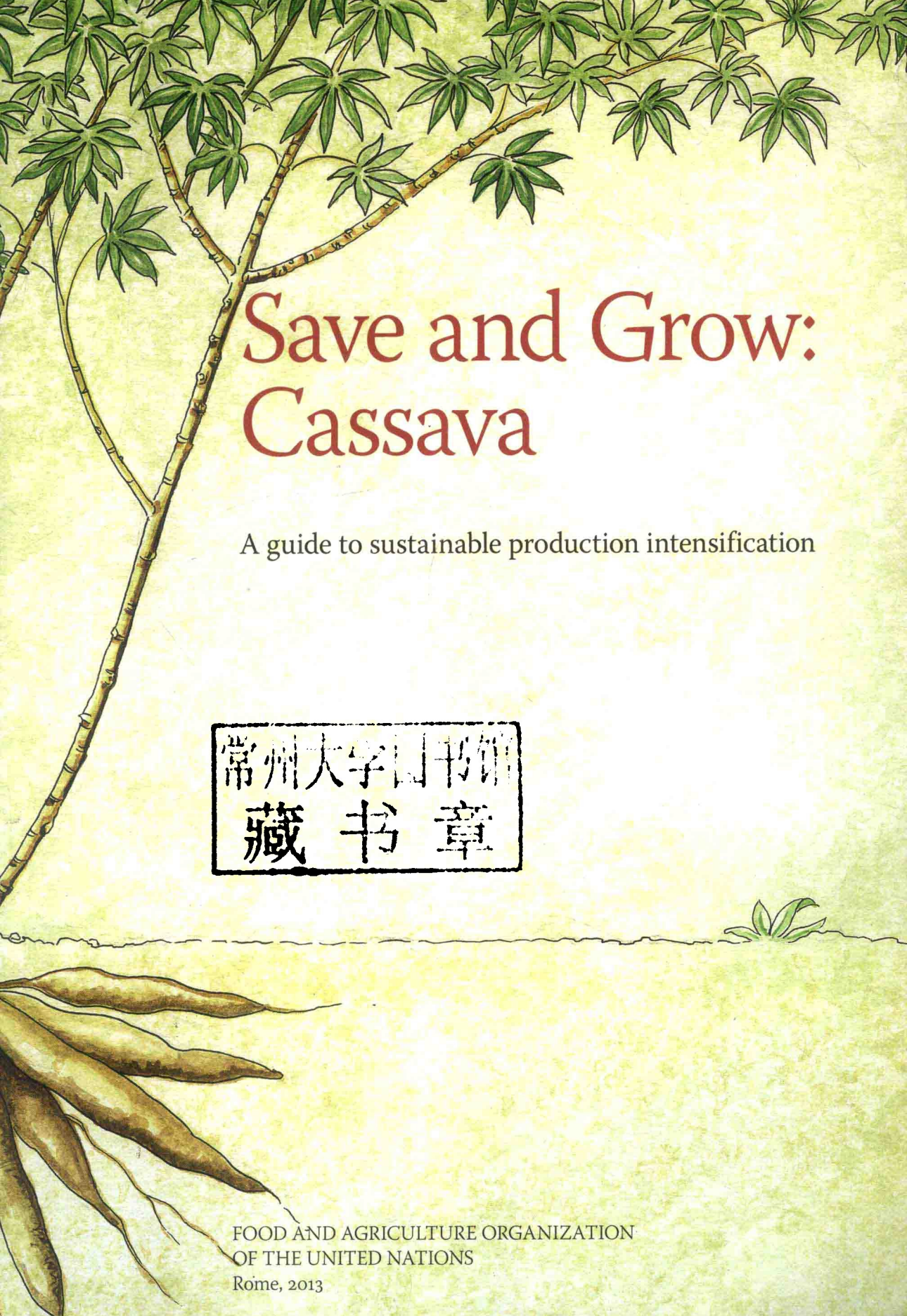
SAVE AND GROW

Cassava

A GUIDE TO SUSTAINABLE PRODUCTION INTENSIFICATION



Save and Grow: Cassava

A guide to sustainable production intensification

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Foreword

Cassava is a tropical root crop, originally from Amazonia, that provides the staple food of an estimated 800 million people worldwide. Grown almost exclusively by low-income, smallholder farmers, it is one of the few staple crops that can be produced efficiently on a small scale, without the need for mechanization or purchased inputs, and in marginal areas with poor soils and unpredictable rainfall.

