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Domestication of agroforestry trees in Cameroon

Bachelor thesis

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Declaration

I hereby declare, that I have elaborated this thesis independently and quoted only quotations listed in references.

Prague, April 17th, 2015

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Anna Maňourová

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Abstract

Trees form as a natural part of agriculture since its very beginning. Agroforestry principles were extensively used in the past and are increasingly becoming a trend in sustainable agriculture practises today. However, just a small number of tree species went through a directed domestication (e.g. mango, avocado, cocoa, coffee *etc*.). In case of Cameroon, World Agroforestry Centre (ICRAF) has chosen six indigenous fruit tree species (*Allanblackia* spp., *Cola nitida*, *Dacryodes edulis*, *Garcinia kola*, *Irvingia gabonensis* and *Ricinodendron heudelotii*) and focused on their domestication. Our goal was to review the domestication status of selected species and identify, whether the species actually match with farmers preferences in Northwest and Centre region of Cameroon. Results show that the targeted trees could be considered as semi-domesticated, being in a second phase of domestication, with *Dacryodes edulis* showing the most advanced level. The ICRAF chosen species were mostly confirmed to have considerable importance among farmers surveyed. To accelerate the domestication process of the selected species, we would highly recommend focusing on genetic characterization and plant protection.

Key words: indigenous fruit trees, domestication status, ICRAF, preferred species

Abstrakt

Stromy tvoří přirozenou součást zemědělství už od jeho vzniku. Principy agrolesnictví byly hojně používány v minulosti a i dnes se stávají stále častějším trendem trvale udržitelných zemědělských praktik. Avšak jen málo druhů stromů prošlo cílenou domestikací (např. mango, avokádo, kakao, káva atd.). V případě Kamerunu, Světové agrolesnické centrum (ICRAF) zvolilo šest původních druhů ovocných stromů (*Allanblackia* spp., *Cola nitida*, *Dacryodes edulis*, *Garcinia kola*, *Irvingia gabonensis* a *Ricinodendron heudelotii*) a zaměřilo se na jejich domestikaci. Naším cílem bylo zhodnotit úroveň domestikace vybraných druhů a zjistit, zda tyto druhy opravdu odpovídají preferencím farmářů ze Severozápadního a Centrálního regionu v Kamerunu. Výsledky ukazují, že zmiňované stromy mohou být považovány za polo-domestikované, nacházející se ve druhé fázi domestikace, s nejpokročilejší úrovní u *Dacryodes edulis*. V rámci organizací ICRAF zvolených druhů bylo potvrzeno, že většinou mají pro dotazované farmáře značnou důležitost. Pro urychlení procesu domestikace u vybraných druhů bychom doporučili, zaměřit se na genetickou charakterizaci a ochranu rostlin.

Klíčová slova: původní ovocné stromy, úroveň domestikace, ICRAF, preferenční druhy

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1. INTRODUCTION

Domestication of most major crop plants has occurred during a brief period in human history starting about 10,000 years ago (Wang *et al.*, 1999). Tree domestication is a far more recent phenomenon than annual-crop domestication. One of the earliest records of tree domestication is that of manipulating pollination in *Ficus* trees 2,800 years ago by the prophet Amos (Simons & Leakey, 2004). Domestication is a man-driven process involving selection processes rendering the target species useful to human beings by increasing the yield and/or quality of product they produce. The World Agroforestry Centre (ICRAF) defines tree domestication as the socio-economic and biophysical processes involved in the identification, characterization, selection, multiplication and cultivation of high-value tree species in managed systems (Garrity, 2008). Domestication induces a series of profound genetic changes. Kovach *et al.* (2007) suggested that it is not a single ‘event’ but rather a dynamic evolutionary process occurring over time and, in some species, continuing to this day.

Tree domestication is an important act, because trees can provide us with a renewable source of valuable products such as fruits, fuelwood, building material, fodder, timber, medicines, resins and gums. In agricultural systems, they have a potential to increase crop yields by nitrogen fixation, to enhance soil organic matter or nutrient cycling and also to contribute to soil conservation (Young, 1997; Leakey, 2002).

