

# Fruit products for profit

FAO Diversification booklet 16



Diversification booklet number 16

# **Fruit products for profit**

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Rural Infrastructure and Agro-Industries Division  
Food and Agriculture Organization of the United Nations  
Rome 2011

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ISBN 978-92-5-107069-7

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# Preface

The purpose of the FAO Diversification booklets is to raise awareness and provide decision support information about opportunities at farm and local community level to increase the incomes of small-scale farmers.

Each booklet focuses on a farm or non-farm enterprise that can be integrated into small farms to increase incomes and enhance livelihoods. The enterprises profiled in the FAO Diversification booklets selected are suitable for smallholder farmers in terms of resource requirements, additional costs, exposure to risk and complexity. The products or services generated by the enterprises are suitable for meeting demand on a growing, or already strong, local market and are not dependent on an export market. However in this particular booklet, export markets are also considered. This is because international trade in fruits can affect local markets and export markets can provide opportunities for some types of fruits grown by smallholders.

The main target audience for these 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. It is hoped that enough information is given to help these support service providers to consider new income-generating opportunities and how these might enable small-scale farmers to take action. What are the potential benefits? What are farmer requirements and constraints? What are critical ‘success factors’?

The FAO Diversification booklets are also targeted to policy-makers and programme managers 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?

The FAO Diversification booklets are not intended to be technical ‘how to do it’ guidelines. Readers will need to seek more information or technical support, so as to provide farmer advisory and support activities relating to the

introduction of new income-generating activities. To assist in this respect, each booklet identifies additional sources of information, technical support and website addresses.

A CD has been prepared with a full series of FAO Diversification booklets and relevant FAO technical guides, together with complementary guides on market research, financing, business planning, etc. Copies of the CD are available on request from FAO. FAO Diversification booklets can also be downloaded from the FAO Internet site.

If you find this booklet of value, we would like to hear from you. Tell your colleagues and friends about it. FAO would welcome suggestions about possible changes for enhancing our next edition or regarding relevant topics for other booklets. By sharing your views and ideas with us we can provide better services to you.

# Acknowledgements

Gratitude is owed to Doyle Baker, Senior Technical Officer, Rural Infrastructure and Agro-Industries Division, (AGS), FAO, who provided for a detailed technical review on the final draft version of this booklet. Special thanks also go to Paul Vantomme, Senior Forestry Officer, (FOEI), and Mr. H.A. Hilmi, former Senior Forestry Officer, for their detailed reviews and inputs to the various drafts of this booklet. Martin Hilmi, Small Enterprise Management and Marketing Consultant, (AGS), provided the section on *Feasibility of a fruit tree enterprise*.

## *Acknowledgements for the series*

Gratitude is owed to Doyle Baker, Senior Technical Officer, Rural Infrastructure and Agro-Industries Division (AGS), FAO, for his vision, encouragement and constant support in the development of the FAO Diversification booklet series. Martin Hilmi managed the development, production and post-production of the series and provided technical support and inputs. Michael Breece undertook the design and layout of the booklets and desktop publishing.

# Introduction

Tropical and sub-tropical fruit can make a significant direct contribution to the subsistence of small-scale farmers by providing locally generated nutritious food that is often available when other agricultural crops have not yet been harvested. Fruit are a versatile product that, depending on need, can be consumed within the household or sold. Marketing fresh and processed fruit products generates income which can act as an economic buffer and seasonal safety net for poor farm

households. Diversification into fruit production can generate employment and enable small-scale farmers to embark on a range of production, processing and marketing activities to complement existing income-generating activities. Often small-scale and home-based, these fruit-based micro-enterprises may provide a particularly important opportunity for women to earn an income and increase their status in the farm family as well as in the local community.



*FIGURE 1 Tending fruit trees that have been intercropped with maize  
(Photo: FAO/18317/ P. Cenini)*

Fruit trees are typically multi-purpose in that many provide not only fruit but also medicinal products and livestock fodder, as well as fuel wood and timber at the end of their productive lives. In addition to economic benefits, fruit trees provide a number of environmental services. Many of the species discussed in this booklet have traditionally been grown in mixed cropping systems where they enhance biodiversity and strengthen resilience against the effects of adverse weather conditions, poor soils and pests. In

regions where climate variability is commonplace and adverse impacts of climate change are expected, fruit trees may play an important role in buffering against production risks and providing a continuous supply of environmental services.

While most production and primary processing is likely to occur in rural areas, fruit trees can also be incorporated in urban gardens and streets, where they can contribute to household food and income security as well as providing shade and other environmental services.

**CASE STUDY 1    Increased acai production:  
feeding the urban poor and promoting  
forest conservation**

Since the 1950s, the city of Belem, Brazil, on the Amazon estuary has experienced a population increase from 300 000 residents to 2 million, attracting migrants from rural districts with strong family links to the countryside and a preference for rural foods. Acai fruit have been a low-cost staple food source in the region since pre-Columbian times and the palm is extensively cultivated and managed along rivers in forested areas, home gardens and a variety of tree farming systems. While fruit are harvested mainly from cultivated acai, the edible palm-heart is collected mainly from the wild. Consumption of the juice of acai berry in Belem increased from 90 000 litres per day in the late 1980s to 400 000 litres per day in the late 1990s. It is estimated that the volume of juice consumed per person per day is twice that of milk. The tree provides a staple for the growing population of urban poor as well as a fashionable food. As a result of increased demand, farmers have switched from annual crop production to forest based production systems centred on acai. Over the same period there has been a net increase in afforestation in this region of the Amazon, as a direct result of the increase in acai production, in contrast to other regions of the Amazon where deforestation continues.

*Source: Adapted from Padoch, C., Brondizio, E., Costa, S., Pinedo-Vasquez, M., Sears, R.R. & Siqueira, A. 2008. Urban forest and rural cities: multi-sited households, consumption patterns, and forest resources in Amazonia. Ecology and Society 13(2)*



FIGURE 2 Juice being extracted from acai fruit (*Euterpe Oleracea*) that is very popular in Brazil.

(Photo: FAO/6047/ G. Bizzarri)

The fruit trees discussed in this booklet are cultivated in tropical and sub-tropical regions of the world and have the potential of being incorporated into smallholder farming systems to support livelihood diversification. Tropical and sub-tropical fruit trees are usually evergreen and perennial and are frost sensitive with little growth below 10°C. Tropical species are distinct from subtropical species in that they require humid conditions and are sensitive to temperatures below 20°C. They thrive in climates where average mean temperatures are higher than 10°C for the coldest month. Hundreds of tropical fruits are grown in these conditions, but only about 50 are well known.

The most widely cultivated and globally traded tropical and subtropical fruit trees are mango, various species of citrus, avocado, papaya and kiwi. However, this booklet focuses on species that are predominantly of importance in local and national markets, with some beginning to have a presence on global markets, including mangosteen (*Garcinia mangostana*), custard apple (*Annona reticulata*), jackfruit (*Artocarpus heterophyllus*), peach palm (*Bactris gasipaes*), acai palm (*Euterpe oleracea*), tree tomato (*Solanum betacea*, [also known as *tamarillo*]) and safou (*Dacryodes edulis*). Although originating in one tropical region, many of these species are already being cultivated in other tropical and subtropical regions (see Box 1).

## **BOX 1 Fruit trees of importance for trade in local and national markets**

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Cultivation of the **mangosteen** tree has extended into Southern and Southeast Asia, northern Australia, the West Indies, tropical America and tropical Africa from its origin in the Malay Archipelago. It thrives in wet regions up to 600 m above sea level. In Asia, the fruit are generally traded as a fresh fruit or used to make and flavour desserts, jams, juices and wines. Its unique flavour, attractive fragrance and visual appeal have made mangosteen a very desirable exotic fruit in Europe and North America.

**Custard apple** is thought to have originated in the Antilles but has been naturalised in tropical America and is cultivated in South and Southeastern Asia and Australia. Its fruit are eaten fresh and are used to flavour milk shakes, custards or ice creams. It may also be used as rootstock for other *Annona* species which include *A. cherimolia* (cherimoya), *A. muricata* (soursop) and *A. squamosa* (sugar apple).

**Jackfruit** is indigenous to the tropical forests of India, Bangladesh and Malaysia and has been widely introduced to other South and Southeast Asian countries including southern China. It is also cultivated in tropical Africa and tropical and warm subtropical America and Australia. The large fruit are sold fresh or as a dried ingredient to flavour foods in the food processing industry. In Asia the immature fruit are cooked as vegetables while mature fruit can also be fermented and distilled to make liqueurs. The seeds are sold as snacks or ground to make a flour that can be used as an alternative to modified cereal starch. The timber is considered of high value in construction and furniture making enterprises.

**Peach palm** is indigenous to the humid tropics of South America, extending into the dry tropics (Mexico, some Caribbean islands and other continents) and grows best at low to middle altitudes with high rainfall. The fruit of the peach palm is traded locally in the humid tropics of South America as a fruit for cooking, a source of flour and oil and fermented to produce alcohol.

The large **acai palm** is indigenous to the Amazon river, is widely distributed in northern South America, and considered abundant in eastern Amazonian estuaries, flood plains, swamps and upland regions. It is economically important in the Brazilian state of Pará. In the Amazon region, the acai palm berry is sold fresh and as a dried powder to flavour food and drinks. Both peach palm and acai palm are also cultivated for their palm-heart, which is considered a delicacy and exported all over the world.

**Tree tomato** is cultivated in tropical highlands, the sub-tropics and mild temperate areas. It is indigenous to the Andes Mountains of Chile and Peru and is grown commercially in California and New Zealand. The fruit are sold fresh, but can also be processed into jams, jellies and chutneys and boiled or pureed to add flavour to drinks and for use in the food processing industry.

**BOX 1 Fruit trees of importance for trade in local and national markets (Cont.)**

**Safou** is native to humid tropical zones of Africa, but its wide temperature, rainfall, day length and soil range make it suitable for cultivation in sub-tropical and temperate zones. Safou has been introduced to Malaysia as an exotic and prefers shady, non-flooded areas. In the humid tropics of Africa, safou fruit are cooked as a vegetable and both the fruit and seeds are a source of edible oil.

■ **Purpose of the booklet**

The focus of this booklet is on fruit trees for small-scale farmers grown in home gardens and small-scale orchards, rather than on species such

as oil palm that are predominantly cultivated in industrial-scale plantations. The booklet is intended to raise awareness and provide information to people



**FIGURE 3** A rural fruit and vegetable market in Uganda  
(Photo: FAO/19334/ R. Faidutti)

and organizations, public and private, who are working with local communities to promote sustainable livelihood diversification for small-scale farmers. The booklet outlines the potential benefits of a fruit enterprise deriving from increased incomes, but also considers improved diets and food security for the farm family. It outlines the

basic requirements for cultivating fruit trees, marketing fruit and also processing fruit as well as drawing attention to some of the challenges. Even though harvesting of wild fruit trees is not considered in this booklet, processing, packaging and marketing of fruit produce is similar for both cultivated and wild harvested fruit.

# Fruit and sustainable livelihoods

Fruit trees can contribute to household nutrition, food security and income and may be a particularly useful source of livelihood diversification for women and other vulnerable groups. They are a valuable component of sustainable agricultural systems.

## ■ *Fruit for health*

Tropical and sub-tropical fruits have a high and diverse vitamin and mineral content that can form an essential part of a nutritionally balanced diet. As fruit tend to have a substantial amount of potassium, phosphorous, calcium and frequently, iron and

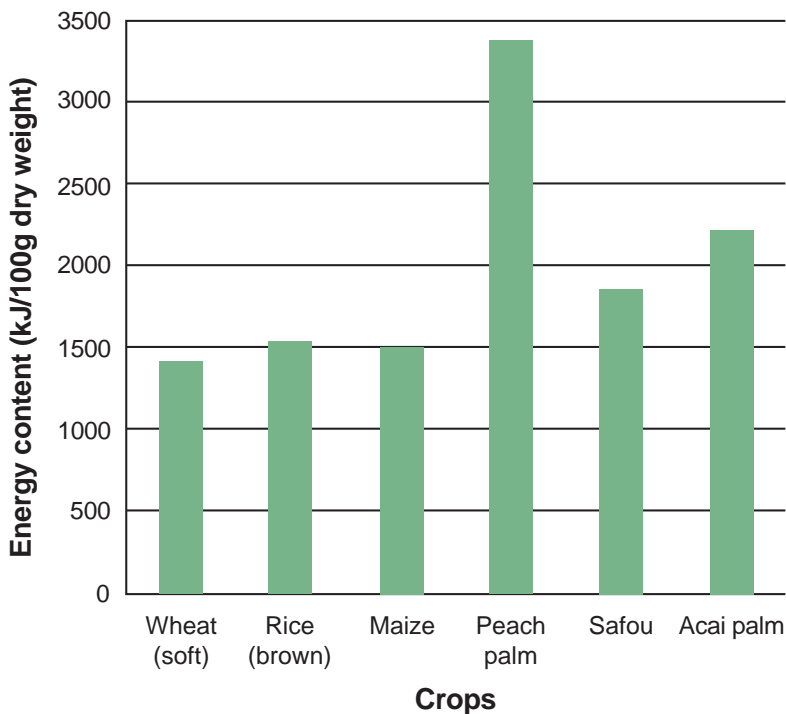


FIGURE 4 A comparison of energy content of some cereal crops and edible fruit pulp of peach palm, safou and acai palm

## CASE STUDY 2 Cuban home gardens provide food security, income and environmental stability

After the collapse of the former Soviet Union in 1989, the economic situation in Cuba deteriorated dramatically with low wages and minimal food rations from the State. As families found it increasingly difficult to feed themselves, individually owned home gardens flourished. They now provide a rich diversity of trees, shrubs and herbs that are intensively managed in harmony with annual and perennial agricultural crops and small livestock, resulting in increased socio-economic and environmental stability.

