Growing vegetables for home and market

FAO Diversification booklet 11

Diversification booklet number 11

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Table of contents

Table of contents

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 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.

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' guidlines. 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.

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Contribution of vegetable production to sustainable livelihoods

Vegetables can make a significant difference to smallholder livelihoods. Vegetable production needs only a small area of land, with minimal capital outlay and can provide access to a valuable food under subsistence conditions, but also has the potential to provide an initial step towards establishing an income base for poorer households.

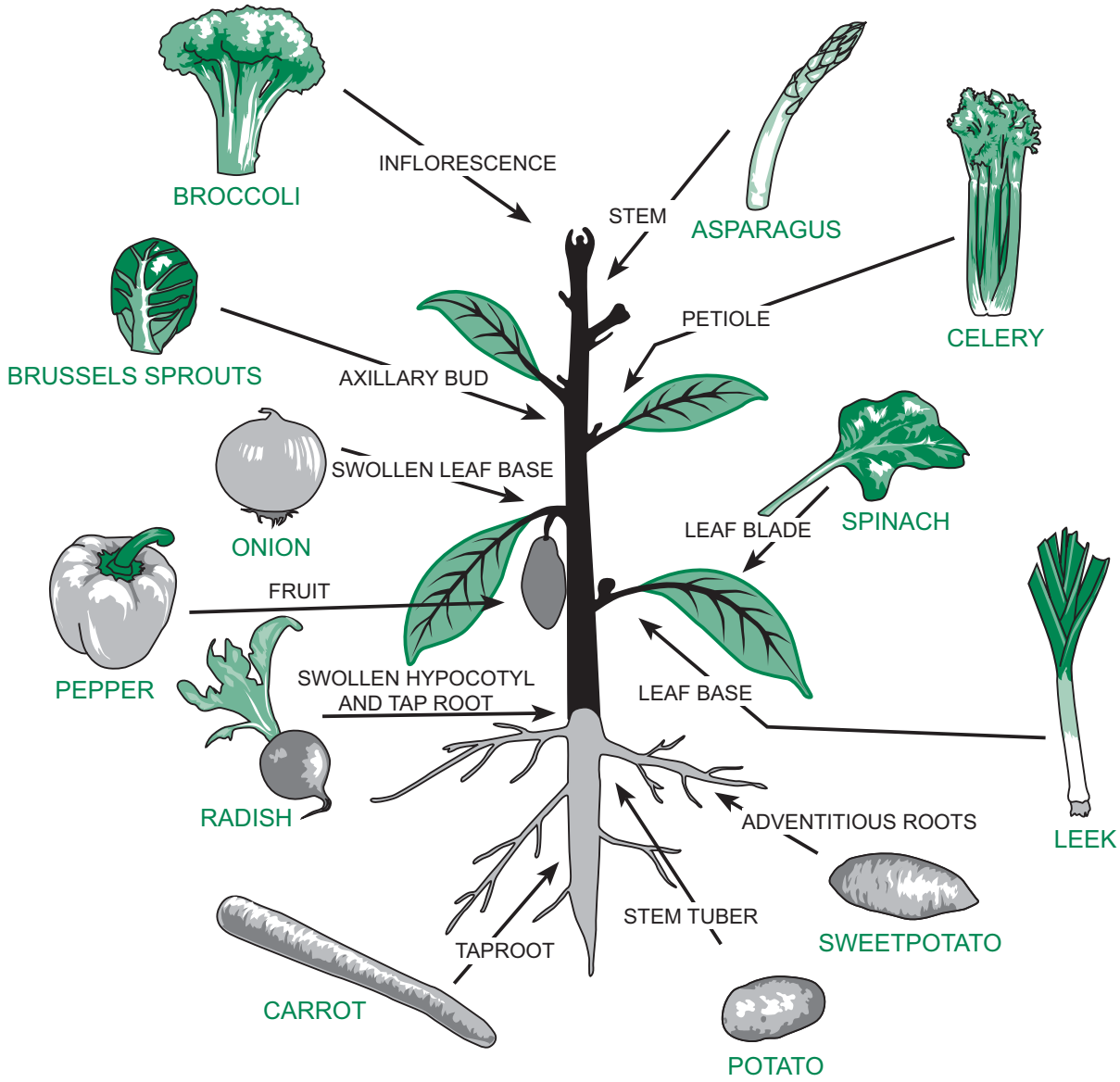
Vegetables form a large and diverse commodity group: although they do not have botanical features in common, they generally share similarities in cultivation methods. For example, tomatoes, melon and watermelon are commonly classified as vegetables, although traders and consumers classify them as fruits (which botanically is correct).

Usually smallholders intensively cultivate vegetables in gardens, and promoting vegetables in gardens can help smallholders in a number of ways:

- it provides vegetables at a low cost;
- it provides a regular supply of vegetables;
- it provides a more varied diet for the farm family;
- it can teach smallholders how to grow vegetables: test cultivation practices carried out in a garden are less risky and less costly, than if vegetables were planted on a larger scale;
- it allows for testing out vegetables that were never planted before;
- it can provide income from the sale of vegetables;
- it can provide gender employment and gender participation in economic activities;
- it can provide employment for the disabled and the elderly.

However, even though home gardens provide advantages for smallholders, often they are seen as small and complicated for inclusion in development programmes. This requires appraising diverse and often location-specific economic, cultural and environmental conditions in traditional farming systems. However, policy-makers and advisors need to integrate vegetable gardens into development programmes and provide training and promotion for

FIGURE 1 Plant parts as vegetables



Source: FAO. 2001. Principles and practices of small and medium scale fruit juice processing, by R. P. Bates et al, Agricultural Services Bulletin No. 146, Rome. (Adaptation by Fabio Ricci.)

such initiatives. For more information on garden horticulture refer to FAO Diversification booklet No. 2: 'Livelihoods grow in gardens'.

Most vegetables are bulky and perishable, in contrast to staple foods that can be stored. As a result of improved roads, vegetable production has developed in areas where land and climatic conditions are good. Improving livelihoods is not only based on increased vegetable production yields, but also on parallel improvements in associated infrastructure, post-harvest and marketing activities.

Purpose of the booklet

The examination of the basic principles of vegetable production and marketing for smallholders and how this can contribute to sustainable and improved livelihoods is the purpose of this booklet. Basic vegetables that are easy to grow can contribute significantly to livelihood diversification and sustainability. This can in turn affect smallholder incomes and have an overall positive effect on local communities. Vegetables provide economic, social and nutritional benefits and importantly can provide gender advantages and an effective means to enable people with disabilities to make a contribution and be part of the development process. By highlighting the most important basic and easy to grow vegetable production systems, potatoes, onions and shallots, but also more advanced speciality production systems, such as greenhouse tomatoes and lettuce, and field asparagus, it is hoped that policy-makers and development personnel will recognize the opportunities that are available for producing and marketing quality vegetables.

FIGURE 2 Woman working on her vegetable garden in Viet Nam
(Photo: © FAO/21343/J. M. Micaud)

Vegetables for health

Vegetables play a major role (along with fruit) in supplying the essential minerals, vitamins and fibre, which are not present in significant quantities in staple starchy foods. Vegetables are usually consumed as a side dish with starchy staple food to add flavour to a meal.

Although they are consumed because they are tasty, healthy and supply both proteins and carbohydrates, vegetables are most important as a source of nutraceuticals (vitamins and minerals) and as protective nutrients for human health. For example, tomato fruits contain lycopene (a valuable anti-cancer and

CASE STUDY 1 Vegetable gardens and vegetable development in the state of Kerala, India

Vegetable cultivation was introduced by marginal farmers on their garden lands as an inter-crop in the 1960s. In the initial years, ponds and wells were used for irrigation, employing primitive methods. These farmers obtained plentiful surpluses in the initial years and gradually vegetable cultivation began to spread into paddy-fields.

The pattern of vegetable cultivation underwent significant changes. In the beginning, vegetables were cultivated only during summer, after two seasons of rice cultivation. But when land demand for vegetable cultivation increased and rice cultivation turned increasingly uneconomic, landowners began to restrict cultivation of rice to one season and to lease out land for vegetable and banana cultivation for the rest of the year.

Different systems of vegetable cultivation emerged, they included: **1** the owner himself cultivated vegetables in wetlands; **2** the entire wetland getting leased out to tenants and marginal farmers where they cultivated vegetables; **3** owner-cum-tenant cultivation. In this case, small and marginal farmers cultivated vegetables on their own lands and on leased-in lands. Marginal farmers and landless agricultural labourers were able to generate reasonable profit margins from vegetable and banana cultivation. A large number of them were able to buy small areas of paddy-fields for vegetable cultivation: they stopped rice cultivation altogether and cultivated vegetables throughout the year.

Following the examples of marginal and small vegetable cultivators, medium sized landowners also took to vegetable cultivation as they found that vegetable cultivation was profitable. This is a specific example of larger cultivators adopting the farm practices of small and marginal cultivators.

With the spread of vegetable cultivation merchants from various markets started coming to production centres on all days ridding the cultivators of the burden of carrying their produce to market centres. In certain areas though, farmers hired motor vehicles to carry vegetables to market centres.

Source: John, K. K. 2004. Crop rotation in Kerala, a case study of the Kaduthuruthy block, Kerala Research Programme on Local Level Development, Centre for Development Studies, Prasanth Nagar, Ulloor.

anti-cardiovascular chemical), carrots contain carotene (precursor of the essential vitamin A), and many fresh vegetables contain vitamin C.

Vegetables at the household level

Vegetables are an important source of food for the household. Although the actual quantity of carbohydrates, protein and fats may be limited in some cases, the real value of vegetables lies in the minerals, vitamins and fibre present in fresh vegetables. When a household produces vegetables on their own land, freshness is guaranteed.

Vegetable production is a form of intensive agriculture. Large volumes of produce can be obtained from very small areas of land, so long as the plants are provided with adequate water, nutrients and pest and disease management. In the field (with good management practices), for example, onion yields of 5kg/m^2 and cabbage yields of 4kg/m^2 (90 days from planting) are achievable.

Fresh vegetables are an important part of the human diet and surplus vegetables usually find a ready market, and have the potential to provide a valuable new source of family income. As familiarity with vegetable production technology increases, the rewards for developing agronomic skills will increase and the potential for increasing financial rewards will be enhanced.

When promoting vegetable production, emphasis should be put on the potential to provide good nutritious food for the family, while at the same time developing the concept of marketing surplus produce for cash.

Gender-focused initiatives

In many developing countries, women and children primarily undertake vegetable production. It is important to ensure that they also participate in sharing the benefits of their labour, especially as vegetable production enterprises become more commercialized. This requires that women and youth be involved in marketing their produce, but also retaining control over the money they earn. This will not only allow women to be more self-sufficient, independent and increase there capabilities of looking after the family, but will also improve their social status in their families and in their communities. It may be necessary to undertake some gender-sensitization activities in the community to ensure people understand why it is important that people are rewarded for their efforts. It may also be necessary to find innovative ways of strengthening women's control over their earnings, for example by promoting group savings.

FIGURE 3 Students at school also learn about vegetable production, Peru
(Photo: © FAO/18908/G. Bizzarri)

Opportunities for the poor and the disabled

The cost of starting vegetable production is not excessive provided that land is available; garden and communal land vegetable production has a very low entrance cost. Water and access to it is often the key factor in vegetable production: without irrigation, it is not possible to exploit the income potential of the dry season when returns are at their highest.

For the disabled, clearly depending on the level and type of disability, vegetable production offers opportunities. Vegetable production normally requires physical mobility, but this depends very much on the type of crops grown and where and how they are grown. Many of the vegetable production operations are repetitive, and can be adopted by people with learning difficulties.

Technical knowledge and skills

Vegetable production, like all other aspects of primary production, requires a wide range of skills. Some of these skills, for example, harvesting at the correct stage of maturity, at first sight appear to be simple, but in many cases are only

FIGURE 4 A roof vegetable garden in Senegal; harvesting aubergines
(Photo: © FAO/22109/J. Koelen)

acquired by experience. Other key areas of expertise include using appropriate sowing (or planting) dates, correct plant spacing, fertilizer rates, choice of site, weed control, irrigation strategy, pest and disease management, etc. These sound agronomic skills must be linked also to good marketing skills.

Peri-urban and urban agriculture

Today almost 50 percent of the world population lives in urban areas. The urbanization trend is expected to continue and even to accelerate, especially in Africa and Asia. This phenomenon has given birth to an increased demand for fresh fruits and vegetables, which needs to be met by new production areas combined with more intensified crop management in order to raise the productivity per unit of land and water. It has been forecast that the uncontrolled growth of cities will lead to poverty and malnutrition for more than 600 million people by 2025.

The intensification of urban and peri-urban horticulture production systems to secure year-round supply of fresh horticultural produce to

urban population is a component of FAO's interdisciplinary and multidisciplinary programme on 'Food for the Cities'.

Horticulture within and around the cities is already a preferred activity for many unskilled migrants. Individual households garden on small plots, roadsides, terraces and patios, to feed their family and also to sell produce.

City farmers have developed small and medium sized market gardens specializing in the production of vegetables for sale in city markets. This activity is becoming more popular, especially as it provides employment and income for women and young farmers.

FIGURE 5 Urban agriculture in the historic centre of Sana'a, Yemen
(Photo: © FAO/20861/R. Messori)

Opportunities: finding out what the market wants

Vegetables have a good potential and offer numerous opportunities. Vegetables are of use for family motives, such as a more varied diet, improved nutrition, etc., but they can also be sold, for example to neighbours, to a local market and to visiting traders and can also be processed, for example, fresh tomatoes can be processed into tomato puree or dried and pickled, as commonly done in some Latin American countries.

Importantly in small-scale commercial vegetable production, before it is undertaken and before any production of vegetables is commenced, it is advisable that potential opportunities are verified with potential customers. It is of little use to plant vegetables that do not have a profitable market. Markets can be final consumers markets, such as local village markets, or markets can be business or institutional markets, where vegetables are bought for further use or for re-sale, for example selling potatoes to a processor, who makes chips, selling tomatoes to a school, selling onions to a retailer, who then in turn sells them to final consumers, etc.

BOX 1 Developing and connecting markets for poor farmers

Interventions at policy level in helping farmers to connect to markets are prescribed as:

A stable policy environment

To facilitate private marketing operations. A price stabilization scheme with transparent rules of intervention is preferable to ad hoc intervention, but policy-makers should recognize that even occasional intervention can dampen the incentives for private storage and transportation services.

Building Roads

One of the largest marketing costs farmers face is the cost of transporting goods. Building roads and improving the surface of existing roads reduces both the time and cost of getting produce to market.

Developing market infrastructure

Investing in market sheds, collection points, cold storage facilities and laboratories for testing produce.

Investing in market institutions

Grades and standards become increasingly important with the development of high-value agricultural markets; they can be set by private companies, trader associations, or public bodies, but when common standards are absent the public sector is required to develop them. Once standards have been set, the public sector can also encourage their widespread adoption by providing information, training technicians, arbitration services, and infrastructure.

Enabling cooperative behaviour

Encouraging farmers to market their produce together can reduce marketing costs.

Providing market information

One reason that marketing margins in developing countries are high is that farmers have little information about current prices in nearby markets. Even traders have incomplete information about market conditions. If farmers had better market information, they could bargain for higher prices from traders. If traders had better information, trading would be less risky, so their risk premium would fall. The government and farmer organizations can play a useful role in collecting and disseminating prices and other marketing information.

Agricultural advisory services

Effective and demand-driven agricultural advisory services can enable smallholders to supply quality and reduce the risks they face in doing so.

Contract farming

Contract farming can be defined as agricultural production carried out according to a prior agreement under which the farmer commits to producing a given product in a given manner, and the buyer commits to purchasing it. Often the buyer provides the farmer with technical assistance, seed, fertilizer, and other inputs on credit, while offering a guaranteed price for the output. Proponents of contract farming argue that it links small-scale farmers to lucrative markets and reduces the constraints they face in diversifying into high-value commodities and connecting to markets. Contract farming is not appropriate for all commodities, but it can be useful in making the production of high-value commodities for a quality sensitive market viable for small-scale farmers.

