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PUTTING PARTICIPATORY DOMESTICATION INTO PRACTICE IN WEST AND CENTRAL AFRICA

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ABSTRACT

The World Agroforestry Centre (ICRAF) has been working in the African Humid Tropics (AHT) since 1987. Despite its natural wealth, small-scale farmers of AHT are among the poorest people in the world and have relied on extractive harvesting of forest products and traditional shifting cultivation for their food and other needs. After years of severe deforestation, alternatives now have to be found as land pressure has increased and commodity prices of cash crops have declined. To overcome these problems, the Participatory Domestication of high-value indigenous fruit, nut and medicinal trees is seen as one way of empowering rural households to improve their own situation. Many products of indigenous trees have existing local and regional markets, with additional potential niches in international commerce. In Participatory Domestication, villagers are helped to develop local nurseries, taught skills of vegetative propagation, and assisted with the technical implementation of selecting superior trees for cultivar development, that meet specific market-oriented 'ideotypes'. Farmers are enthusiastically adopting these techniques and are thereby improving their own livelihoods. The most successful community is expecting to make $US10,000 in 2005 from the sale of improved cultivars from its nursery. The AHT tree domestication programme started in two villages in 1998, now 42 villages in two Provinces of Cameroon are active partners, and the programme has been extended to other countries. Currently, about 5000 farmers are practising participatory tree domestication techniques: 3500 in Cameroon, 1000 in Nigeria and 500 in the Democratic Republic of Congo. The programme has also started in Equatorial Guinea and will soon be expanding to Ghana, Guinea Conakry, Sierra Leone and Liberia. This paper describes the steps used to implement a participatory approach to tree domestication, and the lessons learnt. It also examines the perceived advantages and disadvantages of domestication, as well as the constraints and opportunities. The critical importance of local processing and value-adding for improved storage of products with short shelf-life is discussed as a means to ensure that the market for agroforestry tree products expands in parallel with the supply.

Key words: agroforestry, agroforestry tree products (AFTPs), cultivar development, *Dacryodes edulis*, indigenous fruit trees, intellectual property rights, *Irvingia gabonensis*, tree improvement, vegetative propagation.

INTRODUCTION

Despite centuries of urbanization and industrialization, almost half of the world's population still lives as subsistence or small-scale farmers, earning less than US$1 per day. In many countries the production of agricultural export commodities

represents a major source of foreign income, with income from agricultural crops, such as cocoa or coffee, ranking second in importance after oil in international trade. Governments therefore focus their agricultural development planning on the cultivation and expansion of these commodity crops. Unfortunately this modern, large-scale, capital-intensive agriculture based on the advances of plant breeding and extensive use of agri-chemicals has not greatly benefited the resource-poor farmers in Africa, where land degradation, and declining livelihoods have led to increased deforestation rather than increased productivity (Evenson, and Gollin 2003).

The Congo Basin is the world's second largest continuous rainforest. It is home to more than 20 million people, who mostly depend on natural resources for their livelihoods. Poverty is widespread in the African Humid Tropics (AHT – see Table 1) and many farmers practice subsistence agriculture, involving practices such as shifting cultivation. Shifting cultivation becomes unsustainable as the population increases and fallow rotations shorten. To address these issues new approaches are needed for the continuous cultivation of crops on small areas of land in ways which increase the variety and diversity in different cropping systems, while assuring food security and income generation from sources other than major commodity/cash crops.

Since 1998 the World Agroforestry Centre – formerly the International Centre for Research in Agroforestry (ICRAF) – and its partners have developed a participatory approach to the domestication of high-value indigenous fruit and nut trees, and medicinal plants in West and Central Africa (Tchoundjeu *et al.* 1998; Leakey *et al.* 2003). This paper builds on experience in Cameroon and Nigeria with a number of species, especially *Dacryodes edulis* (Safou) and *Irvingia gabonensis* (Bush mango/Dika nut). This approach to improving agroforestry tree products (AFTPs) aims to increase significantly and stabilize income, food and health strategies of rural households and their extended families. In this way it seeks to ensure that

TABLE 1

Development indicators for four Western and Central African countries

	Cameroon	Nigeria	Equatorial Guinea	Democratic Republic of Congo
Population, total (millions)	14.9	126.9	0.457	52.4
Population growth (annual %)	2.2	2.4	2.7	2.7
Rural population (% of total)	51	56	52	70
Life expectance at birth (years)	50.0	46.8	51.0	45.7
Mortality rate, infant (per 1000 live births)	75.8	84.4	101.8	84.9
Forest area ('000 sq. km)	2,386	1,352	17.52	1,400
Annual deforestation (% of change)	0.9	2.6	0.6	0.4
GDP per capita (US$)	1573	853	4676	74
GDP growth (annual %)	4.2	3.8	16.9	-5.7
Illiteracy rate, male (% of males 15+)	17.6	27.6	7.5	25.8
Illiteracy rate, female (% of females 15+)	30.5	44.3	25.6	48.2

Source: The World Bank, World Development Indicators database, April 2002

women, youths and other vulnerable groups in society, obtain maximum benefits from agroforestry.