A study of three villages found that with an average size of just 25x35 m, home gardens nevertheless contained over 100 different plant species. Half of these were fruit trees, the most common being avocado (*Persea americana*), mango (*Mangifera indica*), coconut (*Cocos nucifera*), breadfruit (*Artocarpus communis*), guava (*Psidium guajava*), soursop (*Annona muricata*), sugar apple (*Annona squamosa*), orange (*Citrus sinensis*), papaya (*Carica papaya*), bananas and plantains.

Home garden owners in these villages ranged from medium sized farmers with 60 ha of land to pensioners and low-wage earners. For most, their home garden was a part-time activity dedicated primarily to producing food for home consumption and to feed animals. The food quantity and diversity provided by home gardens, particularly between 1989 and 1993, was essential to maintaining the wellbeing of Cubans when the daily supply of calories was very low and malnutrition was common. As Cuba's economic situation has improved, home gardens have continued to play a central role in providing a diverse source of food throughout the year, while complementing other income-generating activities in resource-poor households. An added benefit has been a reduction in environmental degradation as farmers have sourced food and fuel wood from their home gardens rather than cultivating crops on steep slopes or encroaching into forested areas.

*Source: Adapted from Wezel, A. & Bender, S. 2003. Plant species diversity of home gardens of Cuba and its significance for household food supply, Agroforestry Systems 57, pp. 39-49*

magnesium, they are particularly important in providing the building blocks of healthy muscles, bones, teeth and brain in children, as well as aiding protein digestion, cellular metabolism and a fully functional nervous system.

Some fruit such as acai fruit are extremely high in dietary fibre, which aids digestion and reduces cholesterol in the blood. Certain

fruits have high calorific values. Peach palm pulp, for example, is not very sweet and is equal to, or surpasses some cereals with respect to energy, fats and carbohydrates (see Figure 4). The dried pulp of safou and acai berry, similarly outperform cereal crops when energy and fat contents are compared. Some fruit are also a good source of protein, with peach palm fruit containing all

essential and non-essential amino acids.

Fruit can be incorporated into diets in many different ways. Ripe fruit are often sweet and eaten fresh on their own or in desserts. The flavour of some fruits like mangosteen and custard apple can be improved through chilling. Fruit can also be preserved in jams and pickles or dried and powdered for use in drinks or confectionary (see FAO Diversification booklet Nos. 4 and 5 *Value from village processing and Processing for prosperity*). In many species, such as jackfruit, immature green fruit can be cooked and used like vegetables. Seeds of some species can be fried and eaten as snacks (see FAO Diversification booklet No. 18 *Selling street and snack foods*) and may be a good source of oil. In addition to providing healthy side-dishes and desserts for the whole family, fruit trees planted near the house can be especially important for young children – who have particularly high energy and nutritional requirements – by providing easily accessible snacks.

#### ■ **Medicinal properties of fruit**

There is a wealth of indigenous knowledge about the medicinal uses of different fruit trees. Thus all parts of the jackfruit tree, for example,

are used as remedies for everything from skin diseases and asthma, to dysentery, intestinal worms, diabetes, ulcers, pain, wounds and abscesses. Tannin from the dried unripe fruit of custard apple is used against diarrhoea and dysentery while the bark prevents excessive bleeding and the root is used as a tonic to reduce fever (see FAO Diversification booklet No.17 *Health and wealth from Medicinal Aromatic Plants*). However, as much of this traditional knowledge has not yet been subjected to scientific research, expert medical advice should always be sought in case of illness.

#### ■ **Fruit and food security**

Food security implies that individual households are able to meet their daily food needs from their own farm or have the means to obtain food from local off-farm sources. Fruit crops are a suitable addition to any small-scale farm and home and market garden (see FAO Diversification booklet No.2 *Livelihoods grow in gardens*) because they require little cash and labour input once they are established and, if planted in appropriate locations, do not need to interfere with staple crops. Planting a number of different fruit tree species can provide households



*FIGURE 5 A fruit tree intercropped with cabbages*  
(Photo: FAO/22174/A. Casset)

with a year-round supply of fruit to complement other crops grown on the farm. Unlike some crops which may fail entirely if subjected to climatic stress, established fruit trees that are well adapted to a region, may have reduced yield but will usually survive one or two difficult seasons. Incorporating fruit trees into farming systems (see Figure 5) can help provide the building blocks for the development of sustainable agro-ecosystems by preventing soil erosion, improving soil fertility and encouraging biodiversity.

#### ■ *Fruit as a source of income*

An advantage of fruit is that they can be consumed or sold depending on the household's circumstances. Species such as custard apple are not considered to be a highly commercial species and are mostly grown by smallholder farmers on a casual basis, seasonally complementing other activities on the farm. Their produce are sold to local markets or consumed at home, adding diversity to the local food basket and the farmer's income. Other species are increasingly cultivated primarily for sale. Thus

the durability and two week shelf-life of mangosteen fruit, for example, combined with its delicate flavour and pleasing appearance, is leading to growing exports from Southeast Asia to the People's Republic of China, Taiwan, Europe and North America.

In trading fresh fruit, it is advantageous to grow varieties that fruit early or late in the season when prices are high. During the main fruiting season, the glut in availability may cause prices to fall dramatically. In this case, proper storage or processing can greatly increase a household's income. The price of jackfruit, for example, doubles or triples only a few months after harvest. The Philippines, for example, has seen a 100 fold increase

in demand for jackfruit as a result of advances in technologies that have allowed the fruit (fresh and processed) to be sold out of season. Some species such as the tree tomato, which is grown extensively in South American home gardens, fruit continuously in subtropical areas providing a year-round income stream. Others, such as safou in Central and West Africa, play a critical seasonal role in family finances by providing an income at a time when farmers have few other income sources but need to pay for school fees, uniforms and books. Small-scale processing can ensure year-round availability of fruit tree produce, thereby improving food security and income generation for poor farmers.



FIGURE 6 Transporting acai fruits (*Euterpe oleracea*) to market  
(Photo: FAO/22241/ G. Bizzarri)

## **BOX 2 Multiple products for marketing from the mangosteen**

The tree is ideally suited for home garden as well as small-scale orchard production. It has numerous products that derive either from the fruit or the tree. The products marketed to consumers are:

- Fresh fruit
- Dried fruit
- Jam
- Preserves
- Seeds roasted for snacks
- Twigs for chew sticks

Moreover other products that derive from mangosteen are:

- Fruit rind being used for leather tanning and black dye
- Leaf and bark extracts being used to treat diarrhoea, dysentery and urinary disorders
- Dried fruit used for skin disorder and astringent lotion

### **■ *Suitability for women and vulnerable groups***

Fruit tree crops are considered less labour intensive than other crops. Once established, they require little weeding or tending and, if necessary, labour can be hired in for a few days to help with the harvest. Fruit trees can therefore be particularly suitable if labour is a limiting factor in a household as may be the case when the very old are taking care of the very young or in women-headed households. These situations can arise in communities with a high prevalence of HIV/AIDS or when young men migrate to cities in search of employment. From a poor, elderly or female farmer's perspective, fruit tree cultivation provides an opportunity to develop a regular food and importantly income source that can comfortably fit

around other daily household and farm tasks, while providing relatively low risk returns.

Fruit trees are also suitable for households or individuals with limited access to land, as one or two trees can easily be planted around the homestead or even in an urban courtyard. Location near the home may be important for women in cultures where it is difficult for them to work outside the home. It also means that the trees can be supervised without interfering with the woman's domestic duties and the fruit are easily accessible for food preparation. The fact that food is considered to be the woman's domain often makes fruit tree enterprises an acceptable income-generating activity for women. Small-scale processing, such



*FIGURE 7 A women home processing fruit and vegetables into jars for sale  
(Photo: FAO/22031/ G. Bizzarri)*

as solar drying, requires little capital investment or technical skills and may be a suitable activity for people with few capital assets or little time to integrate into their daily routines. Community-based processing enterprises can provide employment for disabled or elderly people in work such as cleaning or chopping fruit and filling containers.

### ■ *Fruit and sustainable agriculture*

The introduction or expansion of tropical fruit tree cultivation on smallholder farms can increase the

biodiversity of plant species on the farm and within the local area. The farm acts as a repository of germplasm for a range of fruit tree species and varieties that are typically obtained from the surrounding forest, neighbouring farms, markets and nurseries or exchanged with family and friends. This additional biodiversity can attract a wide variety of other organisms, which can feed on crop pests, reducing the need for pesticides. The flowers of melliferous species, like safou, can attract bees, which not only provide honey but are also

### CASE STUDY 3 Women's Maya nut enterprise wins prize

Maya nut (*Brosimum alicastrum*) is one of the largest trees of Central American forests. It used to be part of the indigenous people's staple diet, since it is highly nutritious, drought resistant, climate change resistant and the nuts can be stored up to five years. Although still valued as an emergency food – and enabling many families to survive after hurricane Stan in Guatemala (2005) and hurricane Felix in Nicaragua (2007) – its popularity declined when forested areas were felled for timber and maize growing. General consumption dropped to less than five percent of local diets. To reverse this trend the Equilibrium Fund has encouraged communities to establish community nurseries, reforest depleted areas and highlighted the nutritional value of the nut by training 8 000 women from villages in Mexico, El Salvador, Guatemala, Nicaragua and Honduras, since 2001. The endeavour has resulted in improved community health, increased self-esteem and status of women, supplemented food and income, while protecting water resources and forest biodiversity.

In 2005, a Guatemalan women's producer group opened the first Maya nut processing plant in the world. They own and operate the plant and have received US\$40 000 in recognition of their business efforts, including winning the Equator Prize in 2007. They have used the money to implement school lunch programmes that provide Maya nut-based school lunches to rural Guatemalan schools. Their aims are to improve children's health, reduce dependency on imported goods and encourage reforestation and protect the Maya nut tree. Through these activities the economies of the producer communities are being revitalised.

*Source: Adapted from Kajenje, Y. 2008. Maya Nut: A forgotten treasure, The New Agriculturist*

important pollinators for some crops (see FAO Diversification booklet No.1 *Beekeeping and sustainable livelihoods*). By providing shade, trees can protect crops against excessive evaporation and moderate the effects of drought. At the same time, they can reduce runoff and stabilise the soil by improving infiltration of water. Their roots can also reach nutrients deep in the soil, which are taken up into the tree and

eventually returned to the soil surface through falling leaves, reducing the need for some fertilizers.

The environmental services provided by fruit trees, combined with the fact that their subsistence and commercial products are often available in the non-agricultural 'lean' season, can help to make agricultural systems and landscapes more sustainable and more resilient to environmental change.

# Feasibility of a fruit tree enterprise

Starting a fruit enterprise which involves investment, not only in terms of money, but also in terms of labour, equipment and so forth, requires the small-scale farmer to ascertain the feasibility of such an enterprise. This is especially important as fruit trees are perennial in nature and returns of money invested, labour and other efforts undergone may only bear fruit over some years.

In conducting a feasibility study small-scale farmers will need to be supported by advisors. Advisors need to provide information, for example about markets for fresh fruits, processed fruits, marketing opportunities and alternatives, post harvesting as well as fruit processing operations. Advisors will also need to support and help small-scale farmers in making cost estimates of the enterprise, for example the costs of a simple home garden or market garden or a small-orchard enterprise. Ultimately, however, it must be the small-scale farmer who decides whether or not to start the fruit enterprise.

## ■ *Market research: Which fruit products?*

Market research is a first step in estimating the feasibility of a fruit enterprise. Small-scale farmers will need to have a good understanding of consumers, markets, prices and quantities demanded of both fresh and processed fruits. This will give the small-scale farmer an indication of what fruit is popular in the local area, urban markets and possibly national markets. It will give an idea of what quantities are required, the quality, whether fresh and/or processed fruit products are in demand and so forth.

However the perennial nature of the enterprise will mean that market research information gathered at the start of the feasibility study may not represent the market when farmers are ready to sell their fruit. Here is where the adviser will need to assist small-scale farmers by providing trend (historical) information about prices for fresh and processed fruits in the local area, quantities demanded, quality requirements and the fruit supply chain. This will provide and supplement the information base on which farmers

will make decisions. Providing such marketing intelligence, however, will not eliminate business risk, but will only reduce the probability of making and taking the wrong decisions by farmers.

■ ***How to organize the enterprise and scale of operation***

As a result of marketing information the small-scale farmer can estimate the size of the enterprise that is required and how it needs to be organized: home garden, market garden or small-orchard. The farmer can estimate how many trees need to be planted, where they need to be planted, labour and equipment needed and management requirements. Commonly small-scale farmers plant a few trees in their home gardens, verify how tree yields perform and then build the enterprise up from there. However with a feasibility study, farmers will be able to estimate on paper various options of planting several trees in the home garden making it more a market garden and also may consider a small fruit tree orchard. This based on market demand, as well as costs (see section below on costs and profits).

Moreover farmers will also be able to make estimations about how the enterprise needs to be

organized: the inputs required, where they can be sourced from, their costs, how to organize labour, if a small-scale fruit processing enterprise is also feasible ( see next section on processing) and also make estimations about the feasibility of joining a farmers' fruit association whether for production or marketing reasons or for both. Associations provide many advantages, for example reduce prices on inputs (as a result of group buying), better access to training, more bargaining power in marketing and access to more and diversified markets.