Source : Minot, N. & Hill, R. 2007. Developing and connecting markets for poor farmers, 2020 focus brief on the world's hungry people, IFPRI, Washington D.C.

In all cases, it is important that smallholders are well aware of opportunities that are real and feasible, before they start their vegetable production. All consumers buy to obtain satisfaction, this means that vegetables need to be of good quality, be uniform, be of an expected colour, ripe and have a good aroma. Buying may vary according to age, gender, cultural, ethnical and religious aspects of the final consumer and these all have to be considered, when thinking about what to produce. A method of finding out what various markets want and what consumers want is marketing research.

Financial rewards

The rewards that may accrue from successful commercial vegetable production and marketing depend on the skills of the farmer, and the particular market(s) being targeted. In near subsistence production, the level of skills is unlikely to be high, the productivity low, and the ability of the consumer to pay a high price will be low. The chief advantage will be that the produce can be sold locally, with minimal packaging and transport costs and the smallholder will be knowledgeable of the local community's tastes and preferences. In fact at this level the marketed produce may simply be the surplus of family requirements, and therefore a 'bonus'.

As production becomes more commercialized, the skills required and levels of investment increase. However, although the potential rewards are greater, in terms of higher yields and better quality, the level of risk is increased. Post-harvest and marketing methods become relevant aspects for smallholders, since markets may have a considerable distance from the place of production, for example large urban areas. This means that smallholders need to become familiar with post-harvest and marketing skills.

Producing a crop for an overseas export market has the potential for excellent rewards, but if the market disappears it is possible for the produce to have minimal value domestically. For example, asparagus has little value in many domestic markets, but can provide excellent returns if exported, as the case of Peruvian producers amply demonstrates.

Opportunities and challenges

Opportunities for improved livelihoods

In the short term growing vegetables provides poor families with the opportunity to eat a much healthier diet than one based solely on cereals. A better diet also will enable a much healthier prospect for the family.

Vegetable production on a small-scale is accessible to many. The cost of entry is fairly low and typically the major input required is family labour. In areas though where water is scarce, vegetable production can be costly, this caused by the need for irrigation. Learning the basics of vegetable production is fairly easy and once minimal experience has been gained, understanding more specialized production techniques is not excessively difficult. Importantly training smallholders is essential; a 'learning by doing' approach in vegetable production and support is required.

Surplus produce from a production cycle can be stored for family use or it can be sold providing a source of extra income throughout the year. Normally selling to neighbours and at local markets does not imply excessive barriers that impede entrance, and marketing costs and post-harvest costs are minimal.

In the long term, once experience has been gained in production, growing vegetables provides an opportunity for moving away from subsistence farming towards cash-crop farming, where smallholders start producing for market.

The creation of vegetable trade in some localities represents an opportunity for the poorest members of a population to improve their livelihoods significantly. In rural areas this can contribute to rasing incomes, improving living standards and giving an incentive for rural inhabitants to remain in rural areas and not migrate to urban centres. Improved infrastructure and the creation of links to urban centres, together with the establishment of a service and supply industry, results in an increased standard of living for the rural population in general. The urban poor, which carry out farming in urban and peri-urban areas, have the opportunity of an immediate market on their doorstep for selling their vegetables and earning extra

CASE STUDY 2 Increased production and marketing of vegetables in the state of Kerala, India

The Kerala Horticulture Development Programme (KHDP) was a scheme started in 1994 for promoting vegetable and fruit cultivation with the financial assistance of the European Union (EU). Its support was available in three areas: production, credit and marketing. To encourage and boost vegetable production, it imparted technical and managerial assistance to farmers and provided high yielding seeds. The KHDP made arrangements with commercial banks to provide financial assistance to vegetable growers.

The KHDP also assisted farmers in opening marketing centres near their farms. It operated markets at 98 centres in seven districts. These market centres were set up with the financial support of KHDP with a view to empowering farmers by providing them direct market access, eliminating middlemen. The EU's assistance for the programme ended in 2001. The KHDP was replaced by the Vegetable and Fruits Promotion Council Kerala (VFPCK) with its head quarters at Kakkanad, Kochi. Now the VFPCK is engaged in planning and implementing schemes for developing infrastructure facilities, including cold storage.

Source: John,K.K.2004. Crop rotation in Kerala, a case study of the Kaduthuruthy block, Kerala Research Programme on Local Level Development, Centre for Development Studies, Prasanth Nagar, Ulloor.

income, which will improve their livelihoods. All in all production and marketing of vegetables creates opportunities for increasing rural and urban employment, the possibility of earning income, especially for those typically excluded from economic activities, such as women and other disadvantaged people, and provides quality and varied food for the poor.

CASE STUDY 3 Safe vegetable production in Hanoi, Viet Nam

Since the beginning of economic transformation from a centralized economy to a market economy, vegetable production has increased rapidly in the Hanoi district. In 1991 the vegetable area was 5 100 hectares and in 2002 it reached 8 000 hectares. However, because many smallholders lacked knowledge on production technology and because they were attracted to short term benefits, many smallholders overused chemicals to increase crop yields. This resulted in many consumers being poisoned and in time spurred the first experiments to be held on safe vegetables production in 1989. In 1995 a trial protocol for safe vegetables was established and in 1996 a safe vegetable programme was implemented. This has offered a more sustainable opportunity for smallholders and the area used for safe vegetable production has gradually increased; in 2000 it accounted for 4.5 percent of the total area used for vegetables grown in the Hanoi district.

Source: Dinh Hung, N. et al. 2004. Environmental requirements, market access/entry and export competitiveness for horticultural products from Viet Nam.

FIGURE 6 Training on growing vegetables, Senegal
(Photo: © FAO/22110/J. Koelen)

Challenges: what vegetables to grow?

Some farmers may only be interested in producing vegetables for family needs, others may want to produce for family needs and some surplus sold to a market, others may want to become more commercial and produce a majority of vegetables for sale. This is undoubtedly the first real challenge; ascertaining what the smallholder's objectives are and what is desired. A second challenge is that marketing opportunities are correctly evaluated, before commercial production even begins. The third major challenge is financial support, as there is a clear need initially for some financial assistance. This is followed by providing sound technical advice to ensure that the crop production practices being used are appropriate and further that post-harvest and marketing skills are promoted to smallholders as they become more commercial. All this will be very demanding for professionals involved in organizing such projects.

Marketing research

The key to producing any crop, at any level of commercialization, is to be market driven. Investments of resources for commercial production should only be made when there is an assured market for the produce.

Mastering vegetable production is a fundamental requirement, but it is also important to be able to master marketing. To be able to do this requires marketing research. In learning about vegetable production, smallholders need to investigate such aspects as what time of the year to plant, what water requirements are needed, what fertilizer to use and in what quantities, etc. In very much the same way, marketing research requires farmers to investigate what consumers want, where they are, what price they are willing to pay, the price of produce, how to transport produce to market and what transport facilities are available, etc. Marketing research helps the smallholder learn about all those activities that are required to market their produce.

Marketing research will sensibly reduce the risk of making and taking the wrong production and marketing decisions.

The type of marketing research to be undertaken will clearly depend on commercial objectives. For example, if the objective is simply to supply a local market, then a simple investigation establishing which crops are popular in the market is fundamental, and also what returns can be expected and what are the production costs. This type of marketing research is commonly referred to as rapid market appraisal and more information on this can be found in the selected further readings of this booklet.

If the objective is to produce a crop to market in a town market or large urban centre, for example supplying large wholesalers or retailers, such as supermarket chains, a very extensive marketing research process will be required. This will involve higher costs and time, for it may involve investigating such aspects as: different prices of vegetables in various wholesale or retail outlets, what quantities can be sold at each outlet, quality requirements of wholesalers and supermarkets, minimum residual levels of pesticides allowed, transport costs, etc. Normally this is far beyond the reach of smallholders in terms of costs and time, and benefits can be accrued when smallholders associate into marketing groups. In general, associations will allow for sharing of knowledge about existing marketing conditions, and the sharing of resources and relative costs that can be incurred in carrying out such marketing research.

Typical market research questions

- Where can I sell vegetables?
- How many consumers live in the area?
- Who are the consumers?
- What vegetables do they like?
- What vegetables do they consume?
- Do they want new types of vegetables?
- Do they want processed vegetables?
- What prices do they pay?
- What prices are they willing to pay?
- What quantities do they want?

Marketing information can be very helpful to smallholders in guiding decision-making for production and marketing, for example:

- ***planning their production:*** what to plant, when to plant, how much to plant, how much it will cost;
- ***planning marketing:*** what quantities are required, where to sell, when to sell, who to sell to, what price to sell at and how much it will cost.

Marketing research is a prerequisite for any commercial operation, but it cannot guarantee success. Marketing research cannot fully eliminate risk and uncertainty in decisions about vegetable production and marketing; it can only reduce risks and uncertainties. More information referring to marketing research can be found in the selected further readings of this booklet.

Advisors need to carry out marketing research in areas to see if commercial vegetable production is viable. They need to ascertain competition, processing opportunities, infrastructure needs, etc., in the intended area of interest. They need to provide for feasibility studies, before any interventions are planned. Advisors need to be fully aware of how to train smallholders and smallholders' associations in marketing techniques, if the area proves to be fit for commercial vegetable production.

Test planting of market-oriented vegetables

Test planting of vegetables destined to market is a good method of reducing risks for production and marketing. Smallholders can use small parcels of land, such as home gardens or communal village land to grow vegetables that marketing research has indicated as having a profit potential. Planting a small parcel of land will give smallholders an opportunity to become knowledgeable of the production techniques, if the crop is new to them, and enables them to estimate such aspects as how much they can grow on their land, other inputs that maybe required, costs involved, quality of produce, possible quantities per area planted, etc. It will also give the farmer an opportunity to taste what has been produced and test market the produce by, for example, letting others like friends and neighbours, taste and get their opinion about the vegetable and if they like the vegetable and if they would be prepared to buy it.

If farmers are knowledgeable about market prices, they can calculate the potential of production by deducting their costs of production and marketing and then choose which vegetables seem to be the most profitable. This can typically be done by using a simple gross margin analysis. Advisors need to train and promote such practices among smallholders and smallholders' association. Appropriate management methods are required for planning a vegetable enterprise and a 'learning by doing' approach is recommended. Training in farm management is a prerequisite

FIGURE 7 Test planting in Mauritania
(Photo: © FAO/11667/J. Van Acker)

for any successful vegetable enterprise (see the selected further readings and sources of further information and support at the end of this booklet for more information about farm management training).

Vegetable production

Environmental factors

The choice of which vegetable to grow depends very much upon the environment, in particular temperature and day length.

Temperature

Vegetables may be divided into three major groups, which are determined by their temperature requirements:

- plants able to withstand frost at sub-zero temperatures (e.g. cabbage);
- plants unable to withstand frosts, but able to grow at temperatures between 0° C and 20° C (e.g. potato, tomato);
- plants requiring temperatures in excess of 10° C (e.g. melons, sweet potato).

Some vegetables, for example cauliflower, cabbage and carrots require cool temperatures if they are to provide a high quality product. This type of environment can be found at high altitude in tropical countries, although it is usual for these areas to experience excessively high rainfall.

Day length

Many plants require specific day length for development. A good example of this is onions, which require long days (a minimum of 12 hours of day length for 'tropical' varieties, and even longer (up to 16 hours) for temperate climate varieties in order to develop a bulb. Varieties of onion have been selected which will form bulbs with a day length of as little as 12 or 13 hours for tropical climates, but it is critical to match the variety to the latitude. For example, varieties developed for high latitude and temperate climates will not form bulbs in the tropics, whereas those selected for tropical short-day length climates will form only small bulbs prematurely, when grown at high latitude.

Protected cultivation

Vegetables may also be grown under protective cultivation, for example, greenhouses. This method can be expensive, but has the advantage of producing a far higher quality product, with a lower risk of pest and disease infestations and protection from heavy rains.

FIGURE 8 Vegetables grown in a greenhouse in Syria
(Photo: © FAO/12431/F. Botts)

Soils

Soil type

Soil is not a perfect medium in which to grow plants. It is either too wet, and thus provides adequate water but poor aeration, or else it is too dry and consequently provides adequate aeration but insufficient water. This is why there has been a move towards hydroponic systems, with improved aeration using specialized artificial media such as rockwool, in intensive greenhouse cultivation systems. Nevertheless the bulk of vegetable crops are grown in the soil, because it is what we have in large quantities, it is available, and in most cases there is no economically viable alternative.

Soils are basically of two types. First, mineral soils are derived from the basic rocks, either by weathering in situ, or from the basic rocks transported by erosion to their final site or, on occasions, as a result of volcanic action (volcanic ash, etc.). The second soil type is derived from organic matter, and results mainly in the development of peat soils.

Mineral soil can range from coarse sands to fine clays. The larger the soil particles (the coarser the sand), the better the aeration and the poorer

the moisture holding ability. Clay soils (fine particles) have excellent moisture holding characteristics, but very poor aeration. The physical characteristics of sandy loams, loams and clay loams depend primarily on the relative mix of clay and sand particles.

Soils derived from organic matter (such as peat) tend to have excellent aeration and moisture retention characteristics. Organic matter retains water and aids aggregate formation thus improving the soil structure. Organic matters in soils are materials such as plant and animal waste that have been transformed by soil organisms into soil organic matter. This is normally called humus. Organic matter thus makes nutrients available to plants.

Soil nutrition

For good and successful growth plants require 16 elements. Carbon, hydrogen and oxygen are obtained primarily from water (from the soil) and carbon dioxide (from the air), while the remaining macronutrients (nitrogen, phosphorus, calcium sulphur, potassium, and magnesium) and micronutrients (chlorine, iron, manganese boron, zinc, copper and molybdenum) are absorbed by the roots as soluble ions from the soil. Small quantities of aluminium, silicon, cobalt and sodium may also be required by some specialized plant groups, but are considered as non-essential for most plants.

Irrigation

Soil water relationships

Most vegetable plants comprise 90 percent water content and some such as lettuce have as much as 95 percent. However it is not the water content of the plant that is important, but the quantity of water that must pass through the plant during its life.

The purpose of providing the plant with irrigation, when there is inadequate natural rainfall, is to ensure that the small apertures (stomata) on the leaves remain open. This enables the plant to continue to absorb carbon dioxide from the air, and thereby continue to photosynthesis and have new carbohydrates available to produce further growth. The closure of the stomata is the first effect of plant water stress. This is followed by the plant wilting and finally damaging the plant through overheating. Crop loss occurs once the plant wilts.

The rate at which plants transpire water through their stomata depends primarily on solar radiation, temperature, humidity and wind speed. The role of soil is that of a reservoir for water, and thus the amount of available water in the soil

for the crop will depend on the soil type and the effective rooting depth of the crop. Deep rooting crops are able to tap a larger volume of soil for water than shallow rooting crops.

There is a maximum amount of water that the soil can hold, and this is called 'field capacity'. As the soil dries so the water available to the crop is reduced until, at the 'permanent wilting point' (although there is still water in the soil), it is no longer available for plant roots to absorb. The difference between field capacity and wilting point is known as the 'available soil moisture', and varies with soil type.

For reliable crop yields, irrigation is an important production tool. Even though some crops are able to 'withstand' drought (e.g. sweet potato, sorghum), they will not produce heavy crops if they experience moisture stress.

It is frequently considered that because rain falls as droplets that this is the preferred system of irrigation. Nothing is further from the truth.

Furrow irrigation

Furrow irrigation involves letting water, distributed by gravity, run down furrows that have been made between the crop grown on raised beds. It is the most common system worldwide. This method does not

FIGURE 9 The treadle pump for irrigation in Malawi
(Photo: © FAO/24088/J. Spaull)

provide for a very efficient way of watering, unless land is accurately contoured and there is a consistent soil type.

Drip irrigation

Drip irrigation is potentially the most valuable of the current water delivery systems. It requires very low water pressure (so it is possible to use small pumps), and can be laid on the soil surface, or in some cases actually buried beneath the soil surface. It can also be used as a means of providing the crop with fertilizer (fertigation); incorporating soluble fertilizers into the water by using a diluter.

The disadvantage is that it is relatively expensive, and since the drippers are small and the water pressure is low, it is essential that the water be filtered. On rolling countryside, care must be taken to ensure that special (pressure regulating) nozzles are used to ensure even application of water both on the ridges and also in the dips.