In 1995, ICRAF had started a programme domesticating tree species producing indigenous fruits and nuts, which are well-adapted to the climate and important to diet of local people. With the aim to improve yield and product quality, this programme began in Cameroon in 1997 with a focus on species identified as the farmer priorities – *Cola* spp. *Dacryodes edulis*, *Garcinia kola*, *Irvingia gabonensis*, *Pausinystalia johimbe*, *Prunus africana* and *Ricinodendron heudelotii* (Asaah *et al.*, 2011). At this time, domestication efforts further continue focused mainly on: *Allanblackia* spp., *Cola nitida*, *Dacryodes edulis*, *Garcinia kola*, *Irvingia gabonensis* and *Ricinodendron heudelotii* (Tchoundjeu *et al.*, 2006; Franzel & Kindt, 2012; Asaah *et al.*, 2014).

The domestication of indigenous fruit and nut trees is increasingly becoming recognized as an important component of agroforestry, starting to have meaningful impacts in rural development with application in the alleviation of poverty, malnutrition and hunger (Asaah *et al.*, 2011).

By means of this study, I would like to review the domestication status of agroforestry tree species in Cameroon. This was done by an overview of research conducted on the preferred indigenous fruit trees, trying to also show the domestication status of these species. Moreover, I would like to find out whether the species on which ICRAF focuses its domestication efforts match with the needs and preferences of local small-scale farmers.

2. LITERATURE REVIEW

2.1. Study area

A basic description of elements that form the current shape of agriculture in Cameroon.

2.1.1. Geographical and biophysical conditions

Cameroon used to be called ‘Africa in miniature’ and is regarded as the 4^{th} richest African country in terms of biodiversity (Eyebe *et al.*, 2012). In the areas of higher rainfall, there can be a single wet season with a single dry season, or two wet seasons (one typically longer and wetter than the other) interspersed by two dry seasons (one usually cooler than the other) (Leakey, 2012). Annual rainfall varies from 1,500 mm in the drier parts of the forest zone to about 10,000 mm along the western slopes of Mount Cameroon (Jones *et al.*, 2013); average temperature is up to 25 °C (Epule & Bryant, 2015). Geographical map of Cameroon is presented in *Figure 1*.

Arable land covers 13% of total surface area in Cameroon, which is estimated at 475,400 km^2. Main soil types are: acrisols, alisols, ferrasols, gleysols, lixisols, nitisols and planosols. However, the dominant soil type are red or yellow ferrasols, containing high levels of iron and aluminium sesquioxides, which are generally infertile. Organic matter and nutrient levels in these soils are low because plant remains are rapidly decomposed by bacterial action in the hot and humid climate before they can accumulate as humus in the soil (Jones *et al.*, 2013).

South of the country is covered mainly by wetlands composed of tropical rain forest and mangroves. Northern part of the country is essentially dominated by tropical grasslands mixed with some arid-zone trees (Epule *et al.*, 2014). There can be three different agro-ecological zones find in Cameroon: humid savannah (Northwest and Western regions), dry savannah (Adamawa, North and Extreme north regions) and forest zones (South west, South, Centre and East regions) (Foundjem-Tita *et al.*, 2014).

Cameroon's forests are part of Congo Basin, which is the second largest tropical rainforest hot spot in the world after Amazon Basin in Latin America (Epule *et al.*, 2011). These forests represents about 10% of the Congo Basin total area (Epule *et al.*, 2014). Since independence and use of forest policy law in Cameroon, local populations were excluded 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 local populations, consequently, farmers perceived the new law as an opportunity to exploit the forest for timber rather than realizing its potential as a renewable source of traditionally important and marketable non-timber forest products (NFTP's) derived from indigenous fruit trees and medicinal plants (Tchoundjeu *et al.*, 2006).

With growing population, which increased 4.5 times since 1961 (Epule *et al.*, 2014), and arable land expansion, the deforestation continues following by resource loss of traditionally important nutritious foods and medicines, as well as by a loss of wild animal species (Asaah *et al.*, 2011).