■ ***Processing: What equipment, technology and packaging to use?***

Estimating whether along with the fresh fruit enterprise a small-scale processing enterprise may also be feasible will be based on market demand for processed fruit products and also on the availability of finance. Markets will define the type, nature and quality of processed products that are required. This will enable the small-scale farmer to work backwards and estimate what type of processing operation is required, for example a simple 'kitchen enterprise' to process jams for example or a slightly more

complex enterprise that may require a processing room in the farm homestead where fruit juices, for example, can be made and bottled for sale.

Small-scale farmers will importantly need to estimate, with information support from advisors, what tools, equipment and machinery may be needed, their cost, where, if necessary, credit can be obtained, spare parts availability, energy sources required and if importantly they may need training to learn better and improved methods of processing to uphold product quality and safety. Information on packaging, the appropriate types, where it can be sourced and its costs will also be needed.

Small-scale farmers, with the support of advisors, will need to verify regulatory requirements for fruit processing, for example in terms of facilities, hygienic practices, safety, labelling, registration of the enterprise, taxes, the number of procedures needed to open a formal enterprise and importantly the costs involved.

Farmers will also need to estimate, based on the size of the intended processing enterprise, production planning. For example what fruit inputs are required, the

quantities, when they are needed, if fruit can also be sourced from other farmers in the surrounding area, other inputs that may be needed, for example, sugar and so forth. Farmers will also need to plan what labour will be needed, when it will be needed and if it will be available.

#### ■ *Credit availability and access*

A fruit tree enterprise, by its very nature (perennial) requires money to cover establishment costs as well as annual operational costs. This will be more pronounced in the case of a small-scale processing enterprise, where money will be needed more frequently, especially in terms of working capital. Investments made will have a long term perspective as the enterprise will only provide costs over the initial years and no returns. This requires a particular focus on estimating cash out flows to the farm as well as importantly where credit can be sourced from.

Small-scale farmers may source the required funds from their own savings or from family members or from friends. However these types of credit sources may only be viable for a very small home garden enterprise and a kitchen enterprise for processing fruit. In cases where the enterprise may be based on a market garden or small orchard

and the processing enterprise has a room dedicated to such operations in the farm homestead more capital will be required. Small orchards and more specialised processing equipment require more money.

Short term loans are viable for such equipment as kitchen utensils, but more specialised equipment, such as a large mechanized fruit pulper requires a longer term loan. Farmers will need to ascertain and estimate the type of loans that may be required, the interest rates and payback periods as well as their ability to access such loans. Advisors will need to assist farmers in this and provide information about various credit organizations found in an area, the terms of loans and what is required to take out a loan.

### ■ *Costs and profits*

The costs of a fruit enterprise need to be estimated along with expected profits. Costs can be split into establishment costs and annual operational costs. Such costs will need to be estimated for both the fresh fruit enterprise and the processing business. Establishment costs may include a number of capital costs such as purchasing the land, the seedlings, processing equipment

and machinery, harvesting and post-harvest equipment (baskets, poles, ladders, storage boxes,) fencing, water pumps, etc.

Establishment is also a labour-intensive period as land needs to be prepared appropriately, holes dug and seedlings planted, staked and watered. Annual operational costs include the costs of renting and/or maintaining all the above items as well as buying and applying any fertilizers, pesticides, fungicides, herbicides or insecticides used.

In anything but the smallest farms, it is likely that there will be a need to hire in short-term seasonal labour to help with harvesting. In some areas, farmers may be able to buy insurance to protect their fruit crops against potential risks of pests, fire or bad weather. In calculating the overall returns of investments in fruit trees, it is necessary to look at the costs and benefits over the whole productive life of the trees, recognising that establishment costs are likely to be the most expensive period in the crop's life and that regular income from the fruit often only materialises after some years. If fruit is being produced for market, the possibility that prices will change in the future must be taken into account.

#### CASE STUDY 4 Costs of establishing 1ha of jackfruit in India

To establish a jackfruit plantation (1 hectare at 10 m x 10 m spacing, with manure applied to the base) in India, the following costs may be incurred:

Item	Cost	
	(INR)	(US\$)
100 jackfruit plants (at 20 INR per plant)	2 000	
0.3 kg of farm-yard manure per 100 plants	300	
Labour costs per hectare	400	
<b>Total establishment costs</b>	<b>2 700</b>	<b>58.5</b>
<b>Gross annual income</b> (US\$8-20 per tree, based on 250 fruit per tree)		<b>1 500</b>
To determine profit margins, establishment, harvesting and transport costs must be deducted		

Source: SCUC. 2006. *Jackfruit (Artocarpus heterophyllus) Field Manual for Extension Workers and Farmers*, Southampton Centre for Underutilised Crops, University of Southampton, Southampton, United Kingdom

Once all costs have been established these need to be compared with prices for fresh fruit produce as well as processed fruit products. This will give some indication of profit margins that can be obtained. However advisors will need to help farmers in forecasting possible future prices as fruits crops will be harvested in some years from the preparation of the feasibility study. This will give a somewhat more realistic picture of profit margins and give farmers a better idea of possible profit margins to expect.

#### ■ Evaluation of the activity

Once all estimates have been made the small-scale farmer will be in a position to better evaluate the feasibility of the fruit enterprise. Importantly the farmer will be taking a long term decision if he or she decides to go ahead with such an enterprise. Advisors need to make this clear to small-scale farmers that establishing a fruit tree enterprise will require investments ( time, labour, money, etc.) and hence will require two factors: i) patience in obtaining benefits from the fruits of such hard work; and ii) importantly persistence with the fruit enterprise over time.

## The livelihood activity

Fruit tree cultivation begins with the decision about which species to plant. Farmers then need to think through a number of issues, ranging from where to plant the trees, how to propagate and manage them, what is involved in harvesting and post-harvest requirements.

### ■ *Selecting the right species and variety*

Many considerations go into selecting an appropriate species (see Box 3 on the next page). Within each species there are also many varieties to choose from with local clones often having local names that relate to the variety's attributes. Farmers may select for a wide range of traits. In the case of bush mango in Nigeria, for example, local dietary customs determine whether farmers prefer varieties with a thick fruit flesh (eaten fresh) or oily seeds (used to make a traditional condiment). In the case of acai palm, berry colour can vary from green to black but varieties with darker

fruit are preferred if producing for antioxidant content. Tree tomato fruit also vary in colour with yellow fruit having a milder flavour but red varieties are considered more attractive for fresh fruit markets.

Some farmers are simply interested in obtaining the highest fruit yields possible, while others prefer early or late-fruiting varieties that provide crops outside the main season. A variety of acai palm, known as para dwarf, is liked because its low stature facilitates harvesting. For the same reason, for example, elderly people in Cameroon prefer short safou trees. Farmers who are more risk averse may value drought tolerant varieties over high-yielding ones, while others may need species and varieties that combine well with specific annual crops and are adapted to the particular environmental conditions of their farm. If producing fruit for a particular market (for example oils), farmers will need to evaluate and consider the right varieties, prior to planting.

### **BOX 3 Factors to consider in choosing the right fruit tree**

Species and number of fruit trees to plant:

- Consumer demand, prices and market quantities required
- Family food needs
- Fruit production and its fit with the current farming system and with other food and income-generating activities in the household
- Fruit trees' fit with other crops in terms of shading, water use, labour requirements, etc.
- Availability of and access to appropriate seeds, seedlings and clones of the desired tree species
- Land requirements
- Distance from the homestead
- Water sources
- Family labour availability for planting and maintenance of trees
- The possible need for extra tools, equipment, machinery and labour to plant and maintain the trees

Harvesting and storage:

- Harvest time
- Special equipment or additional labour requirements
- On farm transport
- Where and how to clean and prepare the produce for market
- Storage availability and requirements

Marketing:

- Feasibility of processing enterprise from farm household
- Possibility to collaborate with other farmers and related interested parties
- Presence of local or national farmers, growers and/or business cooperatives
- What markets to sell processed products in?
- Prices in various markets
- Quantities demanded
- Transport for marketing
- Options for storage at home and/or at market

Finances:

- Money required for investments
- Time for returns on investment

#### ■ ***Choosing the right location***

Many farmers begin by experimenting with a few individual fruit trees in their home gardens over which they have secure tenure. Here

they can easily protect and water the seedlings during establishment and watch over the maturing fruit. They can also observe how trees interact with other crops, providing shade

at different levels and times of year as well as fruit, leaf litter and other products like timber. Peach palm is traditionally planted for subsistence production in home gardens, where the fruit can easily be harvested for home consumption, but can also be planted in larger gardens, such as market gardens, and in some cases also in small-scale orchards if exploitation is more commercial.

If farmers have no land of their own, they need to reach an agreement with a landowner to allow them to plant trees and reap the benefits for an agreed period of time. As many customary tenure systems consider tree-planting to be a sign of ownership, permission may be difficult to obtain under these circumstances. However, landowners may permit tree-planting if they can receive a share of the fruit or a proportion of the income for an agreed time and if it is clear that they retain the rights to the land itself. In such cases, it is often easier to plant exotic species as these are clearly new to the environment, whereas landowners may argue that indigenous tree species arrived on the land through natural propagation. Alternatively, indigenous species can be planted in hedgerows or small –scale orchards (as opposed to randomly in a field) to indicate that they are not the product of natural regeneration.

Fruit trees can play an important role in traditional shifting cultivation systems, where many farmers enrich their swidden fallows with a range of fruit and timber tree species. Leguminous species are particularly useful in such situations as they have the additional benefit of providing additional nitrogen to the soil.

Some crops, such as coffee and cocoa, may grow better under shade and fruit trees can play an important role in such production systems. In West and Central Africa, for example, cocoa is typically grown under the shade of safou trees. Safou may also be grown in small orchards and in intercropping systems with shade tolerant food crops such as the tubers, new cocoyam (*Xanthosoma sagittifolium*) and old cocoyam (*Colocasia esculenta*). In India, jackfruit may be found shading coffee and areca nut (*Areca catechu*), and can also provide a support for black pepper (*Piper nigrum*) vines.

When choosing a planting site, consideration must be given to the harvest and how this will be transported home. Protecting fruit against predators, such as birds or monkeys, may also be important in some areas. If the trees are planted too far away from home, the family may not have enough labour to devote to these activities. Some species

## CASE STUDY 5 Integrating fruit trees with other crops

In West Java, Indonesia, the Dudukuhan agroforestry system illustrates how fruit trees can be integrated into farming systems in different ways depending on changing family needs. The system begins with farmers clearing old fallows to cultivate a mixture of bananas and annual crops for 3-4 years. They then enrich these fields with other fruit and timber species, which shade out the annual crops as they mature. Once some of the timber is harvested, annual species may be reintroduced to create a multi-layered system of mixed fruit-timber-banana-annual crops. In this system, bananas and annual crops meet short-term food and income needs while fruit (like jackfruit) and different species of bamboos meet medium-term needs and timber species provide long-term returns. If the productivity of the system declines or the family needs more short-term income, the trees can be felled and it can be returned to a banana and annual crop system. Alternatively, if a family is seeking to invest for the future and the plot of land is some distance from a family's house, it may be converted into a timber woodlot.

*Source: Adapted from Manurung, G.S., Roshetko, J.M., Budidarsono, S. & Tukan, J.C. M.2006. Dudukuhan tree farming system in West Java: How to mobilize the self interest of smallholder farmers? ICRAF & CGIAR*

may also have particular growing requirements, such as acai palm which grows naturally in swamps and floodplains or tree tomato which prefers high altitudes and high levels of humidity.

### ■ **Propagation**

Tropical fruit trees can be propagated from seeds. However, many tropical fruit seeds are recalcitrant, that is they do not survive drying or freezing and therefore need to be sown within days of being collected from a mature fruit. For other trees, the reverse may be true, and seeds may need to be treated, for example with scarification, before they will germinate. However, as many tropical fruit trees have not

been through a scientific breeding programme, the tree architecture and fruit quality of seedlings produced from seed can vary greatly from the original mother fruit tree.

Vegetative propagation (cloning of the mother plant) can ensure that the desired fruit tree traits present in the mother plant are present in the propagated seedlings. Vegetative propagation from mature trees can also reduce the time until the tree starts to bear fruit, sometimes from 10 years to as little as three years. This involves 'training' the young tree via pruning and bending branches as well as inducing a 'stress' period. Vegetative propagation can be carried out through different methods, such as cuttings, layering, inarching, grafting, budding or micro-

propagation, since different species and varieties respond differently to each technique. Farmers in West Africa have had great success with participatory domestication of safou and other indigenous fruit species.

Seeds or vegetatively propagated planting material are usually allowed to establish in a nursery and are then transplanted into the field. It is rare for species to be planted directly into the field. Once the seedlings are considered ready to withstand field conditions they are transplanted into

home or market gardens, etc. This is usually carried out at the beginning of the rainy season when water is plentiful to aid establishment. The land either needs to be ploughed and harrowed, or the seedlings are placed in dug out holes with appropriate stakes to support individual seedlings. In dry areas, seedlings will need regular watering for at least the first year until they are well established. They may also need to be fenced to protect them from grazing animals. In open areas, windbreaks may be beneficial.

#### **CASE STUDY 6 Participatory domestication of safou (*Dacryodes edulis*) in Cameroon**

Also known as safou or African plum, *Dacryodes edulis* is a widespread forest tree in the humid lowlands of West and Central Africa. Farmers like it as a shade tree for cocoa and because it yields an oily fruit that forms a staple part of the local diet and is an important source of income just before school fees are due.