Overhead sprinkler irrigation

Overhead sprinkler irrigation not only requires investment in pumps and sprinklers, but also can pose major problems in obtaining an even application of water. Uneven water application can result in certain parts of the field receiving insufficient water to return the soil to 'field capacity'. Alternatively, applying too much water to certain parts of the field is a waste of water and can also cause leaching (draining) of valuable soil nutrients. Overhead sprinkler systems also wet the foliage and this can stimulate disease problems.

Low cost systems

There are a number of low cost systems which eliminate the need for electric or petrol driven pumps. The treadle pump is a low cost foot-operated water lifting device that can irrigate crops where the water table is no deeper than 8 metres. Water is normally delivered to the crop by furrows or by flood systems.

The cheapest delivery system is the watering can, but this has a number of major disadvantages, in that the water has to be carried from source by hand, delivery is by hand, the foliage is wetted, and the rate of water application exceeds the soil infiltration rate. Nevertheless, it is very useful in nursery situations with young seedlings.

Propagation

Vegetables are propagated (grown) either from seed or by vegetative means.

Vegetative propagation

Vegetative propagation means that the plant is genetically similar to the

mother plant, and this is important when a farmer wishes to propagate a plant with specific yield or quality characteristics. It is commonly used for potatoes, sweet potatoes, etc., where it is desirable to retain all the genetic characteristic of the variety.

Propagation by seed can in certain circumstances result in a considerable variation in genetic characteristics, but has the advantage of providing a reasonably cheap source of propagation.

Seeds

A seed is best described as a living plant in a state of suspended animation. As such it requires being stored in specified conditions. The ideal storage conditions for most vegetable seeds are low temperature (0-5°C). The scope is to slow down the metabolic activities and therefore the deterioration of the seed.

Different types of vegetable seed have different storage properties. Some vegetable seeds have a long storage life, while others have a short storage life. Once seed has been harvested it deteriorates, and all that good storage does is to delay this inevitable deterioration.

The conditions required for germination are primarily a satisfactory temperature (this will depend on the species), moisture and good aeration. The depth at which seed is sown depends on the size of the seed, and should be deep enough to have sufficient moisture available for germination, and yet be close enough to the surface of the soil for easy emergence of the seedling, and also the availability of air.

Saving seed

It is possible to keep seed from many (but not all) vegetable crops by allowing the plants to grow beyond the normal harvest time, but this is a process fraught with risk. Seed production is a very specialized process, and although keeping the seed from some crops, such as peas, beans or lettuce, is possible, it is still a difficult job. One of the main factors that uphold seed quality and thus seed viability for the next production season is when the seed is actually harvested. Seed needs to be harvested when they are ‘ripe’. Further low moisture content is yet another key element in the upkeep of seed viability. Importantly seed drying has to be done carefully so as to avert damaging the seed embryo. Pests and diseases need moisture to grow and develop, hence the drier the seed the better it is protected against such problems. Drying also causes the seed ‘life cycle’ to slow down, thus aging of seed occurs less rapidly and the germination capacity is better maintained.

Seeds do breathe, they require oxygen and produce water vapour, and hence this needs to be considered in storage. Seeds in storage have determined factors which need to be considered: type of seed cultivar; temperature; humidity; and length of storage period. Depending on seed variety and species, with regard to temperature and humidity, the tolerance range for the two factors will change. Importantly constant moisture levels of seed in storage need to be kept. Seed damage can be caused by bad harvesting practices, temperature and moisture in storage that can cause fungal growth. Seeds can be 'disinfected' by using fungicides, insecticides and fumigants.

Storage of seeds needs to be done in a dry and cool location that is clean and is protected from possible insect and rodent attacks. Storage can also occur by using airtight methods.

In the case of some varieties (such as varietal tomato seeds) a complex breeding process has been used to develop extremely productive varieties, which have (inadvertently) an in-built plant patent, in which the next generation is genetically very diverse. For this reason, seed from F1 hybrid varieties should never be retained.

FIGURE 10 Potato rows and density in Bolivia
(Photo: © FAO/23022/K. Iversen)

Plant spacing

In efficient vegetable production appropriate plant spacing is required. Plant spacing involves two distinct factors, namely:

- ***plant arrangement:*** the spatial distribution of the plants (essentially distance between the rows);
- ***plant density:*** the number of plants/m^2 .

In practice, density is much more important than plant arrangement. As plant density increases, the yield per plant falls caused by the competition for light, moisture and nutrients.

When the plant is a single product (e.g. onions, carrots), changing the plant density also changes the size of the individual product. At low plant densities, for example, individual carrots and onions are large, while at high plant densities the individual carrot or onion becomes much smaller. Hence, adjusting the plant density provides farmers with the opportunity to modify the size of their onions or carrots, for example, from large to small, and thereby to maximise the yields of a specific size grade.

Mixed cropping

The same vegetables being grown continuously on the same piece of land for extended periods of time will cause the quality and quantity of production to gradually fall until it reaches uneconomic levels. This is caused by a rapid increase in soil organisms, pests and diseases, which use the particular vegetable for food or as a favourable host; perennial weeds are also likely to become a serious problem. Further the soil becomes exhausted as some of the minerals are used by the vegetable for food, thus continuous planting of the same type of vegetable on the same piece of land will reduce nutrients in the soil and lead eventually to deficiencies.

Rotation, not growing the same crop continually on the same site, is one way of reducing soil nutrient, pest and disease problems. Further individual crops need different cultivation practices, for example, some need surface hoeing, others earthing up, still others mouldering.

Plant nutrition

Nutrients can be supplied either as well-rotted organic material or as inorganic fertilizer. Well-rotted organic material, such as animal manure, usually contains all the required nutrients for plant growth in a relatively balanced form.

In contrast, inorganic fertilizer usually contains only specific elements, such as nitrogen,

phosphorous, or potassium. In order to provide the crop with a balanced supply of nutrients it is necessary to have a suitable mixture of fertilizer. The actual quantity of fertilizer will depend on the nutrient status of the soil and the specific nutrient requirements of the crop. Another factor to consider is acidity (pH) or alkalinity of the soil: it normally falls between 5.8 and 6.8. The pH plays an important role in determining the availability of minor and trace elements that a plant requires for satisfactory growth. It is only in unusual circumstances that the soil is actually deficient in minor or trace elements; it is normally a question of availability and this is determined by the pH.

Pest and disease control

The range of pests and diseases that can (and do) damage vegetables is immense, but specific ones that have a major influence on productivity in any particular region are usually limited. Pests and diseases may be soil borne or air borne and can be crop specific or generic, so the range of potential control measures is huge. Nevertheless there are a number of basic principles which can be applied to reduce their impact on yield and quality.

High on the list is crop hygiene. It is sound agronomic practise not to grow the same crop on the same site year after year. In fact it is highly desirable not to grow crops of the same family on the same site more frequently than one year in three. Crop rotation reduces the risk of the build up of soil borne pathogens. Good examples of this would be the control of club root in cabbages, or the control of nematodes in carrots.

A second factor is to use only 'pathogen free' planting material. This is probably too idealistic, but the objective should be to use only healthy planting material, as many virus and bacterial diseases are carried within the plant and are not easy to eradicate. There are also some diseases actually carried in or on the seed.

The use of resistant varieties is an efficient method of reducing pathogen impact on the crop, where suitable varieties are available, as is the use of biological control measures. Such methods tend to be easier to implement in protected cultivation, like greenhouses, but in open field situations can still be effective, economically sound and within smallholders cultural knowledge. Biological control is typically the reduction of pest populations via natural enemies or natural elements and it involves considerable labour activity. Simple examples of biological control are

conservation of natural enemies, for example lady beetles and lacewings , further the use of such plants as sage, deters the cabbage moth and carrot fly. Biological control methods, even though heavily knowledge based on specific local environmental conditions and labour intensive, do provide sound economic returns; estimates of the cost-benefit ratio have been in the range of 1:11 i.e. for every US$1 invested in biological control, it brings benefits for US$11.

Pesticides are the most common means currently used to control pests and diseases in vegetables crops. Their use poses several challenges, in terms of safe storage of the pesticide, safe application of the pesticide by the labourer, appropriate frequency of application for optimum benefit, and critically the necessity to ensure that the chemical residue at harvest is well below the critical level. There is also the danger of resistance development to the pesticide by the target pathogen.

In recent years the development of Integrated Pest Management (IPM) systems has reduced the need for regular pesticide application. IPM uses common-sense practices and comprehensive information on the life-cycles of pests and their interaction with the environment. Such knowledge is used to manage possible pest damage considering least possible hazards to the environment and people, and by the most economical means. IPM is a series of pest management evaluation, decisions and controls. IPM is a four step approach: its first sets action thresholds i.e. a point at which pest populations or environmental conditions suggest that pest control action needs to be taken. This is typically set against the economic thereat to vegetables by pests. Next pest monitoring and identification occurs, so as to avert using the wrong pesticide. Prevention methods are implemented, for example crop rotation, selecting pest-resistant varieties, etc. Only once the preventative methods are not effective does IPM enter its final phase in control of pests, for example the use of highly targeted chemicals. IPM though does have a higher premium on training and knowledge development that may not always be accessible to smallholders.

Greenhouses

Crops have always been protected, in some manner or other, against adverse climatic conditions. Various types of walls have been constructed, as well as the use of shrubs and trees, to ‘break’ winds so as to protect top soil. Other methods have been used, such as collection foliage, and covering soil to protect against heavy

BOX 2 Integrated Pest Management (IPM) training

Vegetables attract high applications of pesticides, and farmers use many acutely toxic insecticides to control pests on these crops. The demand is high for vegetables in expanding cities in developing countries, and farmers in peri-urban areas, and rural areas with good access to cities, are in a position to find a growing market for their produce. Poor storage facilities will often mean that farmers are forced to sell at peak times when prices are low. Farmers rarely have access to training in pesticide use, and have only limited or no access to advice on the complicated management of pesticides.

FAO is concerned about high levels of poor quality and adulterated pesticides on sale in developing countries. Surveys repeatedly show that without training, farmers are unable to make good crop decisions: recognition of pests and their predators is generally low, leading to decisions to spray to kill any insect; knowledge of product selection, application rates and timing is poor; different products are often combined in the belief that the effect will be greater; re-entry periods after spraying and essential harvest intervals are not known; and without knowledge of alternatives, farmers will often assume that the only solution to pest problems is to spray more frequently. From a consumer's point of view, few developing countries are able to monitor pesticide residues, particularly for produce grown for home consumption: most countries do not have laboratories for even simple residue testing.

Season-long field level training in IPM can help farmers to become better decision-makers, and to greatly reduce pesticide use while reducing risks to their own health and environment, producing safer products for consumers, maintaining yields, and increasing incomes.

Source: Dinham, B.2003. Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers, Society of Chemical Industry.

rains, while glass has been used in an attempt to control temperature. But the use of synthetic film has created a major change, over the past three decades for protected cultivation. Small-scale farmers can protect their cultivations with plastic film that is fairly cheap, depending on type, is easy to use and manipulate and is easy to transport and distribute, hence is accessible to many.

Film that is most commonly used for groundcover and greenhouses is Polythene (PE). Other plastic films are Polychoride (PVC), Ethyleenvinylacetate (EVA), Polyester and Tedlar. Each film type has its advantages and disadvantages. The advantages of PE, for example, is that it can be produced in all kinds of widths and thicknesses, is cheap, but has a limited durability over time. Further PE heat retention is limited, while EVA is much better and PVC is exceptionally good. A new development of film, Astrolux, has cooling proprieties without the need of energy supply; it can keep temperatures down by 6 to 7 °C to those of external ambient temperatures; the film though is expensive.

Importantly before any initiative is taken for protected cultivation, greenhouse, determined factors need to be considered in the project. These will have to consider the climate, the influence of the climate on the particular vegetable intended to be grown and, of course, marketing opportunities for vegetables cultivated in such a manner. In specific such factors to consider are:

Rainfall. Rainfall varies from year to year and season to season. The main concern is the dry and wet periods. Greenhouse construction decisions need to take into consideration in the project area rainfall and particularly its extremes.

Temperatures. Vegetables each have their own particular temperature range in which they will grow in and provide a good yield. For example, tomatoes have a temperature range of 18 to 23 °C, lettuce 10 to 18 °C, sweet pepper 18 to 23 °C, cucumber and egg plant 22 to 26 °C, honey melon 13 to 18 °C and cabbage 15 to 23 °C. Some vegetables can withstand deviation from such temperature ranges, but not excessively. Importantly greenhouse construction decisions have to consider temperature in the locality, its variations and possible methods of temperature control within the greenhouse and the economic feasibility of such temperature control methods.

Sunshine. Vegetable growth also depends on the exposure to light; therefore duration of sunlight is important. Vegetables react to amounts of sunlight and hence, day length must be known over the season or year. The total amount of light determines the quality, the growth rate and level of yield. The amount of sunlight that penetrates the greenhouse is dependent on the construction orientation of the greenhouse. Importantly in projected greenhouse construction decisions what needs to be considered is the locality exposure to light, the duration of exposure to light and methods of how light can be excluded, for example, using black film.

Air humidity. The humidity of air and its variation can cause problems to the growth and health of vegetables. High air humidity can cause fungal growth and water evaporation. On the other hand, low air humidity can cause the plant respiration rate to increase. Importantly in greenhouse construction decisions and projects, air humidity in the locality must be known and the methods of how this can be controlled in the greenhouse ascertained.

Wind. The direction and speed of the wind are also important factors to consider. Greenhouse construction decisions need to consider in the locality, wind direction and speed, so as to avert the greenhouse film being damaged, as well as that of the greenhouse structure.

Evaporation. Solar heat creates evaporation and evaporation rates per day need to be known. This is the amount of evaporation that has been caused by solar radiation. Greenhouse construction decisions need to consider in the locality evaporation rates. Typically in a greenhouse, evaporation is two thirds that of the open field.

Soil. Soil proprieties and its water permeability are also of importance in greenhouse construction decisions in a locality. Such aspects for vegetable growth and quality need to be known in the locality for example, top soil, leaching proprieties, ground water, need for fertilizers, etc.

Water. In greenhouse construction decisions, water supply is fundamental. Importantly water sources, how water can be harvested and stored, what type of irrigation is required to obtain good efficiency and water quality, all need to be considered.

Topography. Topography of the locality for the greenhouse construction is important. In general greenhouses need to be built on horizontal terrain, this to allow for irrigation and drainage purposes.

Accessibility to the protected cultivation area. Greenhouse cultivation requires daily control, thus it needs to have a good location and easy access.

Transport. Transport requirements of the intended vegetable cultivation need to be considered. This is not only in terms of getting inputs to the protected cultivation area, but importantly also transport of the harvested vegetable for marketing reasons.

Marketing. Before any greenhouse project is initiated, for any kind of vegetables, marketing potential of such vegetables have to be carefully considered, especially in terms of quality, market price and higher yields.

Improved yields and costs. Protected cultivation and all its efforts in terms of labour and costs need to provide high quality vegetables and increased yields. Estimates will need to be made prior to construction, to verify if such vegetables will provide for higher

quality and higher yields and earn extra income that will also cover the extra costs involved in greenhouse cultivation of vegetables.