Since 2000, the world's annual cassava production has increased by an estimated 100 million tonnes, driven in Asia by demand for dried cassava and starch for use in livestock feed and industrial applications, and in Africa by expanding urban markets for cassava food products. There is great potential for further production increases – under optimal conditions, cassava yields can reach 80 tonnes per hectare, compared to the current world average yield of just 12.8 tonnes.

Booming demand offers millions of cassava growers in tropical countries the opportunity to intensify production, earn higher incomes and boost the food supply where it is most needed. But how smallholder cassava growers choose to improve productivity should be of major concern to policymakers. The Green Revolution in cereal production, based on genetically uniform varieties and intensive use of irrigation and agrochemicals, has taken a heavy toll on agriculture's natural resource base, jeopardizing future productivity. In moving from traditional, low-input to more intensive cultivation, small-scale cassava growers should not make the same mistakes.

Sustainable intensification of cassava production is the subject of this guide, the first in a series to the practical application of FAO's "Save and Grow" model of agriculture to specific smallholder crops and farming systems. Endorsed by FAO in 2010, "Save and Grow" is an ecosystem approach to agriculture that aims at improving productivity while conserving natural resources. It promotes practices that can help the world's half a billion smallholder farm families to produce more from the same area of land while enhancing natural capital and ecosystem services.

Drawing on two decades of research findings and on-farm experiences in Africa, Asia, Latin America and the Caribbean, the guide presents an eco-friendly approach to managing cassava more intensively. Many recommended practices combine traditional knowledge with modern technologies that are adapted to the needs of small-scale

producers. They include: minimizing tillage to protect soil health, optimizing timing and methods of planting, and using biological control agents to counter pests and diseases. The guide shows how well-balanced applications of mineral fertilizer, in combination with intercropping, crop rotation, mulching, manure and compost, can make a cassava-based farming system not only more productive and profitable, but also more sustainable.

The adoption of "Save and Grow" agriculture will require significant improvements in the provision of extension, inputs and production credit to small-scale producers. Moreover, FAO recognizes that improved productivity may not bring about sustainable, long-term development outcomes: a major effort is needed to integrate smallholders into higher levels of value addition. Transforming cassava into a multipurpose subsector that generates income, diversifies economies and ensures food for all will require political commitment, investment, institutional support and a demand-driven approach to technology development.

This guide will be a valuable resource for policymakers in assessing how a dynamic cassava sector can help them to achieve their goals of poverty alleviation, economic development and food security, and of practical use to agricultural researchers, technicians and other professionals in preparing programmes for sustainable cassava production intensification.

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Overview

1. Cassava, a 21st century crop

The "food of the poor" has become a multipurpose crop that responds to the priorities of developing countries, to trends in the global economy and to the challenge of climate change.

Long regarded as unsuitable for intensification, cassava has grown dramatically in importance in world agriculture. The 2012 harvest reached record levels, thanks to expansion of global trade in cassava products and strong growth of output in Africa. Production is intensifying worldwide. In the years ahead, cassava will see a shift to monocropping, higher-yielding genotypes, and greater use of irrigation and agrochemicals. But intensification carries great risks, including upsurges in pests and diseases, and depletion of soil nutrients. This guide shows how FAO's "Save and Grow" farming approach can help developing countries to avoid the risks of unsustainable intensification, while realizing cassava's potential for producing higher yields, alleviating rural poverty and contributing to national economic development.