History of Participatory Tree Domestication in African Humid Tropics

Domestication is the process by which wild species are brought into cultivation through processes of selection and adoption. Put simply, participatory tree domestication refers to the means by which rural communities select, propagate and manage trees according to their own needs, in partnership with scientists, civic authorities and commercial companies. It is usually oriented towards specific local markets and encompasses the use of both indigenous knowledge and genetic selection based on scientific principles (Leakey *et al.* in press). In such cases, scientists generally work at the community/household level with farmers on species of their own choice. Participatory domestication thus empowers the farmers, allowing the outputs and benefits of domestication to remain with the community, as proposed by the Convention on Biological Diversity (Leakey *et al.* 2003). Domestication activities are developed in many 'pilot' villages, each creating their own set of cultivars. At least in the short term, this strategy seems to maintain genetic diversity across the country (Leakey *et al.* 2004). If this can be sustained, the risks of genetic erosion attached to any large-scale programme of vegetative propagation, can hopefully be minimised.

In the early years of the African Humid Tropics (AHT) programme, action was limited to Cameroon and Nigeria, although species priorities were set using techniques developed by Franzel *et al.* (1996), in Cameroon, Ghana, Gabon and Nigeria. The development of strategies and techniques for Participatory Domestication has occurred over the last ten years and has been well documented (Simons, 1996; Leakey and Simons, 1998; Tchoundjeu *et al*. 1998; Leakey *et al*. 2003; Simons and Leakey, 2004). The programme has more recently expanded into Equatorial Guinea and Gabon (2002), Democratic Republic of Congo and Ghana (2004). With this geographical expansion the list of species has also been expanded (Facheux *et al.* 2003) and now includes:

(a) Indigenous fruit/nut trees: *Irvingia gabonensis, Irvingia wombolu; Dacryodes edulis, Garcinia kola, Ricinodendron heudelotii, Cola nitida, Chrysophyllum albidum, Allanblackia* spp.*;*
(b) Indigenous leafy vegetables: *Gnetum africanum*
(c) Medicinal trees: *Prunus africana, Pausinystalia johimbe, Annickia chloranta*
(d) Melliferous trees and shrubs: *Vernonia*, *Alchornea*, *Dombeya*, *Myrianthus*, *Polyscias* and *Vitellaria* species and *Lophira lanceolata*.

The work on *Allanblackia* species, which are important producers of vegetable oils used in food, cosmetic and detergent industries, was initiated in 2003 under a Public-Private Partnership developed between Unilever International plc. and ICRAF, and involves other partners such as IUCN and SNV (Netherlands Development Organization).

In addition, ICRAF has also extended its tree domestication activities to the Sahel (Tchoundjeu 1996, Bonkoungou *et al*. 1999), the Miombo woodlands of southern Africa (Akinnifesi 2006), the Highlands of East Africa (Simons *et al*. 2000), the headwaters of the Amazon (Weber *et al*. 2001) and to SE Asia (Roshetko and Evans 1999).

GETTING STARTED

One important early step in the domestication of any species is the collection of germplasm. In this programme, this was done at random for purposes of gene conservation and through selection of superior individual trees for genetic improvement, as described by Dawson and Were (1997) and Tchoundjeu *et al*. (1998). When getting started, it is important to recognize that farmers may not, at first, fully understand the need, process and importance of germplasm collection. When farmers are first asked to select their best trees for vegetative propagation, they may not necessarily select those that are most suited for commercialisation. Particular trees may be desirable for other reasons. These may include being conveniently located near the homestead. Their choice may also reflect their lack of trust in the domestication team. The consequence, however, can be that the first batch of marcots does not meet expectations when they start fruiting. To prevent this, more time must be spent with farmers, explaining and educating them on the objectives of participatory tree domestication. Effective approaches include:

- using training materials such as visual aids and diagrams, especially ones showing the programme results in nearby villages;
- arranging exchange visits to other participating villages, or to research nurseries and field trials, so that the new farmers actually see the results of former work.