Responding to growing market demand at local, national and international level, and a decrease in wild availability, farmers in Cameroon were increasingly planting safou trees from seed or transplanting wildlings. However, like many undomesticated species, safou trees are very variable in their characteristics and propagation in this way does not guarantee that adult trees display farmer-preferred traits. The World Agroforestry Centre (ICRAF) has therefore worked with farmers to develop a process of participatory tree domestication to enable them to propagate varieties with known characteristics. This involves the following steps:

1. Group discussions help farmers identify desired traits such as tasty or large fruit, fruiting out of season, high yields, disease resistance, etc. These may respond to specific market demand as well as to the particular growing conditions (e.g. wet, shaded) or labour availability (e.g. seasonal) on farms.
2. Farm surveys help farmers select individual trees that perform well on one or more of the desired traits.
3. Training in vegetative propagation enables farmers to create cloned seedlings from the selected parent trees. In the case of safou, air layering (or marcotting) has been found to be a particularly effective method that produces individuals that can fruit within three years.

## CASE STUDY 6 Participatory domestication of safou (*Dacryodes edulis*) in Cameroon (Cont.)

4. Additional business training has helped farmers develop group nurseries from which they are able to sell cloned safou cuttings that provide them with an income in addition to the income their own trees generate.

By following these steps, farmers have been able to increase the income from the sale of their fruit. They have also been able to earn an income from selling their propagation skills to neighbours and/or from the sale of cloned cuttings. The experience with safou has been so successful, that many farmers have applied the same participatory tree domestication approach to other indigenous species.

*Source: Adapted from Pye-Smith, C.2010. The Fruits of Success: A programme to domesticate West and Central Africa's wild fruit trees is raising incomes, improving health and stimulating the rural economy, ICRAF Trees for Change no. 4, World Agroforestry Centre, Nairobi*

### ■ **Inputs**

The inputs required for cultivating fruit tree crops are not very different from those required for any other form of agriculture, but consideration needs to be given to the perennial nature of fruit crops. Key resources required are land and labour but fruit trees can often be integrated with other crops both spatially and in terms of the timing of labour requirements. Seeds or vegetatively propagated material can be purchased or produced on farm. Equipment needed to establish fruit trees may be no more than a shovel to dig holes. However, if a larger area is being planted up, then a tractor, harrow and plough can be employed. Some form of transport, whether a wheelbarrow, bicycle or a pick-up truck, may be needed to

transport planting material from the nursery to the planting site. Timber stakes and ties are generally needed to support the seedlings. Funnels attached near the base of the seedlings are sometimes used to channel rain water to the root system.

To maintain the tree in good health the farmer may wish to apply a liquid fertilizer, herbicide, fungicide or pesticide. These can be applied using a backpack sprayer or in large scale orchards a sprayer attached to a tractor. The choice of application method depends on the size of the enterprise, the resources available to the farmer and the likelihood of getting a monetary return for such expenditures. Pruning shears and harvesting knives are generally essential when maintaining and harvesting fruit trees.

During the harvesting period, farmers may choose to use, ropes, poles with hooks or baskets, orchard ladders or mechanized extendable arms to reach the fruit at some height from the ground. Boxes, bags, baskets or carts can be used to transport fruit to market, as well as some wrapping paper. The choice of container is often determined by the target market. Depending on the type and volume of product and distance to market, the farmer may need access to a vehicle, possibly a refrigerated one, to transport goods to market.

### ■ **Management**

Lack of flowering on fruit trees is one of the main reasons for low crops yield. To ensure consistently good yields

year on year, it is essential that the trees receive sufficient water, nutrients and sunlight and are protected as much as possible from pests and diseases. During the dry season, it may be necessary to provide extra irrigation to drought-prone fruit tree species and weeds should be regularly removed from the base of the tree to reduce competition for soil water and nutrients. The use of organic mulches around the base of these trees can help to reduce soil water evaporation, while also adding some extra nutrients to the soil. Farm yard manure and farm-produced compost can provide a source of nutrients to establishing and established fruit trees. In some cases it may be advisable to buy in extra fertilizer.



**FIGURE 8** *Appropriate watering is an important aspect of managing fruit trees*  
(Photo: FAO/15490/F. Paladini)

Some fruit tree species benefit from pruning. Pruning can reduce the height of a fruit tree, providing 'quicker' fruit bearing capabilities, making it easier to harvest, while reducing the shade on adjacent crops and increasing light penetration into the canopy. Pruning influences the time of fruit set, allowing the farmer to regulate the supply of fruit throughout the year, as well as increasing the quantity and quality of fruit produce and reducing the likelihood of pest and disease attack. Bending of branches also helps in fruit bearing and is an integral part of training the tree to be small and productive. There is also a need for a period of 'stress', either cold or dry season, as this will reduce shoot growth and favour flower budding. However in many parts of the tropics stress will need to be induced as a result of high humidity and lack of cold and dry periods.

The types of pests and diseases that attack fruit trees vary throughout the season and between fruit tree species. Many of the microbial and pest species that attack fruit trees are specific to a particular species. There are many fungicides, insecticides and pesticides on the market that may address these problems. However, these chemicals are expensive and may kill beneficial organisms too. An alternative is a multiple cropping system, that uses

a wide range of annual, biennial and perennial (fruit trees) crops to create niches for a range of beneficial micro-organisms, insects and birds, which can act as natural predators to many pests and diseases, reducing the need for chemical control. Organic farming is based on this premise. This does not occur in large monoculture plantations. In some cases there may be no alternative other than to use chemicals to save a harvest, but these should be used as a last resort.

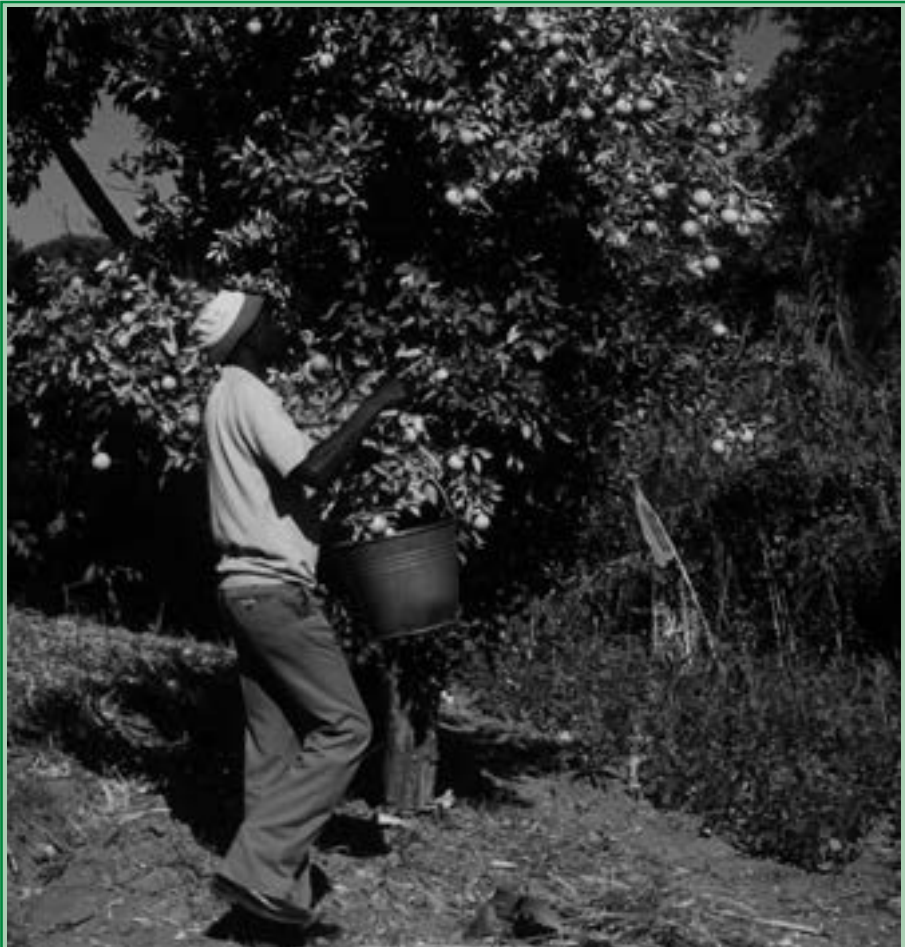
### ■ *Harvesting*

Cultivation of fruit trees is only one part of the livelihood enterprise. The most important part of such an enterprise, as a result of the perishable nature of fruit, is harvesting, post-harvest and marketing operations.

Different fruit trees are variable in their harvesting requirements. Some like tree tomato start to bear fruit within 18 months and continue to do so almost all year-round for up to 12 years, if well managed. More commonly, fruit trees take 3 to 5 years to reach maturity with some like mangosteen taking up to 10 to 15 years to fruit after planting. While most species produce one main crop per year, jackfruit is one of several species that also has a second less productive harvest. In some cases, however, good harvests may be followed by a

reduced harvest the following year as the tree replenishes its nutrients (an alternate ‘on’ and ‘off’ year). Harvesting seasons can be influenced by temperatures and pruning regimes but may also vary by genotype. Thus

farmers can extend their overall harvesting season by planting a selection of different cultivars, while planting many identical trees (clones) will result in a single harvesting season.



*FIGURE 9 Harvesting is an important aspect for fruit quality and overall fruit tree management. This farmer has opted for tall fruit trees, as opposed to small-sized trees and this makes harvesting more complex*

*(Photo: FAO/17761/ A. Conti)*

Some fruits can be harvested when immature and used in cooking or for the production of pickles, and for marketing in more distant markets, like national markets. Other fruits are harvested for fresh fruit immediate markets found in rural areas. The end use (marketing necessities) defines the time of harvesting to ensure the fresh produce is in prime condition when it reaches the consumer. Some fruits ripen simultaneously on the tree while other species such as jackfruit and peach palm may have fruit ripening sequentially over several months. How harvesting is organized depends not only on the timing of fruiting but also on how delicate fruit are and whether they drop from the tree when mature. All these issues influence the time needed for harvesting, the number of extra labourers that may need to be employed and the overall cost of harvesting the fruit. In the case of mangosteen, for example, delicate fruit ripen over a 6 to 12 week period, so hand picking occurs over an extended period, every 2 to 3 days.

It is important to plan how fruit will be harvested. Fruit trees that are of short stature or have been pruned to reduce their height can be harvested from the ground. This is also true for dwarf varieties, such as the para dwarf variety of acai palm, which fruits at a trunk height of 1m, and some

safou cultivars. Given that individual fruit weigh 5-35 kg, the ground-level fruiting habit of *Muttam Varikha*, a clonal strain of jackfruit from India, is particularly welcome. The increasing availability of dwarf varieties makes it easier for anybody including older people or those with disabilities to harvest from the ground. However, the majority of fruit trees still need to be climbed (see Figure 9) in order to harvest fruit without causing bruising to the outer skin. If the trees are shaken to detach the fruit, this usually results in fruit bruising, poor quality and loss of a significant amount of the harvest. Ropes are sometimes used to bend lower branches towards the ground to allow them to be harvested from the ground. Poles with hooks or baskets on the end (see Figure 10), or ladders, can also be used to aid harvesting. However, when large quantities need to be harvested, it may be worth hiring a mechanized extendable arm (see FAO Diversification booklet on No. 19 *Hire services by farmers for farmers*).

In the case of acai and peach palm, palm-heart is harvested from the inner cores and growing buds of the trunks. As harvesting results in the death of some wild single-stemmed varieties of peach palm, palm-heart production usually requires the use of multi-stemmed varieties.

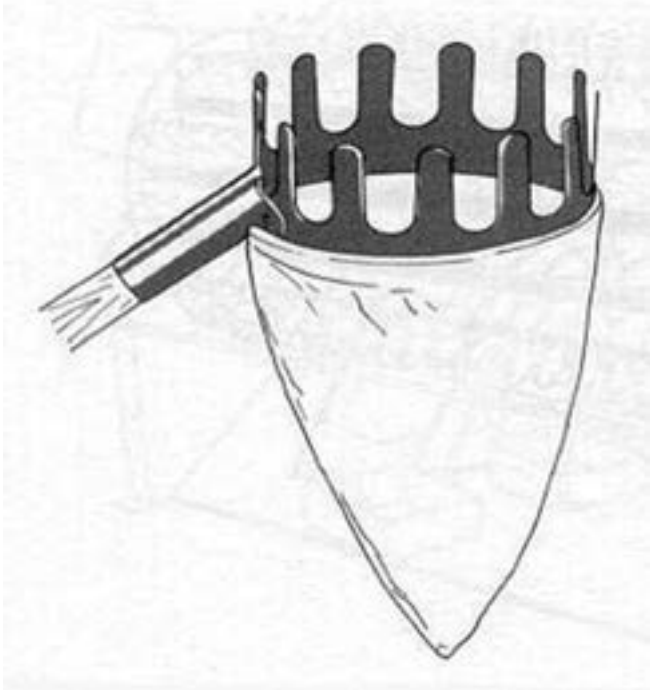


FIGURE 10 A fruit picker  
(Source: FAO/PH05414/ INPHO)

### ■ *Post-harvest and storage*

Post-harvest and storage techniques are greatly influenced by the target market. If the fruit is for home use, it may be enough to store it in a dry clean area or keep it underground in a cool pit. However, if the fruit is destined for more distant markets the farmer may have to adhere to more elaborate post-harvest practices. If the fruit deteriorates rapidly, it may be appropriate either to sell it quickly to a local market or local food

processing company or for the farmer to set up a small-scale processing business (see Figure 11).