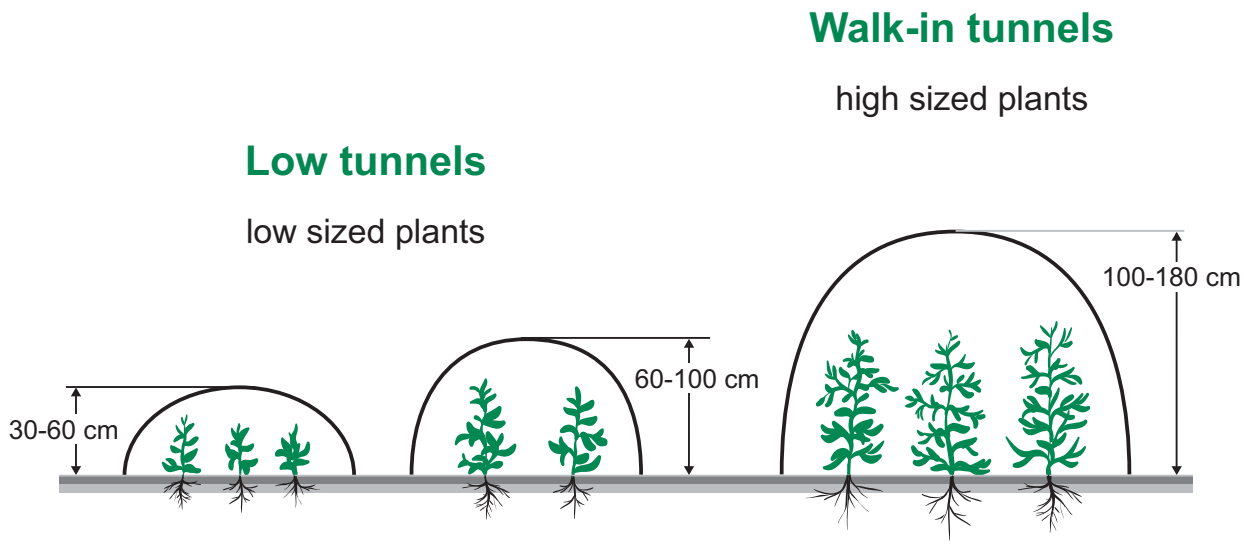
Association. Smallholders on their own may not have the financial resources required to invest in such projects. This is also true for the simplest of greenhouse projects. Promoting associations between smallholders is advisable. It enables the spreading of financial and production risks and can be a starting point for future more complex greenhouse constructions and projects.

Greenhouse types

Depending on the factors mentioned previously, the intended vegetable cultivation and cost estimations, greenhouse construction can vary from very simple structures, to highly complex constructions. Vegetables gardens and small-scale farming vegetable operations will require simple greenhouse constructions, for example using such materials as bamboo for framework structures and film covering.

Close to soil. The simplest and cheapest form of a 'greenhouse' is a film placed on the ground with

FIGURE 11 Various types of simple greenhouse constructions



Source: CTA. 2004. Protected cultivation, by E. van Heurn & K.van der Post, Agrodok 23, CTA, Wageningen. (Adaptation by Fabio Ricci.)

sides weighted down. This type of greenhouse can also be 'constructed' by using foliage, which makes such a 'construction' even cheaper. This type of greenhouse is used to cover seedbed; this will create slightly higher temperatures, moisture will be retained and this will improve germination and growth of the young vegetable.

Low tunnels. Low cost and simple construction are the norm in this type of greenhouse: film and hoops made of bamboo or wood are typically used. But problems with this type of greenhouse are that vegetable management during production is difficult and it has a limited temperature control and ventilation opportunities are minimal. This type of structure can only be used for one type of vegetable, for example, it is commonly used for lettuce or melons; so called low-growing crops.

Walk in tunnels. This type of greenhouse structure is used for tall growing vegetables and enables labour to 'walk into' the greenhouse. Vegetables grown in such greenhouses are for example, tomatoes and cucumbers. Normally they can be built with film, wooden hoops and simple anchoring methods, but will typically not last long as a construction, for storms can create excessive damage. Less vulnerable structures can be made using steel hoops and more fortified film and anchoring methods. This type of greenhouse offers simple ventilation methods and the use of cheap film can mean that film will have to be replaced every production season.

In many tropical high rainfall areas, the main value of a greenhouse is as a rain cover, but this poses problems of excessive temperatures. In order to regulate temperature it is necessary to have ample ventilation. In desert areas, the major problem is likely to be the high level of solar radiation, which combined with low humidity, can cause high temperature stress to the crop. Simple methods of cooling need to be found, such as water being sprinkled on the roof of the greenhouse, or using dark film to exclude sunlight to prevent excessive solar radiation.

Climate control

Inside the greenhouse climate regulation can be done via ventilation, cooling and screening systems. Each of these elements is interconnected with another. For example, ventilation will affect temperature and air humidity. Cleary climate control needs to consider the general ambient climate outside the greenhouse over the production period, the type of vegetable, the

vegetable requirements and the greenhouse type of construction. Further it also has to be remembered that plant transpiration has an effect on the internal greenhouse climate.

Simple methods of climate control are such aspects as water sprinkling on greenhouse roofs for cooling, use of dark colour film to protect against solar radiation, film ventilation can be carried out simply by lifting the side film on the greenhouse and allowing for air passage. More advanced methods are using power supply electric fans with wet pads for cooling.

In internal greenhouse climate regulation the most important factors are temperature and air humidity and not exposing vegetables to sudden and extreme temperature variations. With the potentially high capital cost of environmental control, decisions have to be made regarding the level of control required for any specific locality, compared with the local economic situation and the crop market value.

Pest and disease control

Chemical agents can be used for the control of pests and diseases inside a greenhouse, but because of the secluded nature of the greenhouse, biological methods of control are a lot easier and cheaper to use. Importantly common-sense hygiene methods need to be used, for example in walk in greenhouses, shoes, clothes and hands need to be clean, so as to avert the propagation of diseases and fungi. Tools and materials used for production and harvesting must also be clean. Measures for keeping out insects and rodents have also to be considered. For example, simple netting in front of walk in greenhouse's entrance averts aphids and flies entering.

Irrigation

Greenhouse vegetables are secluded and hence need a method of watering that is appropriate. Importantly water supply, its quality, the quantities required for the particular vegetable and its distribution in the greenhouse needs to be planned. Importantly, watering patterns have to match the needs of the vegetable in a protected environment.

Production management

Training is required for teaching smallholders how to grow vegetables in greenhouses, even if smallholders have experience with growing field vegetables. Vegetable selection for production, plus climatic conditions, will determine the type of greenhouse to be used. For example, lettuce can be grown in ground cover and in low tunnel greenhouses, cucumbers, eggplants and tomatoes can be grown

in walk in greenhouses. Greenhouses also permit the introduction of new crops into local markets, where previously there was no supply. But it is advisable that smallholders have formal training in new vegetable production, before any such initiative should take place.

If a greenhouse project is to be feasible, vegetables deriving from such special cultivation need to be high in quality and yields. Greenhouse cultivation of vegetables is very labour intensive: nursery preparation, sowing, soil preparation, transplanting, disease and pest control, irrigation, ventilation, harvesting and maintenance of the greenhouse are all demanding tasks. Cleary labour intensity will depend on the type of vegetable in cultivation, but it has been estimated that labour intensity in vegetable production per hectare can reach 800 man days. This means that careful labour planning is required for the production season.

Investment and costs

In terms of investment and costs it is advisable that greenhouse projects for protected vegetable cultivation commence with simple greenhouses and move upwards the more experience has been acquired in cultivation practice and the more assured market outlets for such vegetables are obtained. The normal vegetable production costs have to be considered, but what has to be added is the increased inputs , film, wooden hoops, etc. and the increased labour requirements not only to build the greenhouse, but especially in production management.

Further with investments in protected cultivation systems, the resulting improvements in production need to be such that the increase in income i.e. the market value of the vegetables, are higher, so that this can cover, over and above, the initial investment cost of the protected cultivation. Note that an increase in greenhouse facilities needs to grow hand in hand with marketing of protected cultivation yields, without this precondition, no growth in protected cultivation structures should be attempted.

Peri-urban and urban agriculture

Risks to quality of produce

Urban and peri-urban horticulture is making an important contribution to improved food security, nutrition and livelihoods, both in terms of jobs and income. However, in many cases, city farming initiatives lack supervision and guidance. Farmers are expanding in a haphazard fashion, and squatting on any available piece of land. Moreover, the uncontrolled use of

agro-chemicals and doubtful quality of irrigation water lead to public health problems. Consequently, urban and peri-urban horticulture is considered as a high-risk activity, unless guidance, planning and an enabling environment are fostered at policy-level. It is essential and urgent that adequate steps be taken to safe guard urban and peri-urban horticulture, and to ensure its orderly and safe development for the benefit of the population and the environment.

Easy to grow vegetables: onions, shallots, potatoes, sweet potato

Some vegetables are easy to grow and can be a good starting point for more commercially-oriented smallholder vegetable production or for those who are new to vegetable production. Onions, shallots, potatoes and sweet potatoes have a good trade potential and are not particularly complex in their production requirements.

Any project that envisages commercial vegetable production requires production training, thus it is recommended that training be carried out and the Farmer Field School (FFS) method promoted (See section on supporting services). This will not only teach those that have no experience in growing such vegetables, but can also provide smallholders who already do produce such vegetables, improved production methods.

Onions

Onions are one of the oldest vegetables in continuous cultivation dating back to at least 4 000 BC. There are no known wild ancestors, but the origin of onion is believed to be Afghanistan and the surrounding region. Onions are among the most widely adapted vegetable crops. Onions are an important vegetable in tropical countries.

Onions are important for their nutritional value, as they provide water, minerals, ascorbic acid and other components that are good for the human diet. Onions traditionally have been believed to have anti-inflammatory and anti-cancer properties. In traditional medicine onions are claimed to be effective to cure the common cold, heart diseases and diabetes, among others. In the human diet onions offer a range of uses: they can be consumed fresh and uncooked or they can be cooked, they can be processed and pickled and typically onions are used along side many other vegetables, meat and fish.

Onions have a good trade potential, they can be stored for up to 200 days in the right conditions, if cured and packed properly, the bulbs can be transported for considerable distances

without deteriorating and they are known, accepted, and preferred by consumers. Consumer choice is usually based on certain onion varieties that are preferred for certain dishes, for example white onion in salads, red onions in stews and the onions 'pungency'. Onions are easy to produce, require few inputs and labour is mostly used at planting and harvesting stages of the production cycle. The key to successful onion production is choice of cultivar for the specific environment. Onions will only develop bulbs when they experience a combination of long days and high temperatures. In the tropics, day lengths never exceed 13 hours, and thus varieties developed for temperate climates are usually totally unsatisfactory as they will fail to develop bulbs.

Onions are of two types: those grown for bulbs (the normal product), and those grown as 'salad' onions, which are harvested while they are still immature, for the foliage and the immature bulb. Onions tend to be grown at determined altitudes, where conditions are not so humid. Varieties chosen for production need to be based on marketing opportunities.

Shallots

The shallot is a relative of the onion, but is in fact a species on its own. There are more then 500 different types of shallots. The shallot is thought to have originated in Asia before heading to the Mediterranean.

Shallots produce a bulb shape and colour that vary according to country of origin, for example in Asia shallots are small, round and with a reddish colour; one variety grows in the wild in Central and Southwest Asia. Shallot production areas are found in China, Indonesia, Thailand and Southeast Asia, as well as parts of Northern and Southern Africa and some parts of Latin America.

Shallots offer considerable trade opportunities; they are versatile and can be used in many dishes, have medicinal-like properties that are recognized by many, are nutritious and provide for variety in human diets. Shallots are rich in vitamin A, B, C and E. Shallots contain few calories: 50-60 calories per 100 g. Regular consumption of shallots can reduce cholesterol levels and improve blood circulation. The very high concentration of flavonoids reduces the risk of cardio-vascular diseases. Shallots are used in many of the same dishes where garlic and onions can be used, and do not cause as 'harsh breathe odours' as either onions or garlic. Shallots tend to have a faster cooking time than onions, but usually and depending on variety do not have such a long storage life as onions. Varieties

chosen for production need to be based on marketing opportunities.

Shallots tend to be grown in the tropics at low altitude. While shallots can be grown from seed, they are more usually grown from mature bulbs, which develop a number of new bulbs after planting. Optimal results in shallot cultivation depend on variety and on the hours of daylight. For example, there are tropical strains that are happy with a short span of daylight.

Potatoes

Potatoes are one of the world's most important vegetable crops. The first cultivar, seems to have been planted 8 000 years ago near Lake Titicaca, on the Peruvian/Bolivian border. Potatoes are cultivated on an estimated 195 000 sq km (or 75 000 square miles) and annual production is around 315 million tonnes. Potatoes (*Solanum tuberosum*) originate from the Andean region of South America and have diffused to nearly all corners of the world. A potato, of medium size, contains about half the daily adult requirement of vitamin C, is very low in fat, and when boiled, it has more protein than maize, and nearly twice the calcium.

Potatoes have a high trade potential; it is one of the top four crops in the world, are integrated in many traditional diets across the globe, can accompany many dishes and can be easily processed. Potato production is easy and can be grown from true seed or from tubers (vegetative propagation). There are advantages and disadvantages of both those methods. The production of potatoes from true seed has been developed at the International Potato Centre (CIP), in Peru, and CIP has shown that it is possible to produce over 20 tonnes of tubers per hectare from a few hundred grams of true seed. It certainly has a major advantage in production from tubers in relation to the transport of planting material, and freedom from systemic diseases. On the other hand the seed is very small and requires good agronomic skills to produce seedlings.

However, production from tubers is a much more robust crop establishment method, but has three potential down sides: about two and a half tonnes of tubers are required to plant one hectare of land. The major labour requirements in potato production are required at planting and at harvesting.

Potatoes are frequently called the Irish potato, to differentiate from the sweet potato. Irish potatoes are commonly grown in the tropics at an altitude in excess of 1000 m in order to obtain reasonable yields. This is because most cultivars, even if adapted to high temperatures, do

not form tubers very readily at high temperatures. The downside of this is that rainfall tends to increase with altitude and this results in problems from diseases, particularly late blight.

Potatoes chosen for production need to be based on marketing opportunities.

Sweet potato

Sweet potato is one of the most produced vegetables in the world, coming after such crops as wheat, rice, potato, barely and possibly cassava. The sweet potato originates from tropical America and has a high nutritive value. Sweet potato is relatively easy to grow and has a high productivity. It has an ability to be produced in poor tropical soils and where fertilizer is not available. It has a good commercial potential and is valuable in human nutrition. It is a good source of sugars, carbohydrates, calcium, iron and other vitamins, in particular vitamin C. In orange colour varieties it is rich in vitamin A. Leaves and shoots of the sweet potato can also be eaten, unlike the vines of the Irish potato, which are poisonous.

The major advantage that sweet potato has over the Irish potato is that it is easily propagated from cuttings. Another advantage of sweet potato over Irish potato is that the harvest date is not critical because the plant just keeps on growing. The major difference between sweet potato and Irish potato is that although both plants are frost susceptible, the sweet potato grows best at higher temperatures and does not grow at all below 10° C.

The range of varieties is large and this is complicated even more by the ease with which sweet potato plants develop mutations. Not only can the swollen roots (so-called tubers) be eaten, but in some countries, for example, in Papua New Guinea, the leaves and young stem are also eaten as a vegetable. Varieties of sweet potato for production should be chosen based on marketing opportunities.

Initiatives to increase vegetable production

Support services and enabling environment

Advisory services and skills development

For inexperienced smallholder farmers to grow even the 'easy to grow' vegetables requires help and advice. This advice must be based on sound knowledge and the method of delivery will depend on local factors. Where illiteracy rates are low, written advice is the most reliable. Demonstration areas ('learning by seeing' and 'learning by doing') have considerable merit.

A major constraint is often the lack of well-trained extension staff. This can be overcome by 'training of trainers' systems, where experienced vegetable agronomists are trainers who, in turn, train a cadre of educated local extension staff. The latter then advise local smallholders by means of group training organized into a Farmer Field School (FFS).

In FFSs the aim is to build and develop human capacity in farmers' communities, enabling them to analyse their production systems, identify problems, test possible solutions and adapt the most suitable farming practices. All activities are based on experiential participation or 'learning by doing'. Each activity has a procedure for: action, observation, analysis, and decision-making. The emphasis is not only on 'how', but also on 'why'. The FFS are season long training for smallholders based on the crop phenology; seedling issues are studied during the seedling stage, fertilizer issues are discussed during high nutrient demand stages, and so forth. The crop is the teacher, and to ensure that farmers can immediately use and practice what is being learnt, usually communal land is devoted to the school. Typically smallholders meet on a weekly basis and the educational benefits of meeting when problems are present (learner readiness), have been studied and shown to be effective. Schools normally follow the crop cycle and experience has shown that structured, hands on activities provide a sound basis for continued innovation and local adaptation after the FFS has been completed. More information on FFS can be found in the selected further readings of this booklet.