These can greatly increase the understanding of the farmers. For the farmer, however, the proof that vegetative propagation (marcotting) actually makes a copy of the original tree only comes when his/her own marcots start fruiting, 2–3 years later. Acquiring this proof can be essential before a farmer is willing to cut branches off his/her favourite tree and agree to set the marcots.

Leakey *et al*. (2000) suggest that it is desirable to measure and record the particular characteristics of the fruits from each tree. While it is recognised that the morphological differences between trees will be influenced by environmental and genetic variation, this characterization process allows the selection of the best trees to be done on the basis of sound data, rather than on subjective opinions. This quantification makes possible the comparison of different trees and ensures that the market opportunities are well matched and, in due course, will be important for product marketing and for cultivar registration. One approach to visualizing this data is the multi-trait 'ideotype' – the definition of the ideal tree to meet a particular market opportunity (Leakey *et al.* 2002 for *Dacryodes edulis* and Atangana *et al.* 2002 for *Irvingia gabonensis*). The ideotype can include morphological traits like

size of different components of the fruit, visual traits like colour of the skin, or flesh, organoleptic traits like flavour and smell (Kengni *et al*. 2001); nutritional traits like protein, fatty acid and vitamin content; food thickening properties (Leakey *et al*. 2005) and chemical traits (Leakey and Page, 2006). In addition, selections may be based on seasonality of fruiting, yield or any other trait that may enhance the market value or utility of a product.

Having identified the trees in the wild, or in on-farm populations, that have the potential to become new cultivars, the next stage is to propagate these trees vegetatively. Vegetative propagation involves the asexual regeneration of new plants typically from meristematic parts of a 'mother plant' or stockplant, and the resulting plants are genetic copies of that plant and form a clone. When a clone is derived from a genetically superior plant, it can be multiplied up as a cultivated 'variety' ('cultivar'). Vegetative propagation takes a number of forms: rooting stem cuttings, budding and grafting, air layering and tissue culture (Leakey 2004), which can be used under different circumstances. Air layering (or marcotting) is often used to make the first set of clonal plants from a sexually-mature (i.e. fruiting) wild tree in the forest or on a farm and when established as a stockplant are a valuable source of cuttings or scions for multiplication by rooting or grafting. Simple and robust techniques for root cuttings that do not require running water or electricity have been developed for village nurseries where more sophisticated horticultural technologies would be problematic (Leakey *et al.* 1990; Tchoundjeu *et al.* 2002). Appropriate protocols for cutting propagation have been refined for *Irvingia gabonensis* and *Gnetum africana* (Shiembo *et al*. 1996a/b), *Ricinodendron heudelottii* (Shiembo *et al*. 1997, Ngo-Mpeck *et al*. 2004), *Dacryodes edulis* (Mialoundama *et al*. 2003), *Prunus africana* (Tchoundjeu *et al.* 1999; Tchoundjeu *et al.* 2002), and *Pausinystalia johimbe* (Tchoundjeu *et al.* 2004).

IMPROVEMENT OF PROPAGATION TECHNIQUES

In recent years, further refinements have been made to the original design of the non-mist poly propagator (Mbile *et al*. 2004). Techniques for marcotting are also being refined and improved leading to increased post-severance survival from 5–10% up to 50% for *Irvingia gabonensis* and 70% for *Dacryodes edulis*. These improvements can be attributed to the post-severance use of a high humidity tent for nursery establishment. As an alternative to air layering, grafting and budding have also been used, but these techniques require more skills and can also have problems of tissue rejection (incompatibility). Some species such as *Irvingia gabonensis* and *Garcinia kola* have proved difficult to marcot, but are being successfully multiplied (50–60%) using grafting techniques. After mastering the rooting and the marcotting (air layering), farmers in many village nurseries in Cameroon, Nigeria and Democratic Republic of Congo are starting to try grafting techniques. The idea behind participatory domestication is to provide a package of techniques to farmers and help them adopt and use the technologies provided that are most appropriate for their conditions, situation and environment.