To avoid bruising, the fruit should be transported from the field in carts, baskets, boxes or bags in, one, two or three layers, depending on how delicate they are. The fruit then needs to be cleaned and sorted according to size or weight. Damaged fruit can be used for home consumption. Extension organizations need to advise on appropriate methods

of preservation. Building on traditional post-harvest techniques and introducing new methods is a viable way of supporting small-scale farmers in their marketing efforts. Extension advisors also and along with market intermediaries need to provide advice on the specific quality demands of more distant markets, such as urban and national markets.

Once the fruits are graded, they should be placed in boxes or baskets with cushioning, if necessary, good ventilation and possibly wrapped in paper tissues. For some highly perishable fruit, refrigerated transport may be required. Storage guidelines vary depending on the species and the length of time the fruit are in storage.



*FIGURE 11 Making jam is a form of storing fruits and allows for prolonged shelf-life enabling more marketing flexibility*

*(Photo: FAO/18777/I. Balderi)*

## ■ *Fruit trees*

### *Mangosteen (Garcinia mangostana)*

Mangosteen grows best at temperatures of 20-30 °C at elevations of 0-500 m with rainfall throughout the year, or irrigation. Dry conditions before and during flowering aids good fruit set. Soils should be nutrient rich and well drained. The most common form of propagation is from seed, sown 0-5 days after extraction from the fruit. Seedlings are kept in the nursery under partial shade with twice-daily watering. They can be transplanted to the field during the rainy season when 2 years old at a spacing of at least 1.5 m. Seedlings are suited to planting between other fruit trees as they require shading for the first 2-4 years until fruiting takes place.

Mangosteen's juvenile stage has a high nitrogen requirement, requiring good mulch or fertilizer application. Removal of basal suckers and pruning helps to produce trees, by the age of 5-7 years that are 8-10 m high and have 16 pairs of lateral branches to aid harvesting of single fruit. The tree does not suffer from serious pest and disease attack but windbreaks can help to reduce wind damage to leaves and fruit.

Fruit are mature when they turn purplish-violet and detach smoothly

from their stalks. They should be picked by hand or by using a long pole with hook and basket to prevent skin injury. Fruit can be harvested every 2-3 days over a 6-12 week period, preferably in the cool early morning or late afternoon, and then need to be transported carefully to avoid damage. Marketable fresh fruit can be stored for 4 weeks in a cool room at 5 °C and 85 percent relative humidity. Long-term storage (up to 16 months) is possible if high quality fruit are rapidly frozen at -18 °C or -27 °C.

### *Custard apple (Annona reticulata)*

Custard apple can be propagated from seeds which need to be scarified and soaked in water. Vegetative propagation by budding and grafting is also possible using *A. glabra*, *A. muricata*, *A. squamosa* or *A. reticulata* itself as root stock. Seedlings are transplanted into free draining field soil at about 8-15 months old. Lime and phosphorus may need to be added as fruit size, colour, shape and taste are sensitive to low pH. *Annona* species also have a high demand for potassium.

Spacing can vary depending on the rootstock vigour, e.g. spacing ranges from 6 x 4 m (*A. squamosa* rootstock) to 8 x 5 m (custard apple rootstock). Custard apple's shallow roots mean that windbreaks are needed for new

orchards. Pruning helps to shape, maintain and rejuvenate the tree, as well as to control the timing of harvest and to increase fruit production. If not rainfed, the tree needs regular watering except during fruit set. Fruiting takes place at 3-5 years. Thinning of fruit clusters and the removal of misshapen fruit improve the quality of remaining fruit on tree. Pests include chalcid flies which cause mummification of immature fruit. Ripe fruit can be covered with bags or nets to prevent pest damage.

Fruit are harvested by hand, possibly using a pole with a hook, when they are mature, firm and yellowish-green. Harvesting in the morning, just after dew evaporation, reduces fungal rot infections. The easily bruised fruit must be transported carefully, even wrapping fruit in individual bags for long-distance transport. Cooling extends post-harvest lifespan.

#### *Jackfruit (Artocarpus heterophyllus)*

Jackfruit trees are an excellent, shady tree for home gardens – just one mature tree can provide enough fruit to supply several families. However, some people dislike the smell of the fruit making it advisable to plant the tree at some distance from the home. The tree grows well in any tropical or subtropical soil without saline or waterlogged conditions. Trees grown

from seed are good as rootstocks and for timber production. However, vegetative propagation is encouraged for trees grown specifically for fruit production and commercially grafted varieties are available. Seeds are recalcitrant and must therefore be sown immediately. If appropriate protection from grazing is available, they can be planted directly in the field. Alternatively nursery seedlings are transplanted to the field after 1-2 years (height: 1-2 m) at 8 x 8 m or 12 x 12 m spacings (for orchards) and need staking to prevent wind damage.

Trees grown for timber need no pruning, but the first lateral branches of fruit trees need to be pruned in year 2 to slow growth and spread the canopy. Regular pruning of shoot tips leads to a more compact tree while post-harvest removal of vigorously growing upright shoots, diseased and inner branches allows air and light into canopy. Tree height can be maintained at 4-5 m by selective pruning. A disadvantage of jackfruit is its susceptibility to a wide range of pests and diseases and, in some areas, trees are removed after about 20 years as a result of reduced productivity.

Depending on the variety, trees take four or more years to begin fruiting. Fruit should be thinned out before harvest to prevent their weight damaging the branches and to improve

the size and quality of the fruit. Irrigation in dry periods can improve the harvest. Fruits are harvested by climbing the tree or using ladders and are lowered carefully using ropes to prevent bruising. Immature fruits are harvested a month early for culinary purposes. If fruits are pungent they must be processed or eaten immediately. Mature jackfruit ripen within 3-10 days but fruit can be stored for up to 6 weeks at 11-13 °C and 85-90 percent relative humidity. Although copious latex can make the fruit unpleasant to handle, their different parts can be used and processed in a great variety of ways.

#### *Peach palm (Bactris gasipaes)*

A primary consideration in growing peach palm is whether the target market is fruit or palm-heart. Fruit production requires less densely planted trees (up to 400-500 plants/ha for intensive production), selected for high quality and easily harvestable fruit. For palm-heart, trees are much more densely planted (up to 3 000-20 000 plants/ha) with palms selected for multiple shoot production and good response to cutting.

Seeds germinate after 30-90 days in the dark and then require full sunlight until they are transplanted at 6-9 months. Few management practices, besides fertilizer applications,

weeding and mulching are carried out on fruit-producing trees. For palm-heart, twice-yearly pruning after the first harvest can maintain overall production while strengthening the roots.

Fruiting begins at five years and can go on for 50-75 years. Fruits are harvested on the tree by climbing (spineless varieties) or with poles (spiny varieties). Although fruit bunches can remain in good condition on the palm for some time, once harvested the fruit are highly perishable and need to be refrigerated or treated with fungicide and wax. Processing into flour must take place on the day of the harvest or the following day. Palm-heart similarly needs to be transported to the processing plant on the day of harvest.

#### *Acai palm (Euterpe oleracea)*

Acai fruit are an excellent source of energy, dietary fibre and calcium for many Amazonian families (see Case Study 1). If cultivating the palm commercially, smallholders need to decide whether to target the fruit or palm-heart market. Spacing for fruit production is about 5 m x 5 m, whereas palm-heart production requires spacing of 2 m x 2 m. Propagation of acai palm is usually from seed although vegetative propagation through offshoots is

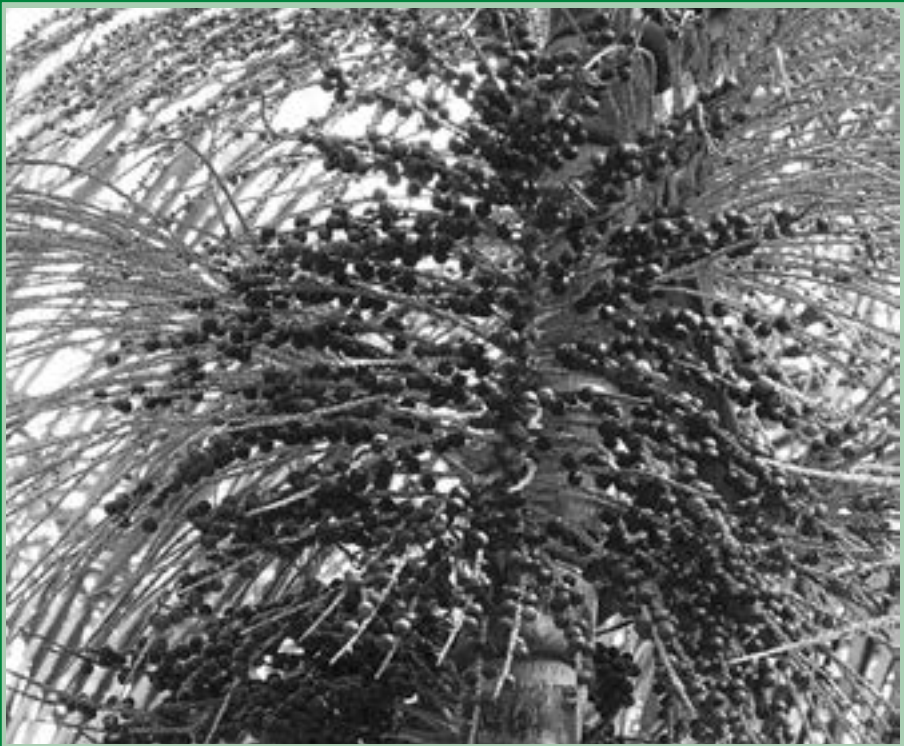
possible. Seeds germinate in the nursery after 20-35 days under low light intensity, high humidity and 25-30 °C. Seedlings can be transplanted to the field after 4-5 months when about 30 cm tall. The seedlings need constant watering and thrive in flooded habitats. They grow well with monthly average temperatures above 18 °C and soils ranging from heavy clay to sandy clay with organic matter.

No major pests or diseases have been detected. The first harvest occurs within 3-4 years. In the

subtropics, large harvests occur in the autumn months. Fruit clusters are harvested by climbing the palm, which can be 15-30 m tall, unless dwarf varieties (Para dwarf) are used or the leader stem is removed to reduce overall growth. Palm-heart is harvested through selective cutting of a number of stems. Acai fruit need to be kept in the shade and transported to markets and processing plants within four days of harvesting to maintain nutrient content (particularly antioxidant capacity) and prevent fruit loss.



FIGURE 12 Peach palm tree (*Bactris gasipaes*)  
(Photo: Centre for Underutilized Crops, University of Southampton/ J. Kengue)



**FIGURE 13** Acai palm tree (*Euterpe oleracea*)  
(Photo: Centre for Underutilized Crops, University of Southampton/ J. Kengue)

#### *Tree tomato (Solanum betacea)*

Tree tomato has the advantage of bearing fruit within 18 months but commercial viability declines after eight years. Its shallow roots make intercropping with annuals difficult. It grows best in a light and well-drained fertile soil, with temperatures of 16-22 °C, in a wind-sheltered sunny position that is frequently rained. The trees are usually sown from seed, which produce erect trees with high branches that are ideal for

sheltered sites. Trees from cuttings develop a short bushy architecture that facilitates harvesting and is suited to exposed sites. Germination is accelerated by washing and drying seeds and then freezing them for 24 hours. Seedlings can be transplanted into the field when 5-7 cm high at a spacing of 0.8 m x 2 m with stakes to prevent the roots being disturbed and to stop swaying. Cuttings taken from wood that is 1-2 years old can be planted directly into the field and

prevented from fruiting in the first year of growth. Seedlings are pruned to a height of 0.9-1.2 m in the first year. Each following year, branches that have already fruited are removed to induce new multiple shoot growth near the main branches, since fruit are produced on new branches.

Mature trees can be pruned in early spring to obtain early fruiting or in autumn to delay fruiting, thus helping to provide fruit year-round. Flowers can self-pollinate but fruit-set is improved with insect cross-pollination. Heavy yields are supported by application of NPK fertilizer in early spring and midsummer, followed by a mixture of superphosphate, nitrate of soda and sulphite of potash in late winter and early spring. Branches may need to be supported when fruit is setting.

Diseases include fungal rot (*Glomorella* spp.) on the fruit stalk and fruit, powdery mildew (*Erysiphe* sp. and *Oidium* sp.) and the aphid-spread bootlace virus which significantly affects the vigour of the tree. Although considered fairly pest-resistant, the tree is attacked by root-knot nematodes in sandy soils and fruit pests such as fruit flies, whiteflies, aphids and the tree tomato worm (*Neoleucinodes* sp.). In non-seasonal countries fruit are produced all-year round and

harvesting is a prolonged and labour intensive activity. The fruit are cut from the stalk and can be packed into paper-lined wooden boxes for market without bruising as a result of their tough outer skin and firm flesh. To extend fresh fruit life, they are refrigerated; otherwise the fruit will deteriorate rapidly.

#### *Safou (Dacryodes edulis)*

Safou trees are usually propagated from seeds, which must be sown within 5 days of harvest. Vegetative propagation through air-layering and stem cuttings is becoming more common as it allows farmers to propagate trees with desired characteristics and can reduce the time of fruiting to just 3 years.