Role of the advisor

Promoting and advising on vegetable production as a way for smallholders to improve their livelihoods is the fundamental role of the advisor, along with providing regular training in vegetable production and marketing. In specific the advisor needs to:

- ***Understand the vegetable industry and how it functions in the country and particular geographical area of interest:*** carrying out research at country level and in the local area looking at such issues as vegetable production processes, statistics, major vegetable businesses, the geographic distribution of vegetable production, price trends, sales volumes, sales methods and when sales occur.
- ***Ascertain and advise on opportunities and challenges in the vegetable industry in the short and long term:*** carrying out marketing research and finding out opportunities in the market, demand trends for various vegetables, production and marketing costs, storage and processing facilities available, also the risks that may be present, such as imported vegetables.
- ***Potential of vegetable varieties that are market-led:*** in unison with research institutions, ascertain what vegetables have market value, what new vegetables might be introduced and what profitability they may have.
- ***Input supply for specified vegetable production:*** via survey ascertain the number of input dealers, their prices and location. What type of inputs can be found, in what quantities and how often they can be supplied, delivery terms, etc.
- ***Financing production and marketing of vegetables:*** determining the extent of available agricultural credit, how farmers can finance the needed inputs for vegetable production and marketing.
- ***Production advice on vegetables that are particular to a specific area and possibly new vegetables that can be introduced into the area;*** advice on traditional crop production methods, improved technical production methods, the fit between traditional and new technical productions methods, the various production cycles, pest, diseases, etc. Encouraging the creation of vegetable gardens, FFSs, Test Planting Plots (TPPs) at local community level.
- ***Post-harvest advice on vegetables:*** methods to prevent post-harvest losses in terms of

quality and quantity, simple post-harvest methods and improved post-harvest methods, the costing of such operations, available facilities existing for storage and processing operations. Encouraging training in post-harvest methods and capabilities development.

- ***Marketing vegetables:*** marketing methods and skills, for example marketing research, finding opportunities, prices, learning how to conduct marketing using direct marketing and marketing channels. Encouraging and promoting training in marketing capabilities development.
- ***Marketing improvements:*** encouraging the prevention of losses, improved quality control and standardization, simple and improved methods of temperature control. Finding new markets and new methods of selling.
- ***Advise on the profitability and costing of production and marketing of vegetables:*** encouraging the practice of costing production and marketing, the importance of calculating profitability for vegetables enterprises; use of tools for estimating profitability and costs. Fostering training and promoting the use of record keeping.
- ***Promote smallholder associations for production and/or marketing:*** advice on the formation of associations for production, transporting, selling, processing; pooling of raw materials, production and marketing capabilities. The advantages and disadvantages of association, managing associations, etc.

Financial services

There is a need for smallholder farmers to access credit in order to purchase such inputs as seed, fertilizer and pesticides. Without such inputs, yield and quality are low and the returns to labour poor. If the conventional banking systems are not appropriate, then alternative sources of finance should be explored. There are various sources where money can be obtained, for example, non-governmental organizations (NGOs) that operate microfinance initiatives. Importantly though, smallholders have to be sure about the interest rate and payback periods of the various options.

Above all smallholders need to be encouraged to save money and use this money as a method of financing vegetable initiatives. Promoting smallholder training programmes on savings initiatives is a feasible manner in setting up good business practices that are sustainable in the long term.

Food safety regulations

As a result of the high value of vegetables and the intensive nature of the industry, vegetable farmers tend to use large quantities of both fertilizer and pesticides. Product appearance is critical because consumers 'buy with their eyes', and this has resulted in a culture of excessive pesticide use in order to ensure a visually perfect product. Thus pesticide residue levels have become a major factor in the food safety component of Good Agricultural Practices (GAP). GAP are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability. GAP may be applied to a wide range of farming systems and at different scales. They are applied through sustainable agricultural methods, such as IPM, integrated ferltilizer management (IFM) and conservation agriculture (CA).

GAP provide an opportunity to assess and decide on which farming practices to follow at each step in the production process. For each agricultural production system, they aim at allowing a comprehensive management strategy, providing for the capability for tactical adjustments in response to changes. The implementation of such a strategy requires knowing, understanding, planning, measuring, monitoring, and record-keeping at each step of the production process.

The four pillars of GAP are:

1. ***Food safety:*** high quality and safe food.
2. ***Environment:*** sustainable production systems.
3. ***Society:*** worker health and safety.
4. ***Economic:*** the need to be profitable.

Worker safety regulations

A key factor in relation to the use of hazardous substances (pesticides) is to ensure a high level of worker safety. This involves:

- storing hazardous substances securely (locked building), so that only approved users have access, and that there is a minimal risk of the substances being inadvertently released into the environment following severe weather (e.g. flooding) or man made disasters;
- applying pesticides in an approved manner using the appropriate protective clothing; and
- harvesting the crop after the withholding period is exceeded, to ensure that any residues are well below the mandated levels.

The importance of post-harvest operations

Qualitative and quantitative losses occur in vegetables from harvesting to consumption, but qualitative loss is far more difficult to asses. Qualitative losses are edibility, nutritional quality, caloric quality and consumer acceptability. These all put serious constraints on the marketability of vegetables and intended increases in vegetable production. Quality standards, preferences of consumers and purchasing power all vary greatly within countries and between countries and these influence marketability.

The reduction of vegetables losses during post-harvest and marketing increases the availability of food, contributes to smallholders' incomes, develops rural and remote areas, decreases the need for expansion in production area, and conserves natural resources. Training and promotion of appropriate post-harvest skills is a necessity for commercial vegetable production.

Harvesting

Good harvesting starts when vegetables are actually planted. According to their physiological needs, vegetables should be planted

FIGURE 12 Harvesting potatoes, Peru
(Photo: © FAO/23270/A. Proto)

so that they can be easily worked on throughout the cultivation stage and during harvesting time. For example, harvesting tomatoes for marketing in the fresh form is a labour intensive matter and can require during one season, according to variety and land planted, from 4 to 15 harvests.

Vegetables are harvested over a wide range of 'maturities', typically depending upon the part of the plant used as food and depending on their final destination, i.e. marketing requirements. Vegetables begin to deteriorate immediately after they are harvested. The rate of deterioration is dependant on the type of vegetables, the part of the vegetable harvested, and, naturally, the environment. The key factors in reducing deterioration of vegetables are to ensure that the product does not wilt and keeping temperature low.

FIGURE 14 Stallholder selling potatoes and fresh onion in Baku, Azerbaijan
(Photo: © FAO/22690/J. Spaull)

FIGURE 13 Freshly harvested onions
(Photo: © FAO/8144/J. Mohr)

Normally vegetables sold fresh are hand harvested. Vegetables that are hand harvested will result in higher quality, with less damage and have the potential of obtaining a good market price. On a small-scale, normally labour used to harvest is family labour and according to need, some seasonal labour. Labour needs to know how to sort the vegetable being harvested and how to avoid damage. Vegetables can be damaged simply by dropping or rubbing against other vegetables,

caused by compression and abrasion. In onions, for example, abrasions on onion bulbs result in the loss of the protective scales.

Handling

Good handling practices are required to keep and uphold vegetable quality. Handling of vegetables starts on the plant and ends with final sale to the consumer. In packing crops for storage or market, handling also must be carried out carefully, crops must not be 'squeezed' by packing, should be evenly spread out and not piled one on top of the other.

Sorting

Grading and standardization consists of arranging vegetables into a number of uniform categories according to physical and quality characteristics of economic importance. The process involves three stages: identification, classification and separation.

Grading and standardization have advantages:

- Uniformity is one of the first attributes that buyers look for. Appearance comes before aroma and before taste.

FIGURE 15 Inappropriate handling of carrots (washing in dirty water) can cause increased post-harvest losses and health hazards to consumers
(Photo: © FAO/16874/G. Bizzarri)

- Different vegetable qualities can be sold to different customers, for example customers who may need or want higher quality tomatoes will be able to identify them and buy them.
- Setting standards will create customer and farmer confidence. For example, rural merchants, wholesalers and retailers will buy from trusted farmers without the need for in-depth inspection and possible disputes.

Typically grades and standards for vegetables refer to such aspects as, colour, size, shape, variety, appearance, firmness, and weight.

Packaging

Packaging provides a convenient way for handling, transporting and storing, and it protects from pathogens, natural predators, loss of moisture, high temperatures, crushing, deformation and bruising. Packaging also has an aesthetic function.

A wide range of materials can be used for packaging. These can vary from simple large green leaves, to clay pots, to plastic reusable crates. Each type of packaging will have its advantages and disadvantages. The ability to reuse packaging material in a domestic (local market) environment is important. Plastic containers, which can be

FIGURE 16 Freshly harvested tomatoes being sorted and packaged in Honduras
(Photo: © FAO/17266/G. Sanchez)

washed clean between uses, have considerable merit, albeit at a cost. Non-returnable packaging made from local plant materials may be a low cost alternative. For packaging which is used only once (for export, for example) it is important to utilise materials which can be disposed of easily in an environmentally friendly manner.

Storage

Storage operations can cause loss of value in vegetables and can range from 20 to 40 percent of the crops put in storage. The main cause of this is inadequate storage operations and facilities at farm and village level, but also inappropriate cultivation methods, harvesting, handling and packing methods. In storage, crops are susceptible to 'attacks' by birds, insects, rodents, fungi, yeasts, bacteria, domestic animals and humans. The produce and its biological activity, when moisture is present, can also cause loss. The stored products, as well as the organisms attacking stored products are biologically active: they breathe. Each product has its own characteristic balance (or equilibrium) between the moisture it contains and the water vapour in the air surrounding it. This equilibrium is known as the moisture content/ relative humidity pattern. During respiration ('breathing'), oxygen is

FIGURE 17 Hand sorting in Bolivia
(Photo: © FAO/GWEIS/M. Zappacosta)

FIGURE 18 Storage crib for potatoes in Peru
(Photo: © FAO/17455/A. Odoul)

used up and carbon dioxide, water and heat are produced. The rate of respiration, and thus the amount of carbon dioxide, water and heat that are produced is strongly dependent on the temperature and the moisture content of the product. The rate of respiration is reduced approximately by one half for each 10° C reduction in temperature. Each crop has its own specific storage requirements and one system is unlikely to fit all crops.

Storage operations for vegetables will depend on their characteristics, when they will be marketed and final use. For many vegetables destined for the fresh market, only a few days of storage are possible; this is common

FIGURE 19 A farmer drying the onion harvest in Senegal
(Photo: © FAO/22113/J. Koelen)

for such vegetables as table tomatoes and lettuce. Other vegetables can be stored for longer, such as sweet potatoes and onions, provided that they are stored in an appropriate manner. Many vegetables that cannot be stored in their original harvest form are often processed, so that their storage durability can be extended over time. For example, tomatoes can be processed into tomato puree, this enables conservation over time, but also the possibility of being able to sell the produce during an entire year and not only in the harvest season.

Storage methods range from highly sophisticated refrigerated cold storage to simple cellars or pits in the ground. One of the easiest forms of storage for root crops is to leave them in the ground until required. Some vegetables can be stored in the form they are harvested in , for they have a natural rind(skin) that protects them well, for example pumpkin. Other storage methods can be earthen pots, baskets, jute and plastic bags, cribs, clamps, earthen silos, ventilated huts and underground pits. For example potatoes, under certain tropical conditions, can be left in the ground beyond harvest time or can be stored in clamps, ventilated huts and underground pits; optimal storage temperature for potatoes, being below 10°C. Another example are sweet potatoes that have a long storage potential in the tropics and can be stored by clamp, pit and hut storage methods. Further cassava storage can be done, by leaving in the field, or with clamps and huts, yam can also be left in the field or in a ventilated hut.

Before any crops can be put into storage, they have to be treated in some way or another. In some cases, simply drying, in other cases curing may be required. For example, potatoes for a few days after harvest can be stored under very warm (25 – 35 °C) and very humid (90 – 95 percent relative humidity) conditions for several days, after that they can be placed in more long term storage. If storage is for a period of time, for example in the case of sweet potatoes, regular checks will have to be carried out on the stored product. In many instances locally developed storage methods can be very effective and may only need slight modifications to improve them.

Processing

Processing is usually carried out for a number of reasons. It is a form of storage, enabling perishable crops to be kept over a longer time period, and can enable smallholders to sell vegetables not only at harvest time, but over a longer period in the year. Processing also creates differentiated vegetables, taking them from a

commodity level to a product level and allowing for less dependence on a few crops for marketing; a greater product portfolio, value added produce and the possibility of obtaining higher returns.

Before considering vegetable processing it is important to assess such issues as:

- What market demand is there for processed products?
- What does the market demand in terms of price and quantities?
- When are the vegetables available for processing?
- What quality are the vegetables?
- What quantities of vegetables are available for processing?
- What tools and machines are available and required for processing?
- What is the price of the machines and the tools?
- What maintenance is required for the machines?
- What spare parts are required?
- What other raw materials, such as salt, clean water, etc. are needed for the processing operation?
- What is the optimal processing capacity?
- What hygine measures need to be observed?
- What skills are needed for the processing operation?
- Can training be found if required?
- What will the processing operation cost?
- How can it be financed?

Processing has a series of advantages:

- It enables consumption in the off season.
- Improves farm household nutritional needs.
- Can improve storage capacities for some vegetables.
- Enables longer storage periods, than fresh vegetables.
- Enables for easier storage; bottles, jars, etc. can be stored more conveniently then fresh vegetables.
- Reduces post-harvest losses.
- Improves marketing by making vegetables more convenient to use for buyers.
- It can provide for labelling which will enhance marketing appearance to consumers.
- It can provide new tastes for consumers.
- It allows for income diversification for the farmer.

Processing has a series of disadvantages also:

- Competition from larger-scale commercial processors that can sell processed vegetables at lower prices than small-scale

processors.

- Cost of setting up processing facilities can be high.
- Costs of actual processing in terms of labour, time, machines etc. can be considerable for a seasonal operation.
- Energy and water sources required for processing maybe scarce and expensive.

Importantly, depending on market demand, smallholders can associate together in processing operations. Associating together will involve the sharing of processing costs, more quantities of produce being processed, hence increasing the throughput of the operation, enabling more quantities to be packed and stored and possibly enabling a better bargaining position with rural merchants, wholesalers and retailers.

A common processing enterprise will require good cooperation among smallholders, good management and good marketing. Further information on processing can be found in the FAO Diversification booklet

CASE STUDY 4 Processing vegetables as a livelihood alternative

Small-scale food processing activities represent a potential source of livelihood for the poorest people in sub-Saharan Africa. Food processing may increase the value of crops to poor farmers and thus yield higher returns, expand marketing opportunities, improve shelf-life and furthermore overcome seasonal and perishability constraints. Adoption of improved and validated processing technologies, good standards of quality and hygiene may assist small-scale vegetable producers overcome some of the problems experienced in the fresh produce market such as lack of market information and market integration, reliance on spot markets, transport constraints and wastage. By processing some or the entire vegetable crop, producers have an alternative or additional means of marketing their produce. This is important given that post-harvest losses of vegetable crops range from 30 to 40 percent, and as a result limit smallholder access to higher value markets in urban areas. Even in circumstances where small-scale producers can access such markets, returns on unprocessed products are typically low. Small-scale agroprocessing activities may also contribute to socio-economic development through improved incomes, employment, food availability, nutrition, social and cultural well-being.

However, research has shown that a number of factors may constrain the ability of small-scale enterprises to effectively manufacture and market processed food products. On a macro level, many policies implemented by governments have served to hinder the development of small-scale industries. At the firm level, limited access to credit, lack of appropriate technologies, a lack of technological capability, the unreliable supply of raw materials, a lack of management know-how and poor quality control amongst other things have served to constrain the development of small-scale industries. These problems apply in many developing countries.