THE IMPLEMENTATION OF PARTICIPATORY TREE DOMESTICATION WITH SMALL-SCALE FARMERS

Resource-poor farmers in West and Central Africa typically clear forest to grow crops such as groundnuts, cassava, maize and plantain. Trees are unfortunately often perceived as obstacles to the expansion of agricultural activities; a perception reinforced by the institutions supporting agriculture, as well as those engaged in managing forest reserves. Since Independence nearly 40 years ago and until recently, forest policy and law in Cameroon has excluded local populations from access to natural forests. However, in 1994 a new Forest Law was passed aimed at correcting this situation by the promotion of community forests managed by the local population. However, the application process (Djeumo 2001) and marginalization of traditional authorities (Oyono 2005) have been constraints to the development of community forests. The Government designed and promoted community forests predominantly with timber extraction in mind and made little effort to inform the local population about the fragility of the forest or ways to develop it sustainably. Consequently, farmers perceived the new law as an opportunity to exploit the forest for timber rather than realizing that it has great potential as a source of traditionally important and marketable non-timber forest products from indigenous fruit trees and medicinal plants. ICRAF's initiative to domesticate these species and to bring the trees into cultivation is an innovative approach aimed at helping farmers to develop a more sustainable approach to utilizing the tropical forest. Farmers in target villages (see Table 2) have responded well to this initiative and have welcomed ICRAF staff and associated Community Based Organizations, Non-Governmental Organizations and National Agricultural Research Systems offering assistance in the form of training and help in the domestication of indigenous trees producing marketable products. As a result, villages have established small nurseries for the propagation of fruit, nut and medicinal trees. These have become the central pilot nurseries in what is an expanding number of nurseries.

Between 1998 and 1999, pilot nurseries were established in Nkolfep, Abondo, Ting Melen and Ngoumou villages within the forest zone and Belo in the humid savannah zone (Table 2). These first nurseries played the role of central or training nurseries, with farmers coming 10–15 km to be trained in vegetative propagation techniques. Since then, new 'satellite' nurseries are developing as farmers who have acquired the necessary skills create nurseries in their own villages, overcoming the constraint of distance for the adoption of the technology (Figure 1).

Establishing pilot nurseries

The first groups of farmers approached were typically those who were already familiar with ICRAF activities in improved fallows and apiculture. Later, when approaching villages that were unfamiliar with ICRAF activities, NGOs that were already working with these communities were used. This was particularly important in the forest zone where farmers usually perceived trees as an obstacle to the expansion

TABLE 2

The location and date orf establishment of village nurseries in the Humid Forest and Savannah Zones of southern Cameroon (Underlined names are the Pilot village in each district. The following names are the satellite villages/organizations. The names of associated NGOs are in brackets).

Humid Forest Zone	
Village nurseries (Associated NGO)	
• *Abondo*	–1998
– Essong Mintsang	– 2001
– Abondo II	– 2001
• *Nkolfep*	– 1998
– Elig-Nkouma	– 1999
– Nkom-Efoufoum	– 2001
– Nkef II	– 2001
– Lekie-Assi	– 2001
– Mpong	– 2001
– Mbelelekie	– 2003
– Mbagbang	– 2004
– Kalnagha	– 2004
• *Ting-Melen (CRATAD)*	– 1999
– Nlobisson	– 2002
– Ayo	– 2003
– Alomba	– 2003
– Essang	– 2003
– Makenene	– 2004
• *Ngoumou (ATD)*	– 1999
- Ottotomo	– 2001
- Nkon-Bibega	– 2003
– Yop (FONJAK)	– 2003
– Akoazole	– 2003
– Ekowondo	– 2003
– Le Vaillant	– 2004
– Bafia	– 2004
• *Ondeck (SAILD)*	– 2003
• *Epkwassong (SAILD)*	– 2003

Savannah Zone	
Village nurseries (Associated NGO)	
•*Belo (MIFACIG /CIPCRE)*	– 1999
– Dichami	– 2003
• *Njinikom*	
– Mboini (CIPCRE)	– 2001
– Baichi	– 2003
– Kikfuini	– 2003
– Wombong	– 2003
– Bohim	– 2003
– Mumifag	– 2004
• *Fundong (CIPCRE)*	
– Abuh	– 2003
– Twafundong	– 2003
– Atoini	– 2004
•*Upper Boyo (CIPCRE)*	
– Upper Boyo	– 2003
•*Santa*	
– Na'ah (MIFACIG)	– 2004
•*Kumbo*	
– Riba	– 2004

of their agricultural activities. It was made clear to farmers that tree domestication was an opportunity to diversify their income through self-employment and not an opportunity for employment by ICRAF.