In humid tropical Africa, trees are typically planted as shade cover for cocoa and coffee, or in small orchards at 10x10 m spacing. Fertilizer (including manure) is only applied when planting and the seedlings are transplanted within 5-8 months using stakes to support individual trees. Pests and diseases include *Polyphagous* fungi (affects all aspects of growth and causes post-harvest rot), *Dipterous* insects (leading to continuous shoot growth), *Pyralid* moth (giving leaves a burned appearance), *Nitidulid* beetle larvae (eat seeds) and birds (may spoil



FIGURE 14 *Safou (Dacryodes edulis)*

(Photo: Centre for Underutilized Crops, University of Southampton/ J. Kengue)

fruit on the tree). Female trees have higher fruit production than male trees. Fruit are harvested when fully mature by climbing the tree. In a clean, dry and well aerated place,

fruit can be kept for up to 8 days, but then deteriorate rapidly. The fruit ripen over 2 months, providing an energy- and protein-rich addition to a family's diet.

# Strategies for marketing

Fruit cultivation and all that is required is only one ‘small’ part of the livelihood enterprise. The other ‘larger’ part, as mentioned previously, is the harvesting, post-harvesting and marketing of fruit and/or processed fruit products. Small-scale farmers will need to be well aware of demand, prices, quantities and which markets want what prior to harvesting fruit. Fruits being perishable by nature will require for the fresh market fast marketing and will not allow, pending on type of fruit, very much marketing flexibility. On the other hand processed fruit products, for example jams and fruit juices have a longer shelf-life and may allow for more flexibility in marketing.

Small-scale farmers will need market knowledge and be skilled in marketing operations to be able to successfully commercialise their produce. This may well involve training farmers in such aspects as market research, handling, sorting and grading, packing and storage methods. It is only with good harvesting, post harvesting, processing and marketing skills that small-scale farmers can earn returns that make a fruit enterprise profitable

and hence contribute to enhancing their livelihoods.

## ■ *Assessing market potential*

The potential of fruit trees to support livelihood diversification depends on the farmers’ ability to identify a growing demand for the produce (fresh or processed) and the ability to meet this demand. This requires obtaining as much information as possible about sales trends for the product at different local markets to get a sense of whether the market is expanding or contracting, whether it seems reliable (year on year) and how prices are determined. This is the same kind of information farmers would obtain for marketing any other crops but may be even more important, given the longer-term investment required for tree products. In many cases, producers may wish to begin by targeting local markets. To minimise risks it may be useful to target more than one final market, for example, to one market sell fresh fruits and to another market jams and/or juices.

Once a local market is well established, there may be opportunities for further expansion into urban and possibly national markets.



*FIGURE 15 Obtaining information about markets is essential for successful marketing of fresh fruits*

*(Photo: FAO/16555/ F. Faidutti)*

However there is currently a growing international demand from developed countries, in Europe, America and Asia, for exotic fruit with new appearances, colours and flavours, while produce of high quality, with organic and fair-trade certification is in great demand from Europe.

In deciding which markets to target, producers need to consider two key differences between local and more distant markets:

- Quantity of supply is a key issue for buyers, who expect to receive a known amount of produce at

agreed intervals. Providing larger product volumes to more distant markets increases transport costs and the need for appropriate storage facilities.

- Quality standards become increasingly demanding in more distant markets, with buyers wanting fruit of a particular appearance (size, colour) and taste and as long a shelf-life as possible. For sale to large domestic consumers (for example supermarket chains) and for export, fruit must also meet certain food safety and

hygiene standards. These may require fruit to be cleaned, treated and stored in a particular way and to be certified as free of pesticide or other harmful residues. For organic markets, further certification of the whole production process is necessary with details varying between certifiers. Farmers must understand the specific requirements of their buyer to ensure the successful sale of their produce.

To meet quality and quantity standards of non-local markets, farmers need a higher level of information, more skills and capital to invest in the correct production, storage and transport methods. This increases the risk of the enterprise as much of the capital needs to be invested in advance and there is the chance that buyers may refuse produce because it does not meet their requirements. Collaborating with other fruit producers and processors can reduce the risks and costs for individuals.

### ■ *Associations*

There are many different types of farmer and processor associations. They can be very informal, such as a group of friends or neighbours

sharing the costs of harvesting equipment or transport and sending one member to the market to check prices and competition. However, as market demands become more stringent, it is better to formalise producer organizations to ensure that each producer contributes and obtains a fair share. Depending on the legal options in the country, groups can be registered as self-help groups, enterprise groups, producer associations, cooperatives, etc., each of which may have slightly different requirements in terms of how they are organized. Having a bank account is usually a minimum requirement and this opens up the possibility for the group to obtain credit as well as accessing business development support from various government and project sources.

Having more members enables a producer organization to share the costs of inputs (for example seeds, fertilizer or harvesting containers) and of expensive equipment, such as mechanized pickers, storage or processing facilities, which can then be rented out to members at a low rate. Producer organizations can also provide capacity-building to ensure that all members produce fruit products of an adequate quality. Another key role is to obtain market information, either

directly or by hiring in specialist expertise, on the basis of which fair prices can be negotiated with buyers. A large group of producers offering a high quality and quantity of product may be able to negotiate a better deal with buyers, for example, by organizing an auction or a sale in their district, to which national-level buyers are invited. It may also be possible to negotiate good rates for health insurance (in case members suffer an accident while working) and crop insurance (to protect against the risk of crop failure). A network of producer organizations can even take on a lobbying role to change policies that are constraining trade.

As many fruit products have a very short season, and groups can struggle if they only have a brief burst of activities, fruit producers may benefit from working through pre-existing groups (for example staple crop producer associations) or extending the seasonality of their activities by introducing processing or additional crop activities.

### ■ *Mapping the supply chain*

Producing a supply chain map (see Figure 17) can be a useful exercise for farmers and the organizations supporting them to identify

opportunities and constraints in developing their enterprise. A supply chain map (or diagram) identifies all the actors involved in getting the product from the producer to the final consumer, their function (or the value they add to the product) and the proportion of the final product value they obtain.

Actors in the supply chain include those who produce the raw materials (for example nursery stock, fruit), intermediate products (for example dried fruit) and final products (for example packaged fruit crisps) and any intermediaries. For each of these direct actors, it is important to understand what value they add to the product (for example grading, transporting, processing and packaging, [see Figure 16] etc.) and how they are linked to each other. Many intermediaries, for example, play a critical role not only in negotiating sales agreements between rural producers and urban or international buyers but also in organizing and funding product transport, thereby taking on a large proportion of the risk. However, producers need to find ways to bypass any intermediaries who are earning money without adding value to the product.



*FIGURE 16 Safou fruit packaged in nets to allow circulation of air during transport to market*

*(Photo: Centre for Underutilized Crops, University of Southampton, J. Kengue)*

A supply chain map also identifies the so-called supporting actors, such as NGOs, business and government organizations, who do not handle the product itself but who nevertheless add value by providing services such as business development, insurance, financial, market information, education, training, and research. Finally, a supply chain map identifies the supply chain ‘influencers’ who determine the regulatory framework (for example food and safety standards), policies (for example tree tenure) and infrastructures (for example roads, markets) at the local,

national and international level and within which the small-scale fruit tree sector must operate.

By highlighting the economic costs along the chain, a good supply chain map can help producers to identify how and where further value can be added along the chain to improve their fruit tree businesses. This may involve collaborating with other producers, negotiating deals with processors or specific buyers, or targeting supporting organizations to provide cheaper credits or undertake research, for example, on specific pest problems.

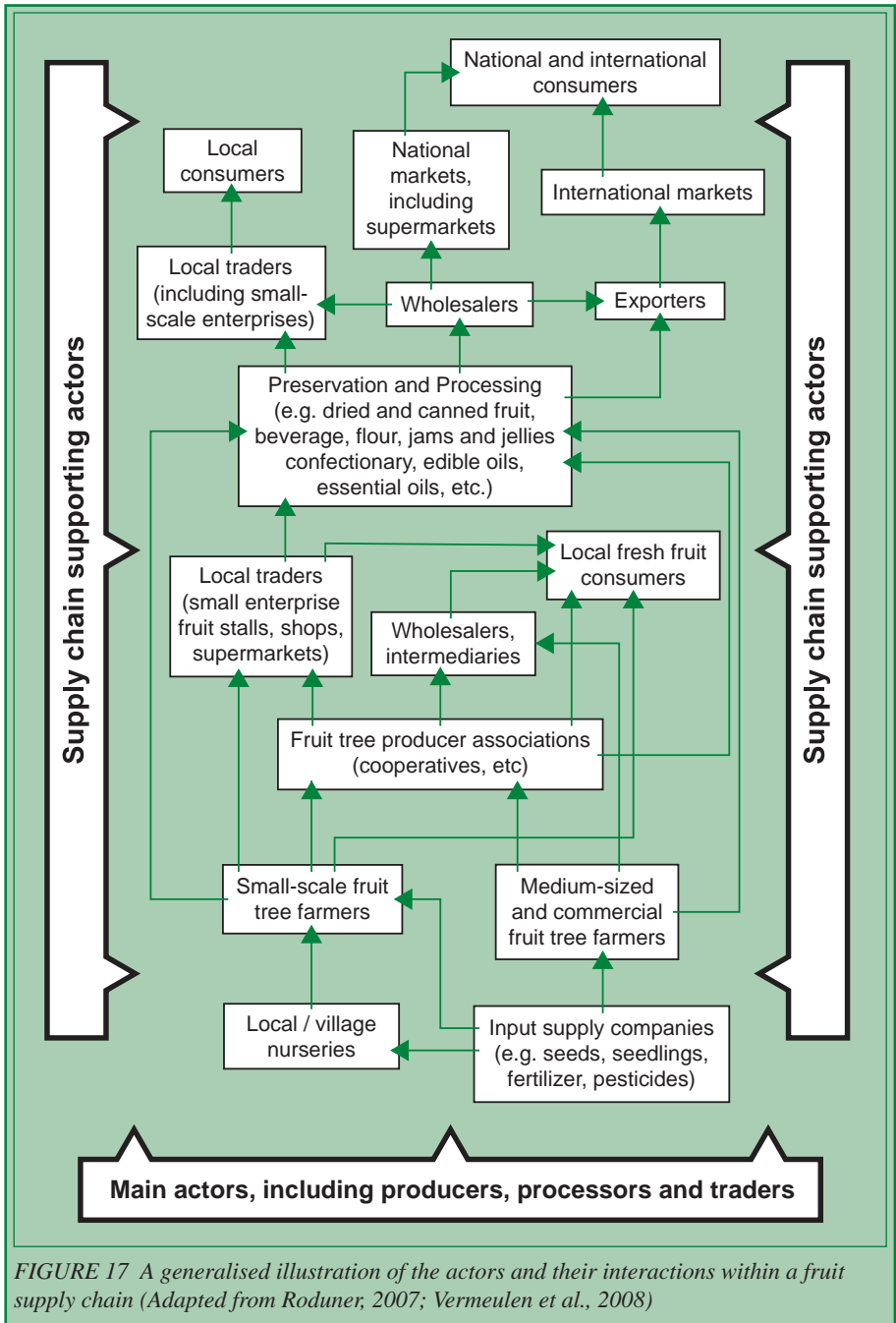


FIGURE 17 A generalised illustration of the actors and their interactions within a fruit supply chain (Adapted from Roduner, 2007; Vermeulen et al., 2008)

*Innovating to keep ahead of the game*

Critical to any business success is the ability to respond to changing market demands to reduce marketing risks and costs and to increase earnings. The more farmers know about how their products reach the final consumer of their product, the better they are able to assess whether the product needs to be changed or whether it might be possible to improve certain steps in the supply chain to increase their profits. Having a good relationship with buyers will reduce the risk of producers being surprised by sudden changes in standards or consumer tastes.

There are many areas in which producers can innovate to improve their chances of sustaining and extending their enterprises. New and improved cultivation and management techniques

of fruit trees, can allow supply of produce to be sustained over longer periods, and in some cases throughout the year, if a range of fruit tree species/ varieties are chosen. Producers can attract buyers by planting new varieties with desired appearance, flavour or shelf-life. Post-harvest losses can be reduced by improving handling during pre- and post-harvest. Innovation in marketing requires developing new relationships with other actors in the supply chain, for example bringing producers together in a larger federation that can negotiate more effectively with buyers, or moving into organic or fair-trade markets. Finally, once confident in fruit production, farmers can also innovate by diversifying into preservation and processing enterprises.

**CASE STUDY 7 Marketing strategies significantly improve livelihoods of small scale jackfruit growers in Asia**

India is the world's second largest producer of jackfruit. However, up to 50 percent of produce was wasted because of inefficient supply chains to markets and processing facilities. The cost and difficulty of getting their jackfruit to market had resulted in farmers selling mainly to middlemen and accepting the offered price. With the support of scientists from the Gandhi KVK (a grassroots vocational and research centre) linked to the University of Agricultural Science (UAS) in Bangalore, small and marginal jackfruit farmers formed the Toobugere Jackfruit growers Association (TBJA). Through the TBJA, farmers pooled their jackfruit and transported them directly to a very large cooperative in Bangalore where they were offered three to four times more than they received from middlemen. The middlemen then doubled their price and many farmers were able to sell locally.



## **CASE STUDY 7 Marketing strategies significantly improve livelihoods of small scale jackfruit growers in Asia (cont.)**

As a result of media coverage for the story through UAS, the demand for jackfruit in urban areas had increased but the farmers were unable to meet the demand. The problem was solved through the launching of jackfruit fairs, where producers earned four to five times more income than they would from selling to middlemen. As a consequence, more farmers are joining the cooperative and 11 jackfruit fairs have been organized in Kerala and Karnataka in 2009.