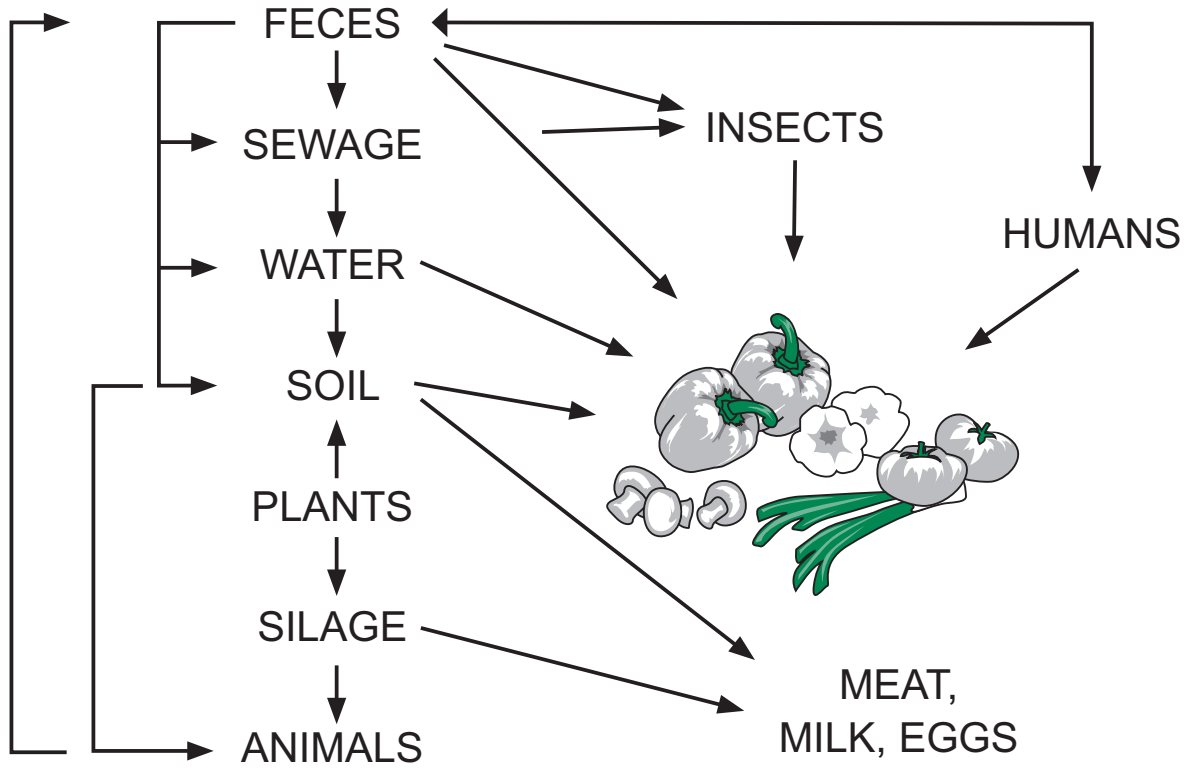
Source: Mhazo, N et al. *2003. Constraints in small-scale production and marketing of processed food products in Zimbabwe: the case of fruit and vegetables, Food Africa.*

No. 4, 'High hopes for post-harvest', and for larger-scale processing enterprises in FAO Diversification booklet No. 5, 'Processed foods for improved livelihoods.'

Hygiene , sanitation and safety

Consumers will reject foreign materials on vegetables, such as dirt, animal faeces, insects, human hair and other debris. Further the presence of pathogens on vegetables of both human and non-human origin can constitute illness in consumption and in some cases a serious threat to human health. A number of factors threaten fresh vegetables, such as naturally occurring toxicants, such as glycoalkaloids in potatoes; natural contaminants, such as fungal and bacterial toxins and heavy metals, like mercury and lead; environmental pollutants; pesticide residues, etc. Of primary concern are those that threaten human health, such as viruses, like hepatitis A, and bacteria like salmonella and parasites. Fungi do not usually constitute a problem

FIGURE 20 Mechanisms by which vegetables can become contaminated with pathogenic micro-organisms



Source: FAO. 2004. Manual for the preparation and sale of fruits and vegetables, by A.F. López Camelo, FAO Agricultural Services Bulletin, No.151, Rome. (Adapted by Fabio Ricci.)

as often they are detected before they become mycotoxins.

There are many ways vegetables can become contaminated at all levels of the production to consumption chain. Prevention requires following GAP and Good Hygiene Practices (GHP); this includes undertaking certain sanitary treatments and keeping produce under conditions (mainly temperature) which do not favour the development of micro-organisms.

Transport

A key factor in establishing commercial vegetable production is access to markets. There is little point in developing a vegetable production operation unless there is a means of physically getting the product to market. Whatever transport used, be it by bicycle, cart, boat, or 'on hoof' , it must be adequate in upholding the quality of vegetables. Typically for more specialised transport, such as cold transport, market intermediaries can have a more prominent role. Commercial transport enterprises have access to financial and specialist physical assets, and they are also in a better position to bulk up the required volumes (and grades) of vegetables. (Further information on transport refer to FAO Diversification booklet No. 10, 'Rural transport and traction enterprises for improved livelihoods').

In some instances transport costs can be one of the highest costs in marketing. Very frequently costs may reach 50 to 60 percent of total marketing costs, hence transport has to be carefully planned and managed.

What is also required is an adequate transport infrastructure that is functional and maintained, so that transport vehicles have the potential to preform their job. For example, roads that are badly maintained and do not connect rural areas to urban areas adequately, can be a large hindrance to vegetable marketing.

Marketing

Importantly marketing starts not at harvest time, but when the farmer chooses the seeds for planting the vegetable crop. This is so because all production must ultimately be in line with what markets need and want. In marketing terms, it is good to have sold the crop before it has been planted or that the likeliness of selling the crop is very high at seeding time.

Marketing is carrying out all of the operations and tasks that enable a farmer to sell vegetables. Farmers can sell directly to a market, referred to as direct marketing, can sell to rural traders, processors, wholesalers and retailers, referred to as non-direct marketing. Farmers can carry

out marketing operations on their own or in association with other farmers. But whatever choice is made, marketing involves a series of interconnected operations including: marketing research, choosing

CASE STUDY 5 **Vegetable transport in Nigeria**

The main kinds of vegetables popularly transported in Nigeria included tomatoes, pepper, onion and okra. There were no clearly defined routes for any particular produce, apart from the common pattern of transport from north to south and market forces dictated the handlers' choice of market. On average the produce normally spent four to five days in transit. There were two main modes of transport available: rail and the road system; however transporters used the road system for their regular and long distance haulage. Major vehicles used for transport were Mercedes, 911 lorry, canter, fuel tanker, pick –up van, buses and articulated trucks.

None of the transporters owned the vehicles and they were usually rented at the market where the fresh vegetables were purchased. It was the desire of most of the transporters to use the 911 lorry. This was because of its capacity and its superior ventilation.

The 911 lorry and other articulated trucks could carry between 250 to 300 baskets or jute bags load of fresh produce (about 7 500 and 9 000 kg). The major problem normally encountered was the non-availability of the vehicle when most needed. In order not to loose their produce, transporters resolved to use any kind of available vehicle, even passenger bus.

The containers (baskets) for transport were usually arranged in five to six layers inside the vehicle with planks (wood) in between these layers. In other words, direct stacking of the baskets was not possible. Some transporters used leaves to separate the layers, which normally did not prevent compression of the produce from the weight (load) of those on top. This practice was thus one of the sources of mechanical damage to the produce. In the case of produce packed in jute bags, for example, onions, the bags were usually stacked on each other inside the vehicles. One problem observed was the restriction of ventilation, which usually resulted in produce rot, caused by the high level of physiological activities of the produce.

In an assessment carried out at the Ipata market in Ilorin, an average of 5 kg of fresh tomato fruits out of the 36 kg basket load were damaged. In other words, in consignments of 7 500 kg (lorry load), an average of 1 041.67 kg or 13.89 percent of the fresh tomato fruits were bad. The damage mainly consisted of bruised, rotten, compressed and water soaked fruits. In terms of money, for an average price of Nigerian Naira 200.00 per kilogramme, the losses caused by this damage were about Nigerian Naira 20 000.00 per lorry load.

Though there were several packaging containers used for packing fresh produce for long distance transport, it was observed that baskets, jute bags/sacks were the most common transport containers used. The baskets woven from palm were used for transporting tomatoes for long distances, while in some cases they were used to package and transport okra for short distances. Onions and peppers were usually transported using the jute sacks or bags woven from polypropylene. The baskets were categorized according to their sizes, which also served as a pricing unit in the marketing of the produce. The handlers, 58 percent, believed that the baskets were not effective, while 42 percent believed otherwise. All in all none of the handlers or transporters used plastic containers as packaging container, being more expensive and not readily available, even though there were and are plenty of plastic packaging producers in the country. Handlers did express their desire that baskets could be replaced, if the alternative would be affordable, however, in the case of the jute bags, 75 percent of the handlers agreed that the bags should not be replaced, while 25 percent preferred replacement.
Virtually all the handlers and transporters interviewed accepted that they did suffer losses in the process, caused mainly by heat, vibrations and impact, but the losses were not usually quantified because they still disposed of the damaged produce at a lower price.

Source: Ida, P. A. et al. *2007. Friuts and vegetables handling and transportation in Nigeria, Department Agricultural Engineering, Federal University of Technology, Minna, Niger State, Nigeria.*

the vegetable product to plant, planning and managing production, harvesting, handling, sorting, packaging, storing, transporting, processing, produce quality and safety, financing, associating with other farmers for production and marketing, deciding how to sell, where to sell, displaying produce, when to sell , costing, pricing, record keeping and ultimately building trust.

Marketing operations are as important as cultivation and harvesting operations. Marketing is a risky operation and can lead to loss of crop and income. This means that marketing has to be carefully planned and managed: it is important that marketing conforms to local marketing practices. Marketing systems are fairly well adapted to prevailing production and consumption patterns. Typically marketing structures are composed of many organizations and people, are labour intensive and transfer frequently small quantities of produce. This is so because consumers typically buy small quantities of produce frequently. Changes to and improvements to marketing organization that do not consider local economic, social and cultural aspects will be destined to failure.

FIGURE 21 Vegetable market in Nepal
(Photo: © FAO/GWEIS/H. Josserland)

CASE STUDY 6 Constraints on vegetable marketing in Kenya

Vegetable production in the Kakamega district is small scale, is heavily dependent on rain and thus leads to low and seasonal production. Vegetable production in the district is mostly undertaken during the short rains when the main staple food crop (maize) has been harvested. Although the Ministry of Agriculture has over the years promoted smallholder irrigation in the country, vegetable farmers in Kakamega are yet to adopt this technology. This has kept farm productivity low, thereby leading to a limited commercialization of farming activities in the district.

About half of the vegetables produced by farmers in Kakamega are consumed at home. The remaining half are sold either at the farm-gate to the middlemen or in the local markets. High marketing costs such as transport, cess payments and other local authority charges, cause the majority (50 percent) of the farmers to sell their vegetables to middlemen at the farm gate. This subjects the farmers to price manipulation and exploitation, especially considering that not many of the farmers belong to membership associations. Farmers also suffer from a cost price squeeze, a situation characterized by increasing input costs and declining producer prices.

The vegetable produce from Kakamega that is sold in Nairobi is transported using public means of transport, mainly upcountry passenger buses. The products reach Nairobi as early as 4 am in the morning. In most of the Nairobi markets, the vegetables are bought by brokers and wholesalers. Most of them operate from dawn to about noon, after which the main market closes, but a few traders continue selling their vegetables outside the main market. Retailing is not allowed inside the main market area. Retailers and brokers play an essential role in determining the prices of vegetables.

Source: Omiti, J. M. et al. *2004. Policy constraints in vegetable marketing in Kenya, Institute of Policy Analysis and Research (IPAR).*

Marketing activities

The training and promotion of appropriate marketing skills is a necessity for commercial vegetable production. Marketing of vegetables require the following activities to be carried out:

Marketing research

Marketing research is a process of investigating marketing matters. It enables smallholders to become more knowledgeable about such things as prices, what vegetables are wanted, quantities of vegetables markets require, etc. It enables smallholders to be more informed about markets and enables them to improve their skills in marketing.

Choosing the vegetable product to plant

Knowledge in marketing will help farmers in deciding which vegetables to plant. Once vegetables are planted, the farmer has committed inputs and labour. and hopefully will earn sufficient income to support the farm business and farm family. Knowing what to plant, how much to plant and

the likeliness of where and too who the vegetables will be sold are all important decisions that smallholders need to take. Support services that can help farmers in such decisions are important.

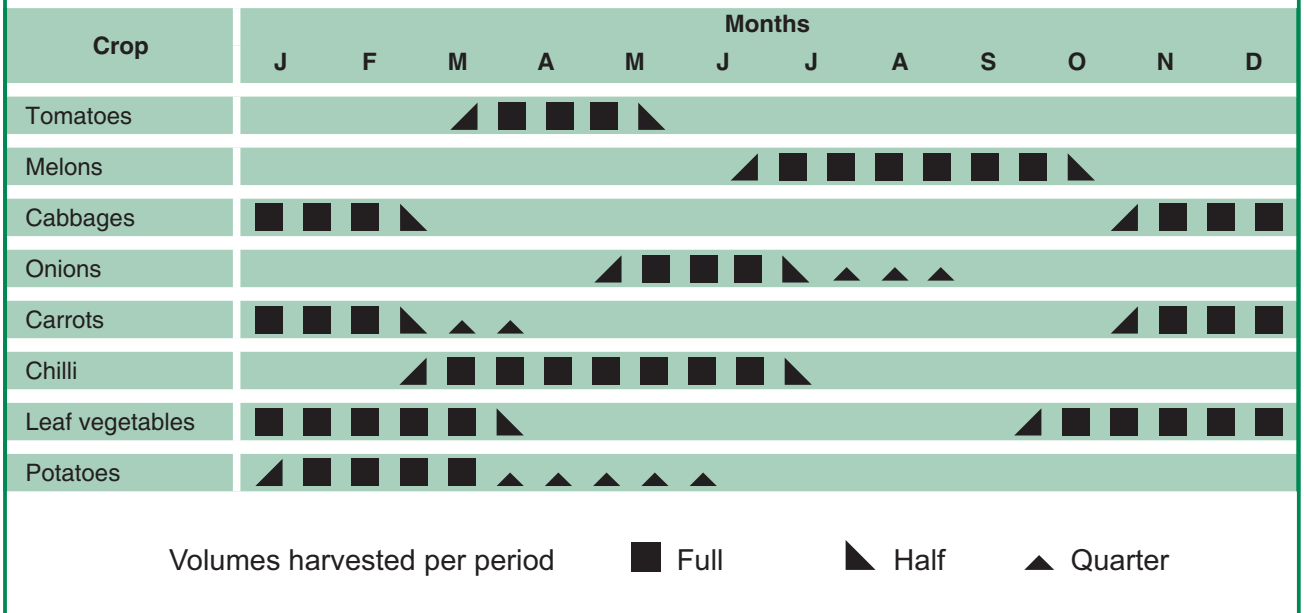
Planning and managing production

Marketing knowledge will be of use in planning and managing production of the vegetable. If, for example, the farmer has some knowledge of what prices will be like in the harvest season and the prices in the off season, the farmer may well decide to produce under protective cultivation and harvest in the off season, obtaining higher prices. Managing cultivation in an appropriate manner will enable the vegetable to be of good quality. Here also, support services are necessary and training in farm planning advisable.

Harvesting

Harvesting will have to consider not only the appropriate biological time of harvest, but also market demand, for the vegetable. For example, in tomato harvesting for fresh table tomatoes, harvesting may have to occur when tomatoes are green, for they maybe destined for distant markets. In other instances, for example, tomatoes destined for sale

FIGURE 22 A typical cropping calendar for production planning



Source: FAO. 2005. Horticultural marketing, by G. Dixie, FAO Marketing Extension Guides No.5, Rome.

to processing businesses that are close to the farm, may need to be harvested when they are fully red and ripe. Careful harvesting operations are also important in keeping the quality of the vegetable. Promotion and training in good harvest practices, based on marketing requirements is essential.

Handling

All handling operations, from cultivation to final sale of the vegetable, need to be carried out with the objective of keeping vegetable quality, safety and market value. Training in appropriate handling practices for vegetables needs to be promoted and carried out. Importantly good handling practices need to be promoted on farm, but also importantly all along the value chain and to the various organizations that are part of it.