Figure 1: Geographical map of Cameroon,

source: http://www.un.org/Depts/Cartographic/map/profile/cameroon.pdf

2.1.2. History – era of colonialism

Africa stagnated for a long time as a direct result of slavery and colonial occupation. This part of global history, for the sake of maintaining a correct historical perspective on Africa and Europe, must always be kept in mind when looking at the contemporary African situation (Brock-Utne, 2000).

Cameroon has a unique colonial past. First, it was a colony of Germany (1884–1919) and then an U.N. trust territory under colonial administrative guidance, simultaneously of Britain (one-fifth of the territory) and France (four-fifths) from 1919 to 1960 (Njoh, 1999) This division created a foundation of future Anglophone minority and a Francophone majority in the region (Awasom, 2000).

Britain and France had sharply contrasting colonial philosophies, while Britain favoured 'indirect rule' using a Westminster model of government, France employed 'direct rule.' A distinguishing mark of direct rule as a politico-administrative strategy is centralization. All French colonies in Africa were governed directly from Paris and no attempt was made to incorporate any aspect of indigenous tradition or culture in the policymaking process. Indirect rule, on the other hand, entailed the use of indigenous power structures and institutions, including local kings, chiefs, village elders and lineage heads to participate in colonial government duties (Njoh & Akiwumi, 2012).

As part of events marking the end of the War, Cameroonian territory was converted into a Mandate Territory of the League of Nations. On 10 July 1919 the two allies who had combined to oust the Germans from Cameroon, agreed to divide the territory up into two unequal parts. French Cameroun secured independence in 1960. In 1961, a plebiscite resulted in British Southern Cameroons becoming part of a federated Cameroon. In the same year, Le Vine allegorically referred to the British Cameroons as a 'bride' which implied that the Republic of Cameroon was the 'bride-groom'. This imagery of weaker and stronger partners is appropriate when we consider the fact that the Republic of Cameroon was ten times the area of the British Southern Cameroons, had four times its population, more natural resources and much higher level of social and economic development (Awasom, 2000). Immediately after the unification, the Francophone-dominated leadership insisted on adopting French politico-administrative philosophy and principles in matters of governance (Njoh & Akiwumi, 2012).

Colonial urban development strategies were externally oriented meaning that the agriculture produce was intended primarily for export. (Njoh, 2002). A focus on plantation agriculture, which was thought to be the most suitable for export, tended to discourage entrepreneurship as most members of the population were lured by low-wage positions and concomitant benefits, such as “free company housing” in the plantations. Most important of all was the tendency of plantation agriculture to discourage activities aimed at producing food for self-sufficiency. First, the most accessible and most fertile land was always reserved for plantation agriculture. Thus, whatever land was left for the cultivation of food for local consumption was either less accessible or rather infertile. Second, because plantation workers must work long and tedious hours, they were often left with very little or no time to spend on their own farms (Njoh, 2002).

Leakey (2012) is adding that the part of the colonial ethic was to discourage the use of traditional local foods from the forest, in name of ‘civilization’, and to replace them with foreign food crops for cultivation on land cleared of woody vegetation.

2.1.3. Socio – economic characteristics

Cameroon is ethnically very diverse country, partly because of its colonial past and partly because of the varied landscape. Main ethnic groups include: Pahouin-Beti from the Central and Southern regions, Douala-Bassa from the Coastal regions, Foulbe-Fulani from the Northern regions, Kaka-Baya from the Eastern regions and Bamileke-related ethnic groups. One common denominator among the Pahouin-Beti, Douala-Bassa and Bamileke ethnic groups is that they are all predominantly Christian, while the other ethnic groups tend to be about half traditional/Christian and half Muslim (Kuate Defo, 1996).

Cameroon, with more than 22 million inhabitants, belongs to the West and Central Africa region which is the area of extreme poverty. Forty percent of Cameroonians live below poverty line (less than 1$ per day) and farmers, with six family members on average, are the poorest group (Degrande *et al.*, 2006; Schreckenberg *et al.*, 2006). As presented in *Table 1*, annual population growth has stabilized at 2.5% per year. However, there is a difference between a rural population, which is still slightly decreasing, and an urban population, which is increasing year by year.