2. Farming systems

Many smallholder cassava growers already practise three key "Save and Grow" recommendations: reduced or zero tillage, soil surface cover and crop diversification.

Planting cassava without prior tillage in degraded soils may produce lower yields in the initial years; once soil health is restored, however, untilled land can produce high yields at a lower cost to the farmer and the farm's natural resources. Mulch and cover crops help to reduce weed infestations and create soil conditions that improve productivity. Growing cassava in associations, sequences and rotations increases net income per unit area of land, and reduces the risk of crop failure. Intercropping with grain legumes can produce higher incomes than monocropping, and supplies food for the household. Protective hedgerows reduce soil erosion, while rotating cassava with legumes and cereals helps to restore soil health and yields.

3. Varieties and planting material

The full potential of cassava will not be realized until production constraints are mitigated in higher-yielding varieties, and cassava growers have access to disease-free planting material.

The time is right for the genome-wide characterization of cassava genetic diversity, to fill gaps in landrace collections, and to create natural reserves to safeguard wild relatives. The harmonization of passport and evaluation data on genebank accessions should be a priority. Breeding should focus on developing varieties that are well-adapted to specific agro-ecologies, cropping systems and end-uses, and produce good yields with minimal need for agrochemicals and irrigation. The routine multiplication and distribution of disease-free planting material of improved varieties are essential for sustainable intensification. While few countries have formal seed systems for cassava, a 3-tier community-based system pioneered in Africa, involving NGOs and farmer associations, has helped ensure that improved varieties and healthy planting material are adopted by cassava growers.

4. Water management

Once established, cassava can grow in areas that receive just 400 mm of average annual rainfall. But much higher yields can be obtained with higher levels of water supply.

Optimizing rainfed cassava production requires careful attention to planting dates, planting methods and planting positions, and soil management practices that help to conserve water. Although it can grow in areas with 400 mm of rainfall a year, maximum root yields in Thailand were correlated with rainfall totalling about 1 700 mm. Cassava responds well to irrigation – full surface irrigation has doubled the root yield obtained without irrigation; drip irrigation can produce about the same yield as surface irrigation using 50 percent less water. In Nigeria, root yields increased sixfold when the quantity of water supplied by supplementary drip irrigation was equal to that of the season's rainfall. Supplemental irrigation that increased the total water supply by 20 percent almost doubled root yields.

5. Crop nutrition

Combining ecosystem processes and judicious use of mineral fertilizer forms the basis of a sustainable crop nutrition system that produces more while using fewer external inputs.

Although cassava produces reasonable yields on poor soils, many varieties perform better with fertilization. Yields in Africa, especially, could be markedly improved if farmers had access to mineral fertilizer at a reasonable price. Farmers can improve soil fertility with other "Save and Grow" measures. Intercropping grain legumes, and mulching the residues of legumes and native weeds, boosts root yields. When combined with fertilizer, both alley cropping with deep-rooting leguminous trees and the use of organic compost or farmyard manure produce higher crop yields and net incomes. Options to reduce the loss of soil nutrients to erosion include zero tillage, which maintains soil aggregate stability and internal drainage, contour hedgerows of vetiver grass, and the application of mineral fertilizer, which leads to faster soil coverage by the plant canopy.

6. Pests and diseases

Protecting cassava with pesticide is usually ineffective and hardly ever economic. A range of non-chemical measures can help farmers reduce losses while protecting the agro-ecosystem.

Growers should use planting material of varieties with tolerance or resistance to major pests and diseases, as well as ecosystem-based practices, such as mulching, maintaining soil organic matter, and planting intercrops to provide a habitat for pest predators. Biopesticides, sticky traps and soapy water can help control many insect pests. Plant health strategies should encourage natural biological agents – the mass release of a tiny wasp defeated serious outbreaks of cassava mealybug in Africa and Asia. To prevent weeds overwhelming young plants, farmers should use optimum planting densities and fertilization, and varieties with vigorous early growth. Regular hand weeding can be as effective as weed control with herbicides. Farmers need to exercise care in the choice of the herbicides and should follow the advice of local plant protection specialists.