Sorting

Sorting vegetables into different sizes, shapes, colours etc., helps marketing; it creates uniformity, different vegetable qualities can be sold to different markets, and setting standards can build trust with customers and avert disputes. Common standards and grades need to be developed and promoted among smallholders, taking account of buyer requirements.

Packaging

Packaging must not only provide for protection of vegetables during transport, storage and handling. Packaging materials to be used and how to pack vegetables need to be promoted and training needs to be carried out. Packaging can also have an aesthetic appeal to buyers. For example, on bottles of tomato puree, labels can be applied. These labels will not only tell the buyer what the produce is, when it was made and possibly by when it should be consumed, but importantly who produced it: a name can be developed to put on the label (brand name) and this can be appealing to consumers.

Storing

Depending on the nature of the vegetable, storage can be for a very short period, a few days, to several months. If it has been processed in some manner, clearly storing will enable marketing over a longer period of time. Usually putting fresh produce into storage is to enable marketing flexibility, for example buyers are not immediately available. Highly perishable crops and perishable crops in general need fast marketing and storage can reduce quality and shelf-life. Other less perishable crops can be stored, enabling selling in the off season for higher prices. Training and promoting good storage methods

FIGURE 23 Unhygienic conditions: tomatoes placed on the ground for selling, Bolivia (Photo: © FAO/GWEIS/M. Zappacosta)

among smallholders and others in the value chain is important, as well as providing a storage infrastructure and guidance on how to create one, either private or in public-private partnerships.

Transporting

Vegetables have to be moved from farm to wholesalers to retailers or the local village market, unless sold at farm gate. Whatever transport used, it must be adequate in maintaining the quality of vegetables and their market value. Maintaining the transport infrastructure and its further development is a necessity for commercial vegetable production.

Processing

Processing of vegetables can provide for a convenient form of storage. It enables the vegetable product to become more durable over time, can be more convenient for the buyer and can add new taste, texture and appearance to the vegetable product. Before any processing initiative is undertaken, feasibility studies are required. Advisors will need to

ascertain opportunities and threats, for such an operation and work alongside smallholders and / or entrepreneurs who intend to start a processing enterprise.

Produce quality and safety

Vegetables can become contaminated in many ways during marketing, for example exposure to heat, damage caused by rough handling and unhygienic conditions at point of sale. This can lead to loss in quality, safety and marketable value. At all levels of the vegetable supply chain, 'from seed to table', preventative measures are required to uphold vegetable quality and safety for consumption. Promotion and training in GAP and GHP need to be implemented, not only at farm level, but all along the value chain.

Financing

Marketing, just as production, needs to be financed. One of the critical aspects of marketing is that it enables money inflows into the farm from the selling of vegetables, while production alone, creates only money outflows from the farm. Marketing does have its costs, but is primarily responsible for bringing money into the farm.

Creating an enabling environment for credit facilities and encouraging and promoting savings groups are all fundamental aspects for commercial vegetable production.

Associating for production and marketing

In many countries farmers have found that they can increase their income and efficiency by joining with other farmers. When vegetable production expands beyond the subsistence level, many smallholders benefit from forming organizations to assist in obtaining their inputs and marketing their produce. Such smallholder associations may be a fairly informal arrangement whereby members gain economic benefits through buying inputs, organizing transport, negotiating collectively and sharing marketing information.

As the focus of production becomes more market-oriented, the organization may become more formal, such as a legally registered producers' association or cooperative. The advantages of increased scale of activities for organized smallholders are:

- economies of scale, both in production, marketing and in the buying of inputs;
- pulling together of local resources and skills;
- members acquire new skills both in production and marketing activities;

- opportunities are made more real for training, such as organizing FFSs;
- improved bargaining power,
- increased capacity to take advantage of market opportunities;
- more quantities of vegetables to sell;
- lowering transaction costs;
- lower costs in transport, processing and storage operations,
- increase quality and safety control on vegetables;
- improve access to credit;
- improve the possibility that smallholders are more sustainable, via increased income, better community cohesion, etc.;
- obtaining communal equipment and services;
- larger organizations can also hire professional staff to undertake key activities;
- makes farmer voices heard in local and national forums.

Associations, either formal or informal, importantly need to be carefully managed for success. This means that rights and responsibilities are clearly defined at the formation of the association. All members must be free to participate and importantly communicate among each other. It is important that the costs of the association are not too high and that the association is created to fulfil specific goals. For example, an association can be formed to carry out credit, transporting and selling activities. Vitally the association should not have too many functions.

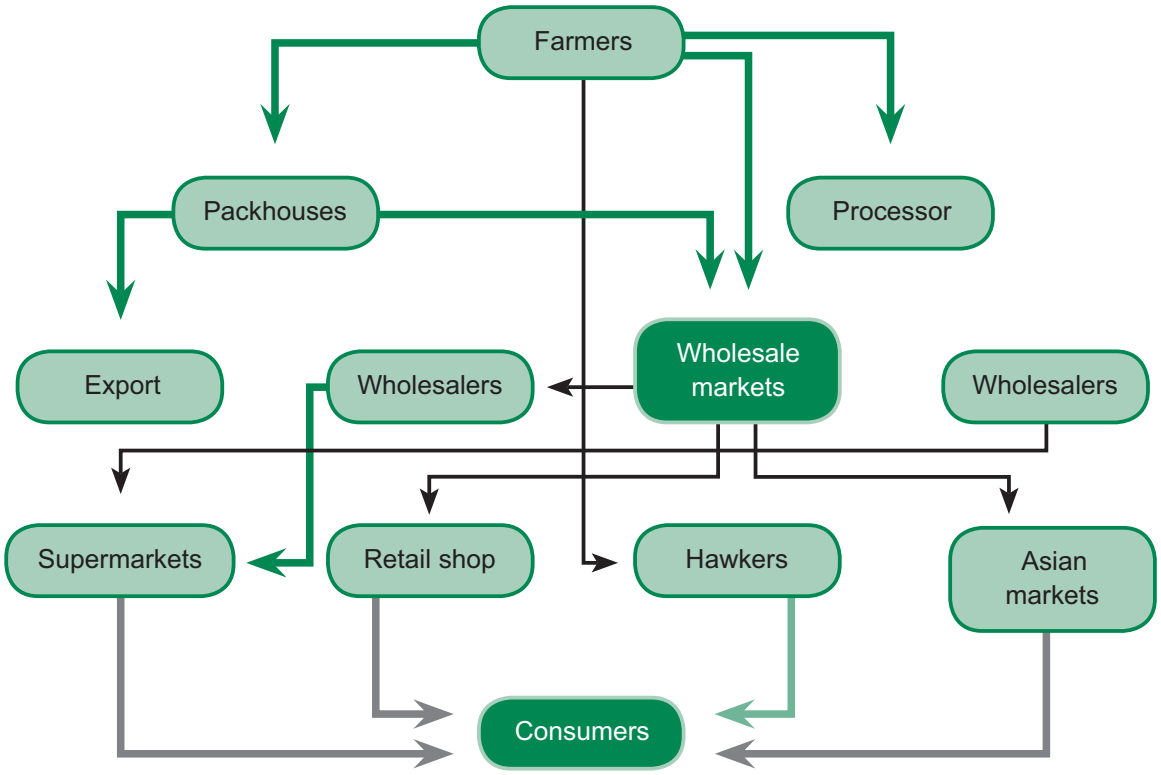
Providing training on group formation and promoting association among smallholders is yet another important step in vegetable commercialization.

Deciding how to sell (marketing channels)

Smallholders must decide how to sell their produce, in other words, selling directly to consumers or selling to other people and organizations, such as rural traders, retailers, etc. This is a very important decision. Farmers have many options, each with its advantages and disadvantages. Importantly what has to be remembered is that highly perishable vegetables have to be sold quickly after harvest, for example lettuce.

Creating an enabling environment for vegetable marketing is important: upgrading and improving wholesale markets and retail markets, creating new ones, via public-private partnerships, training vegetable traders and encouraging vegetable traders with fiscal incentives, for example, are only some among the many options to support vegetable

FIGURE 24 Marketing channels for vegetables, South Africa



Source: FAO.2005. Horticultural marketing, by G. Dixie, FAO Marketing Extension Guide No.5, Rome.

CASE STUDY 7 Cauliflower marketing in Delhi, India

Produce reaches the market through every mode of transport, via head loads, bicycles, pedal and auto rickshaws, light commercial vehicles and tractor trolley. The produce reaches the market almost fully covered with plant leaves, this undertaken by farmers for convenience in transport. Farmers unknowingly fulfil a major and very important task safeguarding consumer's health from contaminated air pollution by leaving the leaves on the cauliflower. The farmers sell directly to consumers or sell to retailers and vendors.

Retailers give a simple value addition by removing the leaves and sprinkling water on the heads of the cauliflower. But retial sales occur mainly in the afternoon, until early evening, when air pollution, caused by city traffic, is at its highest. An important player in the retail vegetable trade is Mother Dairy, a cooperative body which purchases directly from the producers and sells directly to consumers though various retail outlets. Its covered retail outlets protect produce from exposure to weather, air pollution and sunlight.

Source: Bhupal, D. S. et al. *2003. Marketing of vegetables in Delhi: a case study of price spread in the marketing of cauliflower.*

commercialization (see the selected further reading section of this booklet for information about market infrastructure).

Where to sell

Smallholders have to decide where to sell produce. Choice of where to sell must be based around marketing information and marketing costs. Creating an enabling environment for vegetable commercialization will enable smallholders and others in the value chain to choose freely, based on marketing opportunities, and not have to make choices based on commercial monopoly of one or more players in the vegetable value chain.

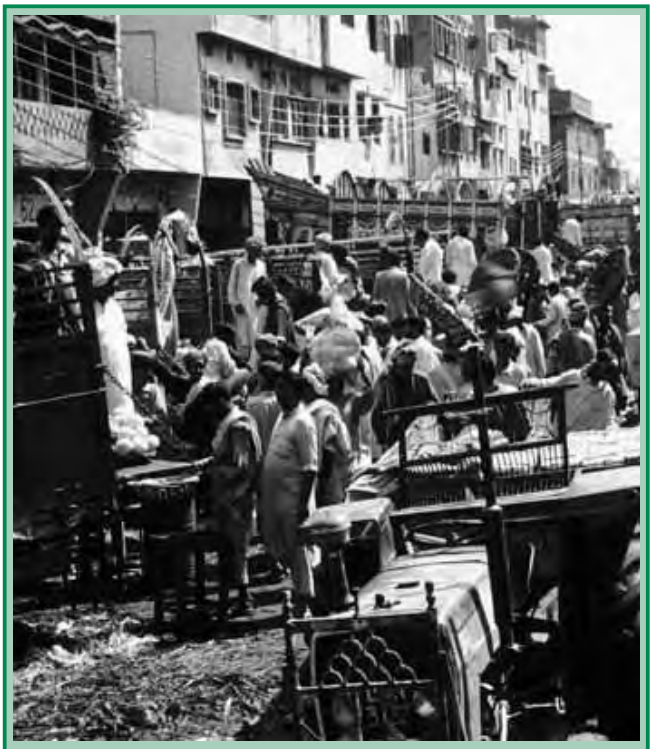


FIGURE 25 A wholesale fruit and vegetable market in Pakistan
(Photo: O. Argenti)

BOX 3 The importance of wholesale markets

Wholesale markets are an essential component of any agricultural marketing system, especially for horticultural crops. The rapid changes taking place within the food marketing chain include an expansion in direct marketing between large farmers, either in groups or as individuals, and the increasingly integrated food marketing chains, represented by hypermarkets, supermarkets and chain stores. Despite such changes the correct question to ask is not: 'Do food wholesalers and retailers still need central wholesale markets', but, 'Do farmers still need food wholesale markets?'

In those countries where the farm structure and the marketing system remain fragmented and cooperatives and farmer groupings are largely underdeveloped (as is the case in most developing countries), wholesale markets are still needed to provide farmers with effective and profitable marketing outlets for their produce. In addition to facilitating farmers' access to the marketing system, wholesale markets, if adequately located, sized and managed, are basic instruments for promoting competition and improving public health and food quality control. This thereby lowers and stabilizes consumer prices and reduces post-harvest losses as well as urban congestion and pollution. The high rates of urban growth in African and Asian developing countries, will continue and create a need for both expanded and new wholesale markets, especially in the rapidly expanding 'secondary' cities in many countries.

Source: Seidler, E. 2001. Wholesale market development – FAO's experience, Paper prepared for the 22nd Congress of the World Union of Wholesale Markets, Durban, South Africa, September 2001.

FIGURE 26 A farmer street hawking his vegetables by motorcycle stops to make a sale
(Photo: © FAO/22265/A. Proto)

FIGURE 27 A shopper choosing among vegetables on offer in the produce section of one of the large supermarket chains found in most major cities and towns in Thailand
(Photo: © FAO/24493/D. White)

Displaying produce

Whenever vegetables are in view of buyers, they need to be presented in an appropriate manner, for example a good display of fresh table tomatoes in a local village market where the farmer has a stall, can help in selling them. Vegetables have to be in reach of consumers, who may like to see them, feel their firmness with their hands, scent their aroma and possibly even taste the vegetables. In many markets, vegetables are displayed in the most varied and creative ways; for example, in some markets, tomatoes are placed to form a pyramid shape. Promoting good display is important in the vegetable trade.

FIGURE 28 An example of a simple but effective display
(Photo: © FAO/22692/J. Spaull)

FIGURE 29 A disorganized and hard to reach display confuses customers
(Photo: © FAO/19364/R. Jones)

When to sell

When to sell implies two important factors for a farmer. The first factor is that of earning the most money from choosing the right time to sell, usually when prices are higher. The second factor is that of reducing risk; fresh perishable vegetable prices usually follow a regular pattern and the nature of the produce and their non-storable factors do not allow for much autonomous decisions in terms of selling time , unless the produce is less perishable by nature, like sweet potatoes for example, and /or have been processed.

Normally individual smallholders have little bargaining power and less marketing information available then smallholder associations. Promoting association of smallholders for increased bargaining power is one of the many aspects that encourage the formation of smallholder associations.

Costing

Vegetable production and marketing require payments initially to be made to buy such things as seed, farm tools, fertilizers, renting land, hiring transport, fees to enter markets, etc. These payments are referred to as costs. Production costs are typically:

- labour: for ploughing, planting, scouting for pests, applying fertilizer, etc.;
- capital costs; equipment, farm tools, buckets, depreciation, etc.;
- fertilizers, fungicides and pesticides: nitrogen, phosphorus, potassium, etc.;
- land: renting land, etc.;
- water: irrigation, etc.;
- unexpected costs: more applications of insecticide caused by a high level of infestation.

Marketing costs are typically:

- labour: for harvesting, handling, washing etc.;
- processing: equipment etc.;
- packaging: wooden crates, sacks, bottles etc.;
- storage: storage shed, renting storage space etc.;
- family consumption: the quantity of vegetables used for family needs;
- transport: hiring and buying etc.,
- produce losses: damage, theft, etc.;
- capital costs : interest rates on borrowed money, keeping processed vegetables in storage, etc.;
- fees, taxes, unofficial payments: fees to pay to access urban markets or pay porters to unload produce, government taxes, road payments to make while in transit etc.;

- unexpected costs: costs of accessing an urban market have increased, etc.

Costing is fundamental for any farm that operates in a commercial way. This will help the farmer understand many aspects of the farm business and enable improved decision-making regarding both production and marketing of vegetables and create more efficiency. Training in costs calculations is advisable for smallholders, as is recordkeeping in general.

Record keeping

Farmers need to keep track of all their costs and sales and should keep written records of them. This will help the farmer understand weekly and monthly costs and sales. Records help farmers to assess how the farm is performing. It takes a lot of time and it requires discipline, but it gives the farmer insight in the following areas, for example:

- what has been bought, farm inputs, etc.;
- produce that has been sold;
- payments made to labour;
- where losses are;
- which are the vegetables that sell the most;
- profitability of operations.

Good record keeping will tell the farmer, with some good degree of precision, how much money is flowing into and flowing out of the farm in specific time periods. Record keeping is a fundamental aspect of good farm management practices and training is required and advisable.