India is still in the initial stages of adding value to jackfruit. Small-scale food processing units and self-help groups are the main location of jackfruit product diversification. Products such as jackfruit burfi sweets, halwa, salted chips, papads, dehydrated ripe flakes, unripe flakes and tender jackfruit are being sold successfully all year round. A larger processing company is using vacuum dry technology to export frozen jackfruit to America and other countries. At the same time, the Pathanamthitta KVK in Kerala is providing training in the making of jackfruit jams, squashes and juices, which has been positively received in the local community. The development of a unique food grade drier that runs on farm waste (coconut husks and dried twigs) has allowed small-scale processing businesses to flourish, with 3 000 driers in operation in Karnataka and some in Kerala. Local TV shows and chefs at fairs have been demonstrating how the whole jackfruit and its processed products can be incorporated into hundreds of recipes.

The popularity of jackfruit continues to grow in India and has to date, resulted in the tripling of farmers' income and the establishment of multiple small-scale processing units providing livelihoods to large numbers of the urban and rural population.

*Source: Adapted from Padre, S. 2009. Rise of the humble jackfruit, Civil Society, Vol. 6, No. 10*

### ■ **Processing activities**

#### **From cottage industry to sophisticated technology**

Processing fruit tree products can help farmers and communities improve and vary their diet, and increase food security in their locality by extending the shelf-life of fruit. It can also importantly provide opportunities for year-round income generation from the

sale of the products. Depending on the products and the markets concerned, the value-adding technology required ranges from the very simple to the highly sophisticated and can often use equipment that is already in use for the processing of other food products, such as dryers, fridges, freezers, ovens and kitchen utensils. A start-up household-level enterprise can initially use domestic utensils

(see Figure 18) and then progress to equipment, such as presses or dryers, that can be manufactured by local carpenters and metal workshops, thereby providing further local employment. Additional investment of up to US\$50 000 may be needed to expand to a small-scale processing operation. This may involve having a dedicated room for the process and buying or renting specialist equipment, as well as employing additional labour and having access to electricity. As the proportion of material discarded during fruit processing may be quite high, processors need to consider the issue of waste disposal. Fruit processing

produces solid waste (for example rind, seeds) and liquid waste (for example juice wash water), both of which can be attractive to flies and rats unless disposed of properly, for example by feeding to livestock or by burying far from the processing site.

Once in competition with other farmers and other processing enterprises, it is also important to produce attractive packaging, implement quality assurance techniques and develop managerial and financial management skills to run a successful business. By working within a farmers' association, sharing financial burdens, facilities and know-how, the rewards to a processing



*FIGURE 18 A typical fruit cottage industry  
(Photo: FAO/18595/ G. Bizzarri)*

enterprise and the community can more readily be realised. A small-scale processing unit, for example, could be located centrally within a rural community with the costs of setting up and using the facilities divided among the participants. Income can be divided according to the number of hours each individual contributed to the venture and the skills involved. Some processing activities may be particularly suited for people with disabilities or those only able to invest a few hours of time alongside other domestic duties.

When processing fruit, it is important to understand the nutrient value of the raw fruit or nut product, the changes to food composition during processing (taste, texture, food composition), the raw and new product's shelf-life and the micro-organisms that can grow on both. Processed food that has an attractive colour, flavour and texture will sell quickly and at a higher price. Food hygiene regulations should be adhered to and processing techniques (such as heating, removing water, cooling, increasing acidity, using chemicals, and excluding air, light, moisture, micro-organisms and pests) can be implemented to minimise food poisoning and spoilage. Appropriate storage techniques also help to

reduce spoilage of both fresh and processed products. Requirements for local, national and international markets vary, particularly in relation to food safety and hygiene standards, packaging and quantities demanded, so small-scale farmer processors must do their homework on the target market before undertaking large-scale production and may need external support.

### **Diverse products**

Fruit can be processed into a wide range of products (see also FAO Diversification booklets No. 4 and No. 5 *Value from village processing and Processing for prosperity*):

#### *Dried fruit*

Drying fruit is potentially the simplest form of processing, both for home storage and for sale. Dried fruit takes up less space than fresh fruit and can often be stored for over a year. The process requires clean and dry surfaces and a source of heat. A solar dryer (see Figure 19) reaches temperatures that make drying much more rapid than open air-drying. However, ovens may be needed if harvests occur during the rainy season. Dried fruit can be sold in a simple packaging, often as snacks, as in the case of jackfruit fruit leather, or as a cooking ingredient, like dried peach palm-heart.

## CASE STUDY 8 Combining forces to support breadfruit export from Fiji

A quarantine treatment plant, built in 1994 with USAID funds and located beside Nadi international airport in Fiji, provides shared facilities for exporters of aubergines, papaya, mangoes and breadfruit (*Artocarpus altilis*), to heat treat their fresh produce in order to kill pests and their eggs, prior to export. The initial costs of the High Temperature Forced Air (HFTA) oven were funded by the New Zealand government (which imports all four fruits), when the Fijian financial institutions refused to meet the costs. The facility is operated and owned by Nature's Way, a cooperative of around 100 growers and exporters. Eight hundred tonnes of fresh produce was treated for export to New Zealand and Australia in 2005. Market analysis suggests there could be a potential increase of 500- 1 500 tonnes of breadfruit exported to Samoa and Auckland per year as a result of the Samoan demand for the produce. To overcome the difficulties of harvesting this tree, the Ministry of Agriculture, Sugar and Land Resettlement is supporting the establishment of orchards, the development of shorter varieties and the distribution of planting material of new export varieties.

*Source: Adapted from New Agriculturist. 2006. Fijian breadfruit: pest-free and picker-friendly*



**FIGURE 19** A simple solar dryer  
(Photo: FAO/15837/ R. Faidutti)

### *Flour and powder*

After drying (and sometimes boiling), many fruits can also be ground into a flour or powder with a wide range of uses. Flour from peach palm pulp, for example, is added to baby formula and baked goods. The powder or dried pulp of acai berry is mixed to make porridge with tapioca or granola and is eaten salty or sweet. Ripened pulp of jackfruit is dried and ground into powder to flavour drinks while its seeds can be dried and salted as a table snack, or ground into flour to mix with wheat flour for baking.

### *Jams, jellies and confectionary*

Clean containers, water and a source of energy, as well as ingredients like sugar and other flavourings, are required to make jams, jellies and confectionary. While fruit pulp is often used for jams, some fruit rind can also be used in this way. The rind of jackfruit, for example, is used to make jellies, syrups and pectin extracts. Some fruit pulp and rind lends itself to being sliced and crystallised, as in the case of citrus and mangosteen.

### *Chutneys and pickles*

A wide range of chutneys and pickles can be made from combinations of different fruit, vegetables and spices. These may also be a good way to

use immature fruit, as in the case of jackfruit pickle. Another product type is savoury sauces, with the tree tomato fruit providing a tomato sauce substitute.

### *Oil extraction*

Many fruit seeds and most nuts are high in fat content. The pulp of some fruits also have an unusually high fat content, for example peach palm and safou. Extraction usually requires a mixture of grinding or pounding (hard work if done by hand) and boiling, requiring a source of fuel and water. Different storage containers are required depending on whether the oil is liquid or solid at room temperature. These oils and butters are sold as edible oils. Saturated and unsaturated fatty acids are extracted from the seeds of acai palm. Some fruit trees are also the source of essential oils, for example from citrus peel or from the tree resin of safou.

### *Beverages*

Many fruit are suited for making drinks. Fruit flesh can be pulped and mixed with water or milk and sugar and other flavourings as desired. Ground peach palm and custard apple pulp, together with sugar and other condiments, are often used to flavour milk shakes, while juices, smoothies and sodas are made from

the acai berry and tree tomato fruit. These beverages generally need to be drunk immediately or refrigerated.

#### *Alcoholic beverages*

Many fruit such as marula (*Sclerocarya birrea*), peach palm and jackfruit can be used to make alcoholic beverages. This often involves boiling the fruit, adding sugar and fermenting it to produce local brews, requiring access

to clean water, fuel and containers (see FAO Diversification booklet on No. 21 *Traditional fermented food and beverages for improved livelihoods*). Higher grade spirits can be produced through distillation. Some fruits are used to flavour alcohol, as in the case of acai berry which adds flavour to tequila. Clearly alcoholic beverage sales will need to comply with local regulatory laws.



*FIGURE 20 A fruit press*  
(Photo: FAO/PH01567/ INPHO)

### *Animal feed*

When processing, waste products (for example peel or pulp after extracting oil) can frequently be used to make animal feed. This can be as simple as feeding the by-product directly to local livestock, or drying it and forming it into pellets. The residue after oil extraction from peach palm pulp is used as a meal for farm animals and fish culture. The seed kernel of safou is fed to sheep and goats; the ground leaves and seeds of the acai palm are used as animal feed and the fruit rind and tree leaves of jackfruit are fed to sheep, cattle, goats and pigs.

### *Building and industrial applications*

Fruit trees can also be sources of many non-edible products (see FAO Diversification Booklet No.12 *Non-farm income from non-wood forest products*). Palm leaves and stalks are often used for thatching, making mats, brooms and handicrafts. Jackfruit leaves are used as food wrappers in cooking and as serving plates while its latex is used in manufacturing varnish and chewing gum, to mend kitchen utensils and seal leaks in boats and as a rubber substitute. Once at the end of their productive life, fruit trees can provide timber for house construction, furniture, tools and fencing. Some timber, like

peach palm, is of sufficiently good quality for making wood parquet and luxury furniture. Bark and rind of some species can be a good source of tannins for the leather industry while peach palm wood produces a green dye used in the clothing industry. Custard apple leaves also give rise to a blue/black dye product used as a clothes dye. Heartwood chips or sawdust of jackfruit produces a yellow dye for clothes and food when boiled. A red food dye is extracted from the acai berry. Green waste from fruit trees can be used as a mulch or composted to provide a soil improver. Finally, many fruit trees can be marketed as ornamental plants within the gardening industry, including citrus, peach palm, jackfruit and safou.

### *Canned fruit*

Canning requires containers and a source of energy, a level of technology that may be beyond household-level food preservation. However, canning allows for many fruit tree products to be marketed internationally as in the case of peach palm fruit, jackfruit pulp and seeds. Care needs to be taken that delicate flavours, like those of mangosteen, are not lost in the canning process. Palm-heart is considered a delicacy by consumers and is widely canned

for export from Ecuador, Costa Rica, Brazil, Suriname and Guyana.

### *Desserts*

A wide range of processed desserts can be made using tree fruits. Ice creams are flavoured with acai berry, tree tomato, mangosteen and custard apple fruit, while the pulp of mature jackfruit is combined with milk to produce an orange custard. The flesh of custard apple is mixed with banana and cream to produce a sauce for cakes and puddings and mangosteen puree and tree tomato fruit are used to make toppings for ice cream.

### *Cosmetics*

There is a growing interest in using fruit products in cosmetics, in part because consumers enjoy products with different smells and may be attracted by the inclusion of 'exotic' fruit ingredients. Pulp flour of peach palm is used in soaps and other products, while peach palm seed fats are used in cosmetics and soap. Oil is distilled from safou fruit pulp, seeds and wood pulp for cosmetic and industrial uses. The acai berry oils are added to moisturising creams. The rind of the mangosteen is used as a lotion and is a known ingredient of soap, shampoo and conditioners.

# Support services to promote fruit as a livelihood

Encouraging the integration of fruit trees into farming systems as a means of diversifying livelihoods requires support of various kinds, ranging from technical to organizational and research support. In addition to government extension services, NGOs and farmer organizations as well as the private sector and researchers have an important role to play.

## ■ *Access to support services*

One of the major challenges facing smallholder farmers who wish to diversify into fruit tree production is identifying a source of extension advice and guidance. More often than not, it is unclear whether fruit trees fall within the remit of the agriculture department, forestry department or horticultural services. Farmers not only need advice on how to plant fruit trees, but also on how they interact with other cropping species in terms of land and labour requirements. Furthermore, they need help understanding the markets to ensure they select appropriate species and varieties, and support in

establishing processing activities. This kind of advice does not all have to be provided by government extension services but farmers need an initial contact who can direct them to other organizations that can provide more detailed information. Fact-sheets and posters exist for many species (see the *Selected further readings* and *Sources of further information and support sections* at end of booklet) and can be adapted for local use and disseminated through local agriculture departments, farmers' organizations or NGOs. Radio programmes can also be a useful means of reaching farmers with poor access to support services.

## ■ *Availability of diverse seedlings*

Beyond the most well-known species, such as mango and avocado, it may be difficult for farmers to locate seedlings of the trees they wish to plant. Interested farmers can be helped to make exchange visits to learn how to set up community or individual nurseries. Training in vegetative propagation techniques like grafting and air-layering to enable farmers

to multiply their favourite trees is a good way of combating this problem and can be achieved through Farmer Field Schools (FFSs). Where farmers develop a particularly successful new cultivar, they need to be helped to ensure their intellectual property rights by naming and registering the cultivar to ensure that they reap the benefits from any widespread commercial planting.

To ensure adaptability to future environmental change and to meet changes in consumer demand, it is necessary to conserve existing genetic variation as an input to both

commercial and participatory tree-breeding programmes. The best way of achieving this is by propagating the different varieties in orchards near their areas of origin, backed up by orchards in other areas. Seed gene banks are also important but are not appropriate for species such as safou or mangosteen which have recalcitrant seeds that do not survive drying and freezing. Jackfruit germplasm tends to be maintained in *ex situ* orchards but these are costly to establish and maintain. A better option is to encourage farmers to conserve diversity at farm or community level.