7. Harvest, post-harvest and value addition

Food for the household, feed for livestock, and raw material for a wide array of value-added products, from coarse flour to high-tech starch gels – cassava is a truly multipurpose crop.

Harvested cassava roots are consumed directly by many farm households or fed to their livestock. Roots can be processed into granulated flour, or into high quality cassava flour which can be used as a substitute for some of the wheat flour in bread and confectionary. In Thailand and China, root starch goes into food products, plywood, paper and textiles, and is used as feedstock for production of sweeteners, fructose, alcohol and fuel ethanol. Two recent cassava mutations have starch properties that are highly valued by industry. The root is not the only useful part of the plant – young cassava leaves make a nutritious vegetable, and plant tops can be fed to cattle, buffaloes, pigs, chickens and silkworms.

8. The way forward

Governments need to encourage smallholders' participation in a sustainable cassava development agenda, and support research and extension approaches that "let farmers decide".

Farmer participatory research and farmer field schools have proven very effective in promoting sustainable natural resources management in smallholder production systems. Cassava growers may also require incentives, such as payments for environmental services, to adopt improved farming practices. Action is needed to make mineral fertilizer and other inputs more affordable to smallholders, and to provide them with quality, disease-free planting material. Investment in roads, storage and processing capacity in production zones will help cassava growers retain a bigger share of value-addition. Policies should promote private investment in cassava processing, and foster associations that link producers with processors, promote standards and share market information. While government subsidies may reduce farmers' exposure to price volatility, more sustainable options are available, such as crop insurance and supply contracts between food manufacturers and farmers' cooperatives.

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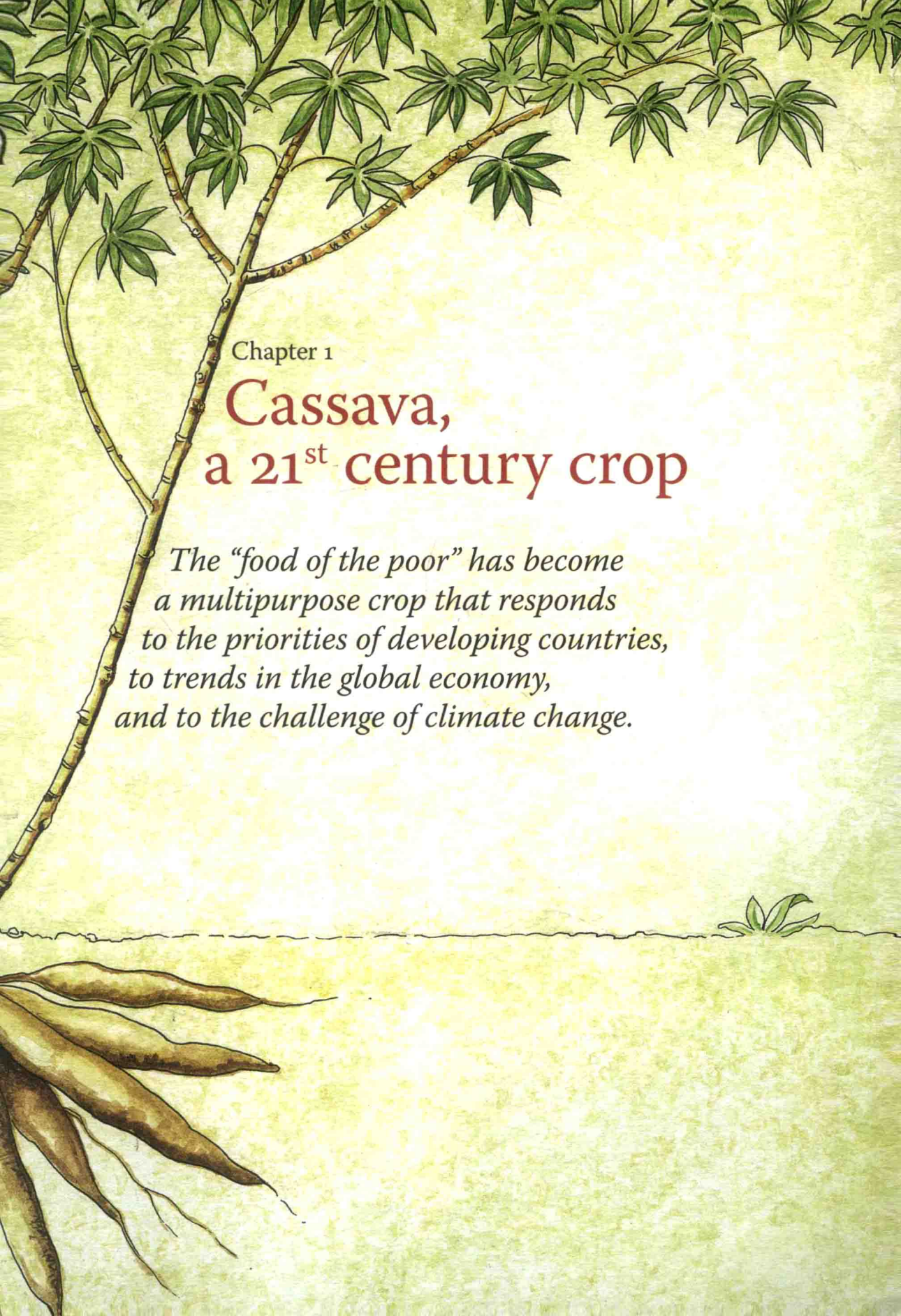