Population in West humid Africa is firmly growing which goes hand in hand with deforestation, arable land degradation, a rise in urban poverty and social problems associated with towns and cities (Leakey, 1998). The major impact have been twofold: a reduction in the length of fallow period practiced by shifting cultivators and migration of young people to the urban areas in search of employment. Frequently, the population pressure also led to decreasing farm size – typical farm recently covers an area between 1 and 5 ha (Leakey, 2012).

Table 1: Comparison of world development indicators for Cameroon

	2005	**2010**	**2012**	**2013**
Population, total number	18,137,734	20,624,343	21,699,631	22,253,959
Population growth (annual %)	2.6	2.6	2.5	2.5
Rural population (% of total population)	51.5	48.5	47.3	46.8
Urban population (% of total population)	48.5	51.5	52.7	53.3
Life expectancy at birth, total (years)	51.9	53.7	54.6	..
Mortality rate, infant (per 1,000 live births)	78.0	66.0	62.4	60.8
Forest area (km^2)	210	199	195	..
Agricultural land (km^2)	92	96	98	..
GDP per capita (current US$)	914.6	1,090.6	1,219.9	1,315.5
GDP per capita growth (annual %)	-0.3	0.7	2.0	2.9

Source: The World Bank, World development indicators database, November 2014

Maathai (2010) said: "There is a paradox in Africa that you have one of the richest continents in the world, yet its people are among the poorest." According to Leakey (2012), farmers are locked in poverty, unable to afford fertilizers and other chemical inputs. As a result, their farmland becomes infertile and yields of crucial staple crops decline. This might become a serious problem, considering the fact that farming provides employment and means of livelihood for 60% of Cameroonians (Yengoh & Brogaard, 2014).

2.1.4. Agricultural systems

There are many types of agriculture practised in Africa, where about 80% of the rural population are farmers (Leakey, 2012). Pictures of diverse agriculture practises of Northwest and Centre region are presented in Appendix C.

In most tropical developing countries, agriculture was largely influenced by colonialism. Changes in agriculture had started with a high demand for spices (nutmeg, cinnamon, vanilla) and cash crops (coffee, cocoa, rubber), which created a new but highly specialized commercial demands. The process of domestication and cultivation developed by the colonial plantation managers induced a disassociation between forest resources and forest ecosystems. In transferring forest resources to colonial plantations, huge areas of specialized, artificial and high-yielding tree monocultures was created (Michon & de Foresta, 1996).

However, in agriculture today, cash crops are planted with scattered upper-storey shade trees, whereas arable crops are managed in the under-storeys. These landscapes evolved from primary or secondary forests and gradually became mixed agroforests or homegarden systems with varying tree/crop intensification (Akinnifesi *et al.*, 2007). For example, Jagoret *et al.* (2011) suggested that cocoa agroforest occupy 60% of all cultivated areas in Central Cameroon.

Cameroonian traditional cropping systems today are mainly based on long-fallow rotations and produce food crops for home consumption or local markets. The reason is that shifting cultivation becomes unsustainable as the population increases and fallow rotations shorten (Degrande *et al.*, 2006; Tchoundjeu *et al.*, 2006). Long fallow periods are required to restore soil fertility, supress weed and reduce pest and diseases. In these days, the fallow period has been reduced to less than five years in most areas (Tchoundjeu *et al.*, 2002). As Sanchez (2002) suggested, the absence of fallowing coupled with limited use of fertilizers is leading to large deficits in major nutrients: nitrogen (N), phosphorus (P) and potassium (K).

Despite efforts of some farmer organizations to promote sustainable practices of maintaining soil health, many of these technologies such as composting, which allows crop residue to rot instead of being burned, and cultivating across instead of along slopes, have not been sufficiently spread and implemented (Yengoh & Brogaard, 2014).

Arable production in Cameroon is variable between north and south of the country. Major crops planted in southern parts include tubers - yam (*Dioscorea* spp.), taro (*Colocasia* spp.), cassava (*Manihot esculenta*); cereals - corn (*Zea mays*); legumes – beans (*Phaseolus* spp., *Vigna* spp