Typically, these groups began with 20–30 farmers and as time passed the group reduced in size to a core group of 10–20 who were committed to the training programme. About 25% of these farmers were women, attracted by the emphasis on fruit trees, spices, medicinal plants and vegetables which are usually sold by women or used to feed their family.

Meetings were held with farmers to agree on the concept and strategies for tree

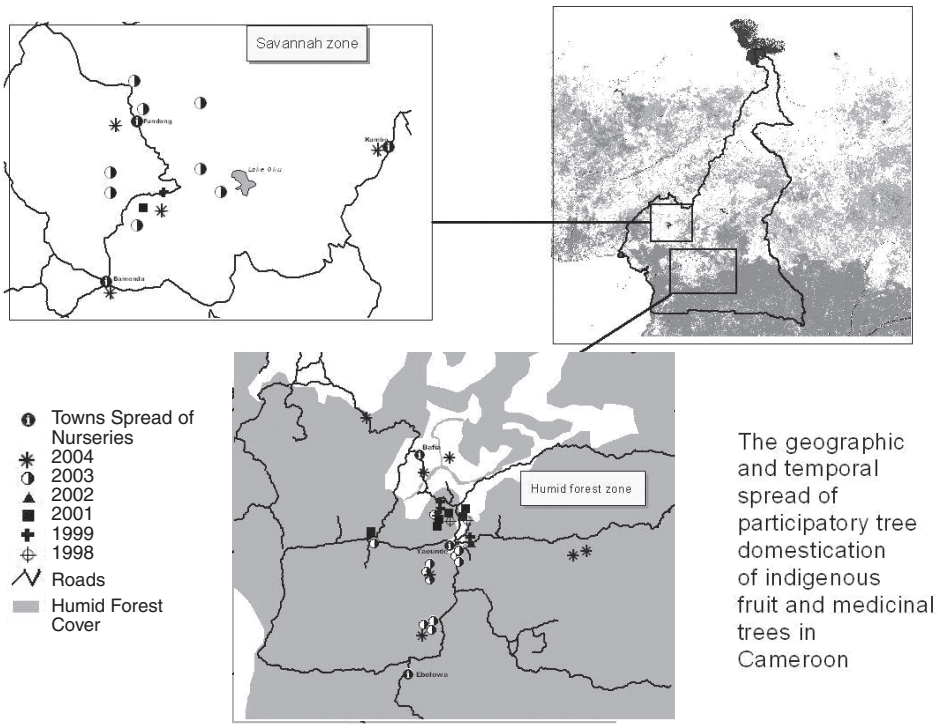

Figure 1. Map of the geographic spread of Participatory Domestication in the Humid Forest and Savannah Zones of southern Cameroon between 1998 and 2004.

domestication. It was agreed that once the farmers' groups had taken the decision to host a pilot nursery, ICRAF staff would only supply the materials that the farmers could not afford, such as a wheelbarrow, watering cans, machetes, fertilizers and polythene plant pots. ICRAF also agreed to provide the materials and technical guidance for the construction of the first non-mist propagators used in the pilot nurseries. All other materials were provided by the farmers, who were then responsible for the day-to-day running of the nursery. Farmers chose their nursery site with guidance from ICRAF staff. The main criteria for this choice were the availability of a regular water supply throughout the year and the security of plants produced. Farmers were asked to appoint someone to be in charge of the execution of the day-to-day activities of their nursery. To assure the sustainability of the project, no financial incentive was paid to this person or any of the farmers. Once the nursery site had been chosen, tasks such as clearing the site, building a shade house, collecting sand from a nearby river and the gathering of stones, were planned with farmers, including dates for the completion of the tasks. The time and way the agreed tasks were undertaken, was found to be a good indicator of the enthusiasm of the farmers' group for the domestication initiative.

Once the nursery had been created, training in elementary nursery techniques was started, and techniques in vegetative propagation (rooting juvenile cuttings,

grafting and marcotting) were gradually introduced to the farmer groups. When the farmers were familiar with the techniques and had seen and understood the benefits of vegetative propagation, they were encouraged to use them on their own trees. Farmers are generally aware of trees in their own area with particular characteristics, such as large and/or sweet fruits, early or late fruiting, long retention of fruit and occurrence of self-cracking nuts, etc. This has led to the development of 'off-season' cultivars of *Dacryodes edulis* that fruit in late December. During the peak fruiting season, the prices are particularly low; while the highest sale prices are for late maturing fruits, which are relatively uncommon. Fruits from late fruiting trees can have the added advantage of being seedless (Anegbeh *et al*. 2005), perhaps due to poor pollination.