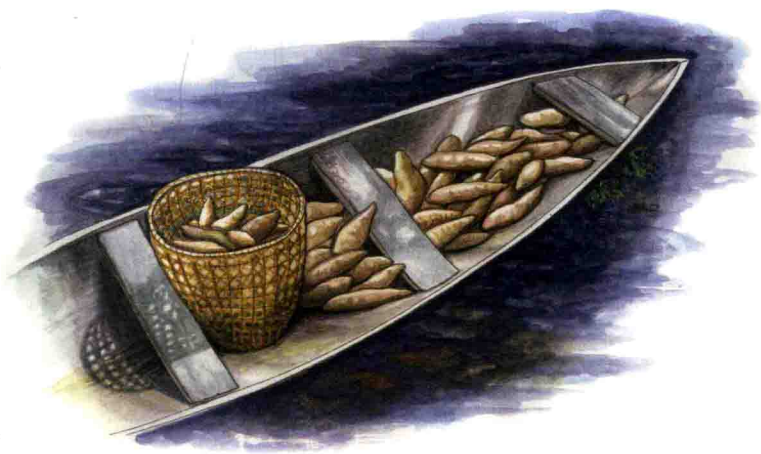
Chapter 1

Cassava, a 21st century crop

The "food of the poor" has become a multipurpose crop that responds to the priorities of developing countries, to trends in the global economy, and to the challenge of climate change.

Cassava (*Manihot esculenta* Crantz) is one of some 100 species of trees, shrubs and herbs of the genus *Manihot*, which is distributed from northern Argentina to the southern United States of America. While some studies indicate that cassava has multiple centres of origin, others suggest that the cultivated species originated on the southern edge of the Brazilian Amazon[1-4]. Botanically, cassava is a woody perennial shrub, which grows from 1 m to 5 m in height. It is believed to have been cultivated, mainly for its starchy roots, for 9 000 years, making it one of agriculture's oldest crops. In pre-Colombian times, it was grown in many parts of South America, Mesoamerica and the Caribbean islands.