Pricing

Farmers producing and marketing fresh vegetables, in general, have to take the market price for their produce. There are some situations where farmers may be able to influence the market price. This type of production moves commodities that are undifferentiated to being commodities that are differentiated, for example, organic tomatoes and a typical regional type of tomato found only in a certain region. This sometimes occurs where specialized products are being produced for a limited 'niche market'. Niche market means a market composed of particular consumers where demand is focused on special or typical products. This type of market can be a highly specialized market or occur only at a specific time of the year when demand for that produce is high and premium prices can be attained. It is also characterized by farmers attempting commodity differentiation. Training in new agronomic practices is required, for

example, in organic production, this allowing for product differentiation and also a price differential. Importantly though, costs and benefits of such plans need to be carefully evaluated.

Prices in markets do not stay the same and change very often. For example, prices vary in consequence of changes in production and demand at different times of the year. Typically prices are high at the start of the harvest season, start to decrease as the harvest season progresses and then rise again, when the harvest season is nearing its end. The supply of vegetables often varies from season to season and because of weather, plant diseases and farmer's decisions, prices can vary from year to year. Importantly prices also vary depending on the availability of competing products. Prices that are found in marketing channels also vary. For example, there will be the farmer's price when selling vegetables at the farm gate and there will be the rural merchants selling price. It is important that all members of the vegetable supply chain are aware of vegetable prices and there differentials along the vegetable supply chain.

Traders in marketing channels are important. Traders perform such tasks as buying farmers' vegetables, collecting vegetables from widely dispersed areas, organize the distribution of such vegetables, find markets in which to sell, etc. Without traders, farmers would not be able to make a living and consumers would not be fed. The greater the competition and the more dynamic the trading sector is , the greater the volume of produce taken out of rural areas and incomes returned to the farming community. Trading in vegetable marketing channels, hence needs to be encouraged and supported.

Building trust

Essential to any marketing operation is that buyers trust the farmer. Buyers need to feel that they are not being cheated and that they are getting value for their money. Without this premise, buyers will not buy from a farmer who they do not trust. Improving and supporting the marketing of vegetables as well as vegetable production, via training, promotion and an enabling environment, can only but foster and improve trust between producers and buyers.

Profits for improved livelihoods

Vegetables production and marketing has a strong influence on improving farmers' livelihoods. If farmers understand that quality vegetables are not only for family consumption,

but can also be marketed, this can help their livelihoods, others in the vegetable supply chain and also in developing local communities.

Typically consumers want to pay low prices for vegetables and farmers want to receive high prices for their vegetables. A manner that enables farmers to achieve a balance is by becoming skilled and efficient in the marketing of their vegetables; lowering marketing costs.

Farmers derive profits from the selling price of their vegetables, and from reducing production and marketing costs. Smallholders derive benefits from improved vegetables yields, but improved prices on current quantities sold have a greater impact on profitability, then increased yield. This highlights the danger of increasing production without being confident of the additional vegetable yield being sold. An increase in price has a significant effect on improving profit, normally because production and marketing costs are constant.

Cost-efficient production and marketing activities will achieve higher profits to farmers and encourage the expansion of vegetable growing and marketing. This inturn will improve smallholders' livelihoods and not only.

FIGURE 30 Vegetables in a supermarket in Asia
(Photo: © FAO/24492/D. White)

Speciality vegetables

Speciality vegetables are an important component for increasing the commercialization of vegetables. Usually they are grown by more experienced smallholders that not only have the knowledge and skills to grow such vegetables, but are also aware of market opportunities. Less knowledgeable and skilled smallholders can also grow such vegetables, but need to be aware of the fact that speciality vegetables are more complex to grow, then the easy to grow vegetables, and do require advice and support, especially in the form of FFSs. Smallholders need to understand that such crops, for example tomatoes, both field and greenhouse varieties, do require good management practices and in the particular case of tomatoes, are labour intensive. Other speciality vegetables, for example asparagus, not only require good planting and management practices, but require careful long term economic planning, even though labour requirements are minimal during the growth season and only become intensive at harvest time. Clearly if cultivation and marketing of speciality vegetables are carried out appropriately, and there is appropriate support in the initial phases of such projects, smallholders can reap the high trade potential of such vegetables.

Tomatoes

Tomatoes are another very popular vegetable and are grown on a global basis. Tomatoes originated in the South American Andes. Tomatoes are grown for two reasons: to be consumed fresh (for example in salads) or for processing into tomato paste or dried tomatoes, for example. There are two major types of tomato plant, the determinate type, which does not require any training or support and grows like a bush, and the indeterminate type, which requires support and regular training to remove laterals, and produces a much higher quality product, in terms of appearance.

Tomato is an annual plant, however, in South America the same plants can be harvested for several years. Tomatoes vary considerably in size and in shape. There are three main types:

1. The cherry type, with small fruit, some 10 to 20 g and 20 to 30 fruits per truss.
2. The standard type, with medium-sized fruit, some 80 to 120 g with five to six fruit per truss.
3. The beefsteak type, with fruit up to 250 g, with one to three fruit per truss.

Fruit shape can also vary considerably from pear shaped to round or flat. Colour also varies; they are generally red but can also be yellow or even pink.

Tomatoes have a high commercial viability and are easy to process. Simple sun dried tomatoes and bottled tomatoes are economically important products. Tomatoes provide for good nutrition in the human diet. Tomatoes have plenty of minerals, vitamins, sugars, vitamins B and C, iron and phosphorus. Tomatoes accompany many dishes, for example meat and fish, are commonly used in soups, can be eaten raw in salads and processed into juice and purees. Choice of tomato variety for cultivation has to be based on marketing opportunities.

FIGURE 31 Greenhouse tomato packing
(Photo: © FAO/11832/F. Mattioli)

Asparagus

Asparagus has been used both as a vegetable and as a medicine for many centuries. The medicinal value of asparagus lies mainly in its diuretic values, and is used to treat urinary tract infections, kidney and bladder stones.

Interestingly asparagus grows well in saline solis, unlike other vegetables that have very little tolerance for salty soils. There are three types of asparagus, green, white and purple asparagus, two being the most widely cultivated, the green and the white varieties, while the purple variety is less diffused. White asparagus, known as spargel, during cultivation is excluded from light and has a less bitter taste then the green varieties.

In the human diet, only the young shoots of asparagus are eaten. Asparagus provide for a good source of folic acid, potassium, fibre and rutin. Asparagus have a very good commercial potential: Peru is an excellent example of how such a crop can help smallholders develop and improve their livelihoods.

If planting as a new crop, considerable attention must be paid to the financial aspects of asparagus cultivation. The first commercial yields are expected normally after three seasons and this means that financial planning is a prerequisite for successful commercialization. Asparagus production has a high entrance cost, caused by complex planting needs, but usually within the fourth year of production, costs are entirely recuperated. Once in full commercial production, asparagus are one of the least expensive vegetable crops to maintain. Since planting asparagus has a long term perspective, when considering such a vegetable, it is advisable that smallholders associate together for cultivation, training in production techniques and importantly marketing.

Greenhouse vegetables

The major greenhouse vegetables considered here are tomatoes, cucumbers, sweet pepper and lettuce. Growing these vegetables in a greenhouse results in higher productivity and also better quality, as well as greatly improved water efficiency, when compared with outdoor crop production. Also such vegetables have good acceptance with consumers, are versatile in consumption and have a good trade value.

Greenhouse tomato

Tomato is a delicate vegetable and it is susceptible to extreme temperature variations. Growing tomatoes in protected cultivation is a viable alternative to field grown tomatoes. Greenhouse tomatoes offer

FIGURE 32 Greenhouse cucumber harvest
(Photo: © FAO/12426/F. Botts)

a range of advantages, such as higher quality, more yield, risk reduction in cultivation and in some areas out of season production. But greenhouse tomato cultivation has unique cultural requirements that are very different from field tomatoes. Smallholders need training on cultivation practices and management. Further it is very labour intensive: more time is required for transplanting, harvesting and daily checks on the crop are the norm.

Greenhouse cucumbers

Cucumbers are one of the most popular vegetables in the tropics. Cucumbers, it is thought, were first cultivated in India and have been in production in Western Asia for more than 3 000 years.

The commercial value of cucumbers is enormous, they are well accepted in many parts of the world and have a good versatility as a food because they can be 'processed' in a number of ways, for example pickling, and can accompany many cold and hot foods. Their nutritional value is lower than other vegetables, but still holds important elements for the human diet.

In the tropics they grow well in the dry season, but can be a yearly crop if cultivated in the shade, with good drainage and careful pest and disease

control. Much like tomatoes, growing cucumbers in greenhouses needs a good knowledge of such particular cultivation practices and training is advised for successful commercial production.

Greenhouse sweet peppers

Peppers, both sweet and hot are originally from Mexico and surrounding Central American regions. Discovered by Christopher Columbus they became popular and were widely dispersed throughout the world. Sweet peppers (*Capsicum annuum*) differ from the hot peppers (*Capsicum frutescens*) because they lack the pungency of the hot peppers, and also because they are larger. Sweet peppers are cultivated in many countries and they have become an important crop in the past 20 years in greenhouses throughout the entire world.

Sweet peppers have a high commercial potential: they can be sold fresh and can be fairly easily processed into powder and sauces. In many countries the sweet pepper is highly accepted and can accompany many dishes, both in the fresh form and in the cooked form. In the human diet they are an excellent source of vitamin C, vitamin A, and calcium. Red peppers have more of these qualities than the immature green peppers.

The sweet pepper fruit starts from green (like tomatoes), but as it ripens colour changes; different varieties have different fruit colours. Although red is the most common colour, it is possible to have yellow, orange and even purple coloured ripe fruit. Size is not the sole criterion regarding variety selection, as thickness of the fruit wall can be a critical factor. A large fruited variety may have a very thin fruit wall, and therefore not be as valuable as a smaller variety with a thick fruit wall.

Greenhouse lettuce

Lettuce as known today, was originally a weed. It originated as such around the Mediterranean and has been eaten for over 4 500 years. Lettuce has always been a very popular vegetable. In terms of human nutrition, lettuce is high in vitamin A, contains also vitamin C in a good proportion and is a valuable source for folic acid, has potassium and is a good source of fiber.

Thirty years ago there were only three main types of lettuce, butterhead, crisphead, and cos. These were all sold as full hearted lettuce. In recent years there has been a major development with the production of leaf lettuce with a range of colours and leaf shapes. These have mainly been developed to supply the ‘cut fresh’ (mesclun) market, but they

may be grown larger, and harvested as a large leafy lettuce.

Lettuce has good commercial viability, is versatile and there is always a good demand for it. Greenhouse production produces a much higher quality product than field production, and is fairly easy to cultivate. Some previous knowledge is required though. But even though knowledge of greenhouse cultivation is required and training can be of great help, training is a requirement for more 'resistant' varieties that are destined to the 'cut fresh' salad markets. 'Cut fresh' salad markets offer higher prices than simple fresh lettuce markets and if packaged 'appropriately' (air tight) can extend the shelf-life of the lettuce. In all cases lettuce requires fast marketing and has very little storage capacity.

CASE STUDY 8 **Locally grown lettuce and a large supermarket chain**

Farmer Ameena Austin is helping the largest supermarket chain in Barbados to achieve complete import substitution for romaine lettuce and she can barely keep up with demand. Three times a week, Ameena delivers a dozen 15 kg boxes of romaine to five supermarket outlets. At BDS$5.50 (€2), she can make up to BDS$1 000 (€364) a week. She has already bought a transport vehicle with her earnings. She started by planting lettuce for her family's consumption, selling the surplus from a roadside stall. One day, the marketing agent of the largest supermarket chain bought a sample. The quality and price compared favourably with the lettuce they were importing, and the chain asked Ameena to start supplying it. She began with a small plot and a garden hose, but has since leased 8 ha, where she plants 20 000 heads of romaine twice a month and uses a drip irrigation system.

"When I was planning to start, my husband was sceptical and asked me what I knew about agriculture," said Ameena. "Since then he has given up his job and is my partner on the farm." The supermarket chain, which is actively trying to replace costly imported products with locally grown ones, has asked Ameena to experiment with new crops and sometimes offers her seeds. She has had good results with zucchini (courgette) and is considering growing coconut trees to help meet local demand for fresh coconut water. She is also looking into finger squash, pimento peppers and leeks. Now Ameena, a founding member of Women in Agriculture in Barbados, is searching for a bank to lend her BDS$10 000 (€3 636) to erect two shade houses for her produce.

Source: CTA. 2007. Local Lettuce, Spore No.130.

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Journal of Vegetable Crop Production, Haworth Press
Journal of Crop Improvement, Haworth Press
Journal of Applied Horticulture
Journal of the American Society for Horticultural Science
Journal of Horticulture Science
Journal of Horticultural Science and Biotechnology
Journal of Environmental Horticulture
Pacific Horticulture: Journal of the Pacific Horticultural Foundation

Sources of further information and support

American Society for Horticultural Science
http://www.ashs.org/

Technical Centre for Agricultural and Rural Cooperation (CTA)
http://www.cta.int/

Cornell University
http://www.vegetables.cornell.edu/

Food and Agriculture Organization of the United Nations
Agricultural marketing
http://www.fao.org/ag/ags/subjects/en/agmarket/agmarket.html
Horticultural crops
http://www.fao.org/ag/AGP/AGPC/doc/crops/4c.html
Horticultural Culitvars Performance Database (Hortivar)
http://www.fao.org/hortivar/index.jsp
Information network on Post-Harvest Operations
http://www.fao.org/ag/ags/subjects/en/harvest/inpho.html
Integrated Pest Management
http://www.fao.org/ag/AGP/AGPP/IPM/Default.htm
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http://www.fao.org/ag/AGP/AGPP/Pesticid/Default.htm
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http://www.fao.org/ag/ags/subjects/en/harvest/index.html
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http://www.fao.org/ag/ags/subjects/en/farmMgmt/index.html
Rural Finance Learning Centre
http://www.ruralfinance.org/

Rural Transport
http://www.fao.org/ag/ags/subjects/en/farmpower/power/transport.html
Crop and Grassland service
http://www.fao.org/ag/AGP/AGPC/doc/default.htm
Good Agricultural Practices
http://www.fao.org/prods/gap/index_en.htm
Eco-friendly roof gardens in Egypt
http://www.fao.org/food/photo_report/Egypt/Egypt1_en.htm

Global farmer field schools
http://www.farmerfieldschool.info/

International Centre for Agricultural Research Organization (CGIAR)
International Centre for Tropical Agriculture
http://www.ciat.cgiar.org/
International Potato Centre
http://www.cipotato.org/

International Institute of Tropical Agriculture
http://www.iita.org/

International Society for Horticultural Science (ISHS)
www.ishs.org

National Sustainable Agriculture Information Service (ATTRA)
http://attra.ncat.org/horticultural.html

Ohio State University
http://www.ag.ohio-state.edu/~vegnet/

Royal Horticultural Society
http://www.rhs.org.uk/vegetables/

Sydney Post-harvest Laboratory
http://www.postharvest.com.au/

University of California, Davis
Post-Harvest Technology: Research and Information Centre
http://postharvest.ucdavis.edu/

University of Georgia
College of Agricultural and Environmental Sciences
Department of Horticulture
http://www.uga.edu/vegetable/

University of Missouri
http://extension.missouri.edu/explore/agguides/hort/

Virginia Polytechnic and State University
http://www.ext.vt.edu/cgi-bin/WebObjects/Docs.woa/wa/getcat?cat=ir-fv

World Vegetable Centre
http://www.avrdc.org/

Video, CDs and DVDs

Food and Agriculture Organization of the United Nations
Agricultural Marketing Resources (CD)
Horticultural marketing-a training video
Horticultural marketing :Extension techniques (Video and DVD)

Notes

SMALLHOLDER VEGETABLE PRODUCTION REQUIRES A SMALL PLOT OF LAND, SOME WATER, LABOUR AND MINIMAL CAPITAL. Vegetables that are easy to grow provide economic, social, gender and nutritional advantages that can significantly contribute to livelihood diversification and sustainability. By highlighting the basic and easy to grow vegetable production systems, potatoes, sweet potatoes, onions and shallots, and also more specialised vegetable production systems, such as tomatoes and greenhouse vegetable cultivation, it is hoped that policy-makers and development personnel will recognize the opportunities that are available for producing and marketing quality vegetables.

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