-oil presses can be used to sterilize the incoming bunches; sometimes the left-over nuts are burnt for sterilizing as well. Prunings, trimmings and old trees from plantations can all be used as a fuel for drying. In the early steam-powered oil mills, all these residues were used to heat the boiler of a steam engine that provided enough energy to drive the whole plant.

Residues can be used in other ways. Through the process of anaerobic digestion, most green organic matter will form methane gas if there is sufficient water available and the temperature is more than about 22 °C. This is a very useful means of disposal and re-use of any inedible green matter, which yields up to 0.4m^3 of gas for 1 kg of dry solids. The green waste is dumped into a tank filled with water to digest for up to three weeks. The resulting methane gas can be used for domestic cooking or even to power a diesel engine. The quantity needed to drive an engine may be too much for a small enterprise, but it shoud be possible to produce enough for domestic cooking. A small amount of equipment is needed, such as a tank with a sealing lid and some pipe work. Domestic waste is also digestible in this manner. In India alone, many thousands of small-scale digesters are used.

If methane production is impossible, any waste organic material can simply be kept in a special area and turned over with a rake or fork every few days. It will turn into compost that is useful as a soil additive and conditioner, returning nutrients to the fields. The heap should be kept in a loose but moist condition. Care should be taken to avoid creating permanent dumps for crop residues, because they can attract flies, create odours and breed disease.

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Intermediate Technology Development group (ITDG), Rugby, UK, available at: www.itdg.org

Central Food Technology Research Institute (CFTRI), Mysore, India, available at: cftri.com/unu

International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, available at: www.cgiar.org/iita

Australian Centre for International Agricultural Reseach (ACIAR), Fernhill Park, Bruce, ACT 2617, Australia, available at: www.aciar.gov.au/

International Centre for Tropical Agriculture (CIAT), AA 6713, Cali, Colombia, available at: www.cgiar.org/

International Rice Research Institute (IRRI), DAPO Box 7777, Metro Manila, Philippines, available at: cgiar.org/irri

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