Following the Spanish and Portuguese conquests, cassava was taken from Brazil to the Atlantic coast of Africa. By the 1800s it was being grown along Africa's east coast and in Southern Asia. Farming of cassava expanded considerably in the 20th century, when it emerged as an important food crop across sub-Saharan Africa and in India, Indonesia and the Philippines. Since it is sensitive to frost and has a growing season of nearly one year, cassava is cultivated almost exclusively in tropical and subtropical regions. It is grown today by millions of small-scale farmers in more than 100 countries, from American Samoa to Zambia, under a variety of local names: *mandioca* in Brazil, *yuca* in Honduras, *ketela pohon* in Indonesia, *mihogo* in Kenya, *akpu* in Nigeria and *sắn* in Viet Nam.



Studies suggest that cassava was first cultivated, as many as 9 000 years ago, on the southern edge of the Brazilian Amazon, where it is still grown today

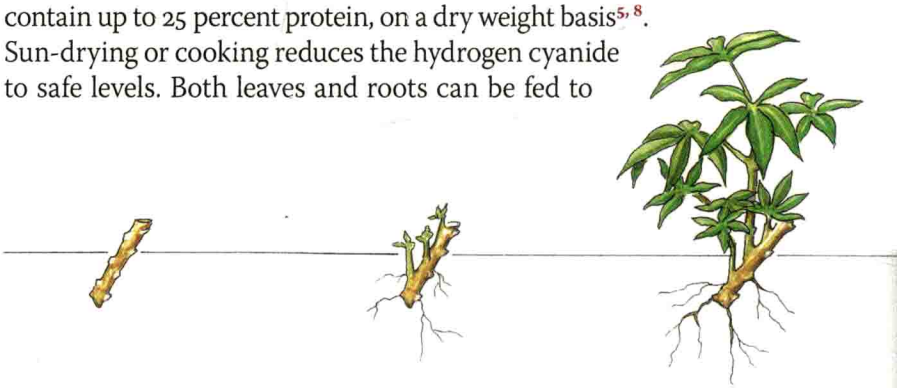
***Manihot esculenta* has characteristics** that make it highly attractive to smallholder farmers in isolated areas where soils are poor and rainfall is low or unpredictable. Since it is propagated from stem cuttings, planting material is low-cost and readily available. The plant is highly tolerant to acid soils, and has formed a symbiotic association with soil fungi that help its roots absorb phosphorus and micronutrients. To discourage herbivores, its leaves produce two glycosides which, when digested, produce highly toxic hydrogen cyanide. Since most of the soil nutrients absorbed during growth remain in the above-ground part

of the plant, recycling the plant tops helps to maintain soil fertility. Under drought stress, leaf production is reduced until the next rains. Thanks to its efficient use of water and soil nutrients, and tolerance to sporadic pest attacks, cassava growers, using few if any inputs, can expect reasonable harvests where other crops would fail.

Cassava roots are more than 60 percent water. However, their dry matter is very rich in carbohydrates, amounting to about 250 to 300 kg for every tonne of fresh roots. When the root is used as food, the best time to harvest is at about 8 to 10 months after planting; a longer growing period generally produces a higher starch yield. However, harvesting of some varieties can be "as needed", at any time between six months and two years. Those attributes have made cassava one of the world's most reliable food security crops.