EXPANDING THE NETWORK OF VILLAGE NURSERIES

To capitalize on the success of the first farmers, exchange visits within and between countries were arranged so that those who were newly involved in tree domestication could go and see what the first batch of farmers had already achieved. Within Cameroon, exchange visits were followed by competitions between nurseries covered by the media (radio and TV) and these increased many farmers' ambitions. People in neighbouring villages were soon keen to become involved and the trained farmers were encouraged to help and train their neighbours, friends and family in the basic techniques of nursery management and tree selection. This has led to a growing network of satellite nurseries (Figure 1 and Table 2). This growth of the nursery network has been especially fast in the humid savannah of Cameroon, perhaps because farmers here are well aware of the importance of the trees for soil fertility restoration and the fact that species such as *D. edulis* fit well into their farming system. In addition, some of their high-value fruit trees (eg. *Cola* spp) were old and unproductive and the farmers wanted to replant them. In the savannah zone, the most successful group of farmers in Boyo Division (North West Province) set up the Tantoh Mixed Farming Common Initiative Group (MIFACIG). This group of farmers successfully combined improved fallow technologies with the tree domestication techniques. Their nursery has become a small enterprise with demonstration plots containing different high-value fruit trees of the region. In these demonstration plots, cuttings of *Prunus africana* grew rapidly and marcots of *Dacryodes edulis, Cola nitida* and exotic fruit trees such as citrus, oranges and mangoes fruited 2–3 year after planting. This early fruiting provided a great incentive to farmers who realized that they could easily generate substantial income from their nursery activities. This success is illustrated by the growth of income from this nursery from US$2,000 in 2002 to US$5,000 in 2004. It is predicted that income will reach US$10,000 in 2005. Another nursery, Lekie-Assi in the Humid Forest Zone has also been very successful and generated US$1,300 in 2004 and has a business plan for 2005, indicating even greater profits. Cost/benefit analyses are on-going in both nurseries to help the farmers to set realistic prices for their plants.

Experience has shown that in the first two years the nursery is mainly used to

satisfy the needs of the farmers themselves, thereafter they start to sell improved plants. Out of 70 village nurseries in operation in Cameroon last year, nurseries older than 3 years were already involved in the marketing of improved plants. Income generation generally depends on the location of the nursery, with those having easy access to a market being the most profitable. In remote villages, ICRAF is now helping farmer groups to sell their plants by linking them with buyers.

The growth of satellite nurseries

In the forest zone, two second generation satellite nurseries were started in 1999 in Nkom Efoufoum and Elig Nkouma, one year after the creation of the first nurseries at Nkolfeb and Abondo. Two years later, another five satellite nurseries were created in Essong-Mintsang, Abondo II, Nkom-Efoufoum, Nkef II, Lekie-Assi, Mpong and Ottotomo (Table 2). These were followed by one nursery at Nlobisson in 2002 and five more at Mbelekie, Ayo, Alomba, Essang, and Nkon-Bibega in 2003. Although there were no pilot nurseries in the Southern Province of Cameroon, five nurseries were created in 2003 at Yop, Akoazole, Ondeck, Epkwassong and Ekowondo through strategic partnerships with two NGOs (SAILD, FONJAK). Similarly, in the humid savannah zone, nurseries were created in growing number of villages – six in Njinikom between 2001 and 2004, two in Belo (1999 and 2003), and three in Fundong (2003 and 2004), and one in Santa and Kumbo in 2004 (Table 2 and Figure 1).

This experience in the adoption of participatory domestication in Cameroon has led to the recognition that over the years, nurseries require differing amounts of technical support, follow-up and management, depending on the length of their experience and the degree of technical competence developed by the farmers. Nurseries are therefore classified as:

- ***Dependent:*** These nurseries are under development and need careful attention and technical assistance from ICRAF staff and partners on weekly basis.
- ***Semi-dependent:*** The group members of these nurseries have mastered at least one propagation technique and only require technical assistance from ICRAF staff or partners twice a month.
- ***Semi-autonomous:*** These nurseries require only occasional assistance as the members have mastered at least two vegetative propagation techniques and are applying them to other species. Members of this group are generating income from the sale of improved plants they have produced as well as from products from their out-planted cultivars.

EXPANSION IN THE REGION

Resources are being developed to scale up these activities in Cameroon and Nigeria and disseminate them to other countries of the African Humid Tropics region.