#### **CASE STUDY 9 Community orchards to conserve peach palm diversity**

The peach palm is considered the only domesticated palm of Mesoamerica. Its domestication has come about as a result of regional domestication by Native American groups throughout the Andes region. Its great biological diversity is a result of its broad geographical distribution from north eastern Honduras to central Bolivia and it has great potential as a food or cash crop within a smallholder farm setting. Collections of germplasm have come from Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Nicaragua, Panama, Peru and Venezuela with germplasm banks in all countries except Bolivia. Farmers in Peru are encouraged to manage peach palm as a future genetic resource through emphasising commercial gains realised through appropriate management practices. ICRAF has developed a network of farm-community level seed orchards using peach palm germplasm chosen by farmers in the field. The orchards therefore represent a means by which farmers earn an income, while conserving the biodiversity of peach palm varieties.

*Sources: Adapted from (i) Mora U.J., Weber, J.C. & Clement, C.R. 1997. Peach palm. Bactris gasipaes Kunth. Promoting the conservation and use of underutilized and neglected crops, Institute of Plant Genetics and Crop Plant Research, Gatersleben/ IPGRI, Rome. (ii) Perez, A.M. 2008. Peach palm (Bactris gasipaes Kunth), PAVUC Biannual Newsletter, June 2008: 5, SCUC, Southampton, United Kingdom*

### ■ *Hire services*

The need to hire extra labour or contract in pest and disease experts depends on the size of the farmer's fruit tree venture. In the case of just a few trees, harvesting and management is usually undertaken by members of the household. However, for higher planting densities, additional or more specialised labour and equipment may need to be employed at certain times (see FAO Diversification booklet on No. 19 *Hire services by farmers for farmers*). Extension services may be able to provide advice or help farmers with similar needs to establish collective modes of working such as rotating labour and sharing costly equipment.

### ■ *Financial services*

Farmers wishing to establish a nursery, a small plantation or a processing enterprise for all but the most well-known fruit trees will find it difficult to access formal sources of credit. Lenders dislike such agricultural ventures because smallholder farmers have little or no collateral, fruit production is seen as unreliable and the markets are not well understood. Where demand is high, the private sector may contract with farmers to supply certain quantities of fruit, even covering the costs of establishment. Extension

organizations can support community members in setting up an association or a formal cooperative to combine resources, as well as facilitating access to a bank account and credit. Governments can also play a policy role by directing banks and rural credit institutions to facilitate natural resource production activities.

### ■ *Business skills training*

For anything more than farm-gate sales, farmers need basic business skills to enable them to manage their fruit tree enterprise in the most profitable manner. Literacy and numeracy are basic requirements which are often a stumbling block for older and women producers, in particular. In addition, producers need accounting skills and help in preparing and implementing business plans. Mentoring by experienced business-people can be very helpful during the early stages of establishing a fruit tree enterprise, as can working in a group so that members can learn from and with each other.

### ■ *Market and transport infrastructure*

High transport costs and the loss of perishable produce as a result of poor storage facilities are serious constraints for small-scale fruit producers in expanding their

enterprises. The state of a country's transport infrastructure, as well as the existence of road checks, greatly influence how quickly and in what condition fruit reach more distant markets. The availability of appropriate packaging material such as wooden crates, polystyrene bags or boxes, cardboard boxes, etc., may also be critical. Municipal authorities can make markets more accessible to small-scale traders, particularly women, by investing in market security, lighting and storage facilities.

#### ■ *Access to technology*

Processing technology needed depends on the requirements of the market. Simple dryers or presses can be manufactured locally, while some basic kitchen equipment such as blenders and pressure cookers can be purchased in larger towns in shops selling electric goods. More sophisticated technology may need to be imported. In this case an important consideration is whether the seller will provide support in setting up and servicing the equipment and showing buyers how to use and maintain it correctly. This is essential if producers want

to retain the key characteristics of their product such as flavour and vitamin/antioxidant content and be sure to meet food safety and hygiene standards consistently. Food fairs are a good way of enabling producers and processors to exchange information and make the contacts necessary to establish or develop their enterprise.

#### ■ *Role of advisor*

The needs of farmers wishing to start up a small-scale fruit farming enterprise are varied in nature. Advisors can assist farmers to meet consumer demand by bringing them together with others who have similar interests or specialist expertise, whether in government, NGOs or farmer organizations. An important role for a local advisor is to draw on existing indigenous knowledge, for example on which species grow well in the area and with local crops, and combine this with scientific knowledge, for example on particularly successful cultivars or new processing and marketing techniques. Where knowledge gaps are identified, advisors can help to locate solutions and transmit these to farmers using a range of local media.

## CASE STUDY 10 **An advisor's role in reducing the detrimental effects of a fungal pathogen on durian fruit**

Durian fruit (*Durio zibethinus*) is very popular in Southeast Asia for its flavour. But its production has recently been affected by the fungal pathogen *Phytophthora palmivora* which affects all aspects of growth, causing leaf blight, seedling and tree dieback, patch canker of the trunk, root rot, and pre- and post-harvest fruit rot. The waterlogged conditions which are common practice in durian production, combined with the high use of nitrogen fertilizer in durian plantations, high density monocultures and poor varietal resistance, all provide ideal *Phytophthora* growing conditions.

A project funded by the Australian Centre for International Agricultural Research (ACIAR), and led by Dr David Guest, developed an integrated disease management (IDM) regime for farmers to control the growth of the fungus. IDM targets the spread of *Phytophthora* from the soil into the tree canopy and from one tree to another. A multiple cropping system is encouraged that includes fruit trees, timber and vegetables, discouraging the build up of the fungus in the soil. The addition of decomposing wheat straw and chicken manure releases ammonia and volatile organic acids which kill the pathogen, while added organic matter stimulates competitive and antagonistic micro-organisms to grow. Farmers are encouraged to harvest fruit on the tree rather than allowing ripe fruit to fall to the ground.

The project has also trialled injecting a water-soluble and inexpensive chemical solution called phosphonate directly into the durian tree trunk, finding that it successfully controls the pathogen if applied at the correct time in the tree's growing cycle. Farmers can reduce the cost of applying phosphonate by sharing the cost of injectors and drills as each tree only needs to be injected once or twice during the year. If the fruit produces only 1-2 extra fruit, the cost of the injection is covered, while the treatment can increase fruit yield by 20 to 40 fruit per tree per year. Together, these initiatives are helping to overcome the pathogen and lead to a sustainable supply of durian fruit in Viet Nam, Thailand and Australia.

One of the main aims of the project was disseminating these recommendations to farmers through training courses, written media, radio and television, growing associations and demonstrations. An annual durian fruit judging competition at the Southern Fruit Research Institute (SOFRI) in the Mekong Delta has provided an opportunity for extension officers to speak to the attending farmers about the IDM recommendations. However, the most effective means of disseminating the information has been from farmer to farmer.

*Source: Adapted from Hein, T. 2006. Cures fit for a King, New Agriculturalist*

# Challenges

## ■ *Regulatory barriers*

If farmers wish to cultivate indigenous fruit trees they may be constrained by conservation-based laws and regulations. This is because many countries have complex regulations in place to prevent or minimise the collection of fruit from wild trees (for example in forests) and apply these same regulations even when the fruit originate from cultivated indigenous trees. As a consequence farmers may have great difficulty in obtaining permits to harvest and transport indigenous cultivated fruits. Clear and well-communicated regulations on the harvesting and transport permits available for individual fruit tree species are needed in each country.

## ■ *Water*

A water supply that can be made available through an irrigation system can greatly enhance the cropping yield of fruit trees if dry spells are common in the locality where the trees are being grown and the species is prone to drought stress. In such situations, extension organizations, health care services, businesses, financial institutions and community

organizations could collaborate to set up such a system that will add value to the fruit tree venture. Clean water is also needed for most processing enterprises.

## ■ *Quality germplasm*

A large proportion of fruit tree germplasm comes from locally domesticated varieties. The trees produced from these seed sources can be variable in fruit quality, quantity, pest and disease resistance, stress tolerance, etc. Clonal selection provides greater assurance to the farmer of the traits to expect in the offspring. Through greater participatory germplasm selection, covering large geographical locations (national and international) a greater choice of acceptable market varieties of fruit tree species would become available to the nursery grower and farmer. Repositories for a selected number of underutilised fruit tree species are available in government institutions around the world, in the form of seed and tissue culture repository genebanks and in situ and ex situ fruit tree orchards. In many cases, the repositories are poorly funded and the numbers of

accession lines are limited. Little research is going into the breeding of true cultivars. By encouraging and supporting farmers (through government policy and funding) to take part in the selection of new varieties of fruit tree species, the genetic diversity within individual species can be conserved, while providing a means of improving farmers' livelihoods. These farms can become sites of underutilised fruit tree genetic conservation.

#### ■ *Land and tree tenure*

For people with no land of their own, it may be difficult to obtain the agreement of land owners to allow them to plant trees on rented land. This issue may be particularly problematic for women who, in some countries, have no legal or customary rights to own land and/or own a tree they have planted on family land. Even where women are unable to own trees, they are frequently responsible for the cultivation, management, post-harvest, processing and marketing of fruit tree products without necessarily receiving any of the monetary benefits. Where market demand suddenly increases, fruit products previously in the women's domain may get taken over by men as related profits increase. Women's groups may be one way of enabling

women to rent land, establish nurseries and plantations and engage in marketing and/or processing of fruit products.

#### ■ *Processing and storage*

A high percentage (often 25-50 percent) of fruit produced from fruit trees is lost as a result of poor harvesting and post-harvesting techniques, as well as a lack of knowledge on how to store and process these fruits. This can dissuade farmers from starting a fruit tree enterprise or lead them to neglect already established trees. To avoid such disappointments, it is critical that sufficient information and expertise on storage, processing and marketing is available, together with any required resources like clean water, energy and credit, before farmers start fruit tree enterprises.

#### ■ *Gender and the disabled*

The key challenge for women and the disabled who wish to diversify their livelihoods through fruit tree enterprises is access to the necessary resources – land (as discussed previously), labour, skills and capital. These challenges may be overcome by working in a group with others or in a family enterprise so that tasks can be divided according to each person's capacity. As women and the disabled

may be particularly lacking in formal business skills, targeted provision of literacy and numeracy classes may help to empower these groups to engage in business activities. Accessing markets away from home may be difficult for women in some cultures, requiring a focus on local sales or collaboration with male producers or traders.

#### ■ *Processing: Technology, repairs and quality assurance*

While basic processing equipment is often available locally, specialised presses, distillation equipment or canning machines may be difficult to obtain. Even where producers manage to identify suitable machines, it may be impossible – particularly for producers in remote locations – to obtain the necessary support to use and maintain the equipment correctly. Ensuring the availability of spare parts and technicians capable of carrying out repairs as needed is another major challenge as is the lack of quality assurance staff to ensure products meet necessary standards. Much of this expertise may be available in national food research institutes but more efforts are needed to share it with producers and entrepreneurs, for example through demonstration days in a range of localities.

#### ■ *Power sources*

Simple processing can be carried out using air- or solar-drying techniques and wood-burning stoves. However, more sophisticated products require a reliable and consistent source of energy, usually electricity. If the business is small, a generator may provide sufficient energy, but for more elaborate processing activities access to electric mains is an essential prerequisite for efficient processing.

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# Sources of further information and support

## **Food and Agriculture Organization of the United Nations**

Agricultural marketing linkages

<http://www.fao.org/ag/ags/agricultural-marketing-linkages/en/>

Food and agricultural industries

<http://www.fao.org/ag/ags/food-and-agricultural-industries/en/>

Horticulture and Industrial Crops

<http://www.fao.org/agriculture/crops/core-themes/theme/hort-indust-crops/en/>

Post-harvest management

<http://www.fao.org/ag/ags/post-harvest-management/en/>

Rural Finance Learning Center

<http://www.ruralfinance.org/>

## **Global horticulture initiative**

<http://www.globalhort.org/>

## **International Fruit Tree Association**

<http://ifruittree.site-ym.com/>

## **The International Fruit and Vegetables Alliance**

<http://ifava.org/default.asp>

## **International Institute of Tropical Agriculture**

<http://www.iita.org/>

## **International Society for Horticultural Science**

Chronica Horticulturae

<http://www.ishs.org/chronica/>

## **The Fruit Tree Planting Foundation**

<http://www.ftpf.org/>

**University of Southampton**

International Centre for Underutilised Crops, Southampton, United Kingdom

*<http://www.cropsforthefuture.org/>*

**World Agroforestry Centre**


*<http://www.worldagroforestrycentre.org/>*

**World Health Organization**

*<http://www.who.int/dietphysicalactivity/fruit/en/index.html>*

Notes

Notes



Growing fruit as an enterprise requires only a very small plot of land, commonly a home garden, some labour and minimal capital. The fruit enterprise can provide a plethora of products: fresh fruit, jams, juices, chutneys and pickles. By-products can be used for fermented products such as fruit wines, fruit waste can be used for animal feed, while fruit seeds and nuts can be pressed for oil. Fruit provides a number of benefits, with important nutritional elements that contribute to improve diets, help support family food security and are an important source of income when sold fresh and/or processed. Fruit trees provide also numerous benefits to the natural environment and to the sustainability of other farm-based livelihood enterprises.

Encouraging and promoting fruit trees as a viable enterprise to small-scale farmers can only but enhance livelihoods. It is hoped that policy-makers and development personnel recognize the numerous opportunities that producing and marketing fruit can bring to small-scale farmers.

ISBN 978-92-5-107069-7 ISSN 1810-0775



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