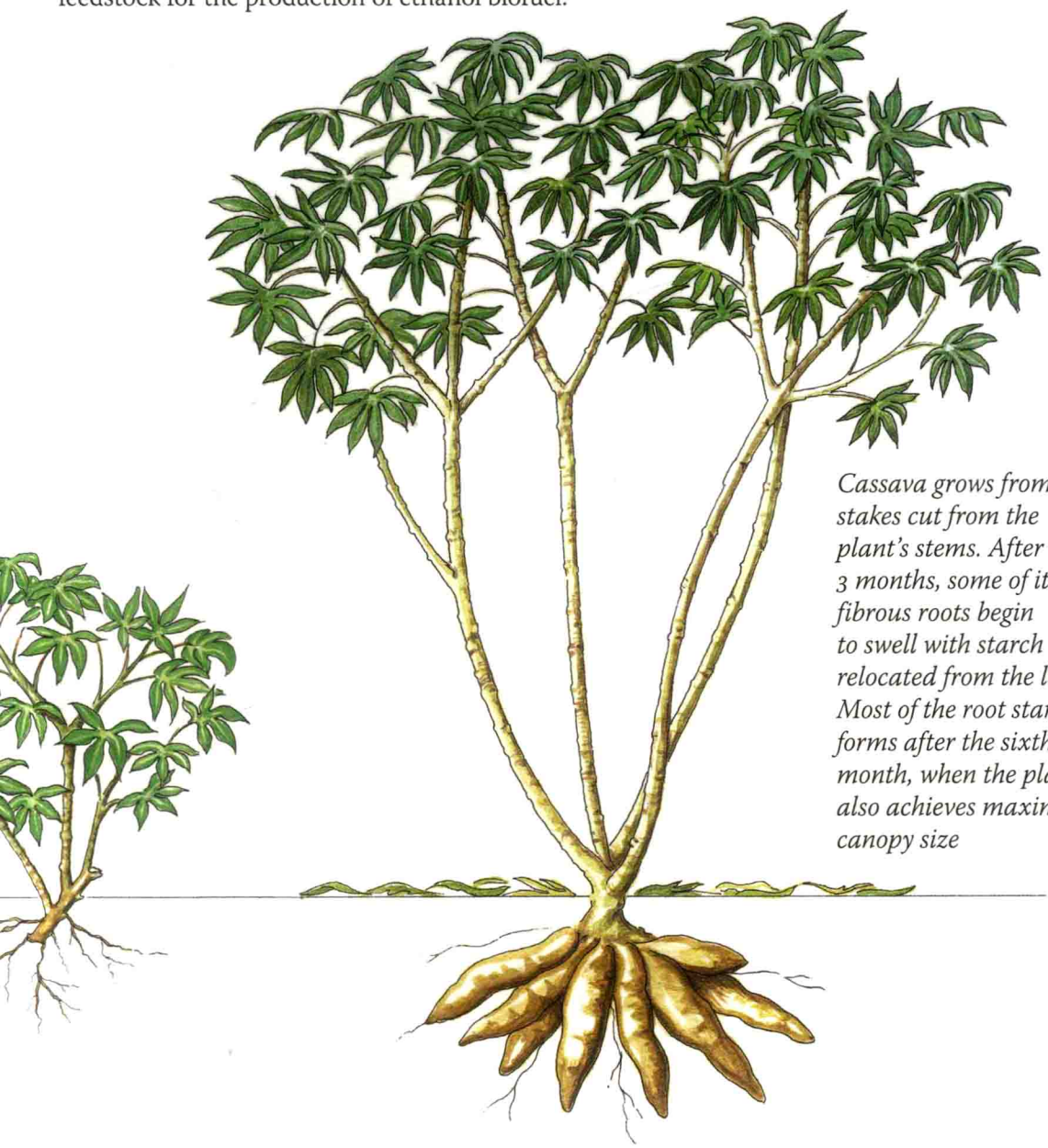
Thanks to its roots' high starch content, cassava is a rich source of dietary energy. Its energy yield per hectare is often very high, and potentially much higher than that of cereals[5]. In many countries of sub-Saharan Africa, it is the cheapest source of calories available. In addition, the roots contain significant amounts of vitamin C, thiamine, riboflavin and niacin[6].

Depending on the variety, they may also contain high levels of cyanogenic glycosides, especially in the outer layers[7]. Once harvested, therefore, cassava roots are peeled, then thoroughly cooked, or peeled, grated and soaked to induce fermentation in order to release the volatile cyanide gas. The mash is processed further – by drying, roasting or boiling – into coarse flour and other food products. In some countries, cassava is also grown for its leaves, which contain up to 25 percent protein, on a dry weight basis[5, 8]. Sun-drying or cooking reduces the hydrogen cyanide to safe levels. Both leaves and roots can be fed to



farm animals, while stems can be used as firewood and a substrate for growing mushrooms.