Similar approaches to that described above are being applied in:

- Southeast Nigeria: ten satellite nurseries have developed from an original one near Onne near Port Harcourt.
- Democratic Republic of Congo: fourteen satellite nurseries have been formed in Badundu and Equateur Provinces.
- Gabon and Equatorial Guinea: the spread here has been slower than in other countries due, perhaps, to the lack of agriculture skills in these oil producing countries and/or the absence of NGOs in rural areas to supervise the farmers' groups.
- Ghana and Nigeria: work on *Allanblackia* spp. will be expanded to include other important high-value fruit trees and medicinal plants.
- Liberia, Sierra Leona and Guinea Conakry: it is anticipated that new funding will soon stimulate tree domestication activities.

The important issue of how to protect the intellectual property rights (IPR) of the farmers developing the cultivars has still to be resolved. Up to now farmers have not been concerned about the dissemination of germplasm collected from their farms and forests, but this may change in the future. Consequently, all marcots and scions collected from farmers' field are labeled with the names of the farmers and their village. In addition, records are kept of the exact position of the mother tree and its characteristics. All this 'passport data' is kept by the World Agroforestry Centre for future reference should farmers decide to seek Plant Breeder's Rights or some other form of IPR protection.

INTEGRATION OF IMPROVED PROPAGULES IN THE FARMING SYSTEMS

Improved plants produced in village nurseries are typically integrated into gaps in different cropping systems. The introduction of cultivars typically starts in the homegardens, but then extends into food crop and cash crop fields, such as coffee or cocoa. Studies of the integration of indigenous fruits and nuts as the shade trees, or companion crops (Leakey and Tchoundjeu 2001) in the latter systems are in progress. One of the challenges is to match domestication techniques with the needs of the production systems. For example, propagation of mature trees by marcotting or grafting reduces the height of the resultant trees, as it eliminates the juvenile trunk, forming a plant resembling the tree crown on a shortened stem. This is highly desirable for early fruit production in the homegarden giving easy access for harvesting, but makes the tree of little use as a shade tree above cocoa, or as a later source of timber (Leakey 1998). In contrast, cultivars developed by rooting cuttings from juvenile coppice shoots result in plants resembling those from seedlings, making them appropriate to be the upper strata of multi-strata agroforests. This has the disadvantage, however, that there is a delay before these trees become productive and then the fruits are more difficult to harvest. This may be an issue for timber trees like *Baillonella toxisperma,* which also produces oil-rich nuts.

These differences in tree stature between different propagation systems have potential benefits when matching the needs of farmers with those of different markets and farming systems, as is being demonstrated in field trials with *Prunus africana, Dacryodes edulis, Irvingia gabonensis* in experimental plots in Yaoundé, Cameroon. These trials also include timber species such as *Triplochiton scleroxylon, Lovoa trichilioides, Khaya ivorensis*, which are raised vegetatively in ICRAF's on-station nurseries in Yaoundé. If multi-strata systems can be diversified and enriched in these different ways, local people will have a more complex, integrated and productive forest addressing their basic needs for food, marketable products, income, medicines, fodder, shelter and energy, while also supporting environmental services. Multi-strata cocoa or coffee agroforests, have the additional advantage that they buffer the risks of price fluctuations in world commodity prices (Duguma *et al.* 2002), by allowing farmers to generate income from AFTPs sold on local and regional markets. This approach allows local people to take more responsibility for the management of their natural resources, but by the same token gives them some autonomy from Government regulations.

ADVANTAGES AND DISADVANTAGES OF PARTICIPATORY TREE DOMESTICATION

There are a number of advantages and concerns about this approach to the domestication of indigenous trees:

Advantages

- capturing the attributes of elite trees within genetically diverse wild populations by vegetative propagation, so avoiding the long, slow process of tree breeding;
- using low cost propagation systems, such as the non-mist propagator, appropriate for use in village nurseries where running water and electricity may be absent;
- circumventing problems of poor and or erratic seed supply by multiply planting stock vegetatively;
- giving an incentive for farmers to adopt tree domestication by vegetatively propagating from mature tissues with the capacity to flower and fruit within 2–3 years – instead of the 10–15 years required by plants propagated from seed;
- using vegetatively propagated cultivars to provide the uniformity required by the markets; (This uniformity is also required to register Plant Breeders Rights and so to protect the intellectual property of innovative farmers.)
- empowering the farmers through a participatory approach to acquire their rights to indigenous knowledge regarding the use of indigenous species, as conferred by the Convention on Biological Diversity. Consequently, the approach is a model for best practices to biodiscovery, in contrast to biopiracy;
- persuading women to see trees as sources of food and income rathan than obstacles for the development of food crops such as maize, plantain and cassava.