Cassava's versatility does not end there. Its root starch can also be used in a wide array of industries, including food manufacturing, pharmaceuticals, textiles, plywood, paper and adhesives, and as feedstock for the production of ethanol biofuel.



Cassava grows from stakes cut from the plant's stems. After 3 months, some of its fibrous roots begin to swell with starch relocated from the leaves. Most of the root starch forms after the sixth month, when the plant also achieves maximum canopy size

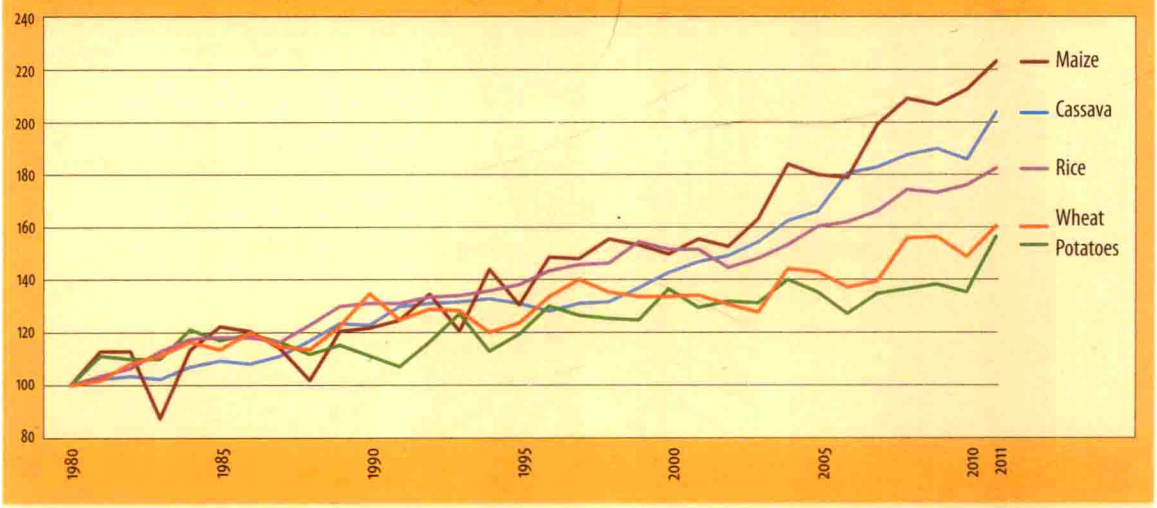
Among the family of staple food crops, cassava was long regarded as the least suited to intensification. Cassava stem cuttings are bulky and can easily transmit serious pests and diseases, and the plant's very low rate of vegetative multiplication retards the adoption of new, improved varieties. Unearthing cassava roots is labour-intensive, and the roots themselves are cumbersome to transport and highly perishable: they need to be processed within a few days of harvesting.

The Green Revolution approach to intensification, based on dwarf varieties and high inputs of agrochemicals and irrigation, dramatically boosted yields of wheat and rice, but it has proven inappropriate for cassava in rainfed areas. Partly because it is grown in developing countries, far less research and development has been devoted to cassava than to rice, maize and wheat[9].

But cassava's importance in agriculture has changed dramatically. Between 1980 and 2011, the global harvested area of cassava expanded by 44 percent, from 13.6 million to 19.6 million hectares, which was the biggest percentage increase among the world's five major food crops. In that same period, world cassava production more than doubled, from 124 million to 252 million tonnes[10].

Over the past decade, growth in cassava production has accelerated (Figure 1). FAO estimates put the global harvest in 2012 at more than 280 million tonnes, representing a 60 percent increase since 2000 and an annual growth rate double that of the previous two decades[11]. Since 2000, the growth rate of cassava output in Africa has been equal to

Figure 1 **Growth in world production of major crops, 1980-2011** (index 1980=100)



Source: FAO. 2013. FAOSTAT statistical database (http://faostat.fao.org/).