Concerns

A number of concerns are regularly raised about developing cultivars vegetatively, for example, over:

- the potential for domestication of AFTPs to disadvantage people relying on the sale of non-timber forest products gathered from natural forests.
- the possibility of large-scale companies establishing plantations of the newly domesticated crops in the region or elsewhere, which then undermine the actions of smallholders.
- the risk of reducing the genetic diversity of the species through the widespread proliferation of a few cultivars and, consequently, increase its susceptibility to pest and disease outbreaks. However, adequate genetic diversity can be maintained through, conservation of wild sources, regular introduction of new clones and the generation of new genotypes through hybridization (Leakey 1991). At least in the short to medium term, the situation with the indigenous fruit and nut species is that there is still a diverse and widespread natural resource and the current approach to promote village–level domestication should ensure that at the national level, the large number of cultivars being grown commercially should minimize the risks.
- possible root structure defects through initiation of insufficient numbers of roots during propagation. Such defects can be mitigated by employing a well-researched and robust technique that ensures that new plants have a radially-distributed plate of roots to provide stability (Tchoundjeu and Leakey 2000). These lateral roots produce 'sinkers' that play the same function as a taproot.

MARKET DEVELOPMENT

For the domestication programme to yield the socio-economic and environmental benefits that should be derived from widespread application of agroforestry with indigenous fruits and nuts it is important that there is a continuing demand for the products. Consequently, a strong marketing component has been developed in parallel with this domestication programme. Market surveys have been initiated to identify the prices and quantities of the main products in local, regional and international markets (Ndoye *et al*. 1997, Awono *et al*. 2002, Facheux *et al*. 2003). Studies are also being conducted to identify the distribution channel of products, the processing, storage, transformation and packaging of the main products (Kengni *et al*. 2004a). For example, work is in progress to develop ways to extend the shelf-life of *Dacryodes edulis* fruits, which are particularly perishable, rarely exceeding one week. Another approach to ensuring a year-round supply of products is to extend the production season by selecting trees that fruit out of season so that late and early fruiting cultivars can be developed.

Several of the nut species in this programme, such as *Ricinodendron heudelotii*, *Irvingia gabonensis,* and *Irvingia wombolu* have such hard shells, that extraction of the edible kernels is difficult and labour intensive. Consequently, ICRAF is in the

process of developing a manual nutcracker with appropriate partners, so that this is less of a production constraint. An alternative approach is to develop cultivars selected for both their kernel traits and for thin-shelled or 'self-cracking' nuts as reported in *Irvingia gabonensis* (Leakey *et al*. 2000).

Market development is also dependent on the establishment of an effect supply chain, quality assurance and pricing structure. To address some of these issues, farmers are being trained in group marketing and ways are being sought to provide market information to farmers. For example, a group marketing enterprise has been created for cola nuts in Boyo Division in northwest of Cameroon and a marketing model has been developed with Haas Business School, Berkeley, in California. This model has indicated that with improved storage, the net benefit from the sale of cola nuts could be two- to three-fold higher than current levels (Facheux *et al*. in press). Parallel studies are in progress for *Gnetum africana*, *Irvingia gabonensis* and *Ricinodendron heudelotii* in the humid forest zone of Cameroon.

Scaling issues are also important, for example, a study of the relationship between market price and fruit traits in *Dacryodes edulis* found that while retailers charged consumers higher prices for fruits with desirable characteristics, wholesalers only paid a single price regardless of fruit characteristics (Leakey *et al*. 2002). Communities that cooperatively market their fruit are likely to overcome this problem if they are able to offer wholesalers bulk supplies of uniform fruits from a single cultivar, so avoiding the problems of a mixture of all possible fruit types..

CONCLUSIONS

The successful dissemination of the programme's results is in large part attributable to the participatory activities that have been used in the research that has ensured that the farmers understand the work and acquire ownership of the outputs. The focus of participatory tree domestication on poverty reduction in rural areas is also important as the income from some high-value indigenous fruit trees is very important for women and children as the harvesting season coincides with the need to pay school fees and associated costs.

This study has provided evidence that participatory tree domestication can help local populations to improve their food and nutritional security as well as to generate income. The challenge now is to scale up the programme to meet the Millennium Development Goals. This will require an even wider array of partnerships than has been achieved so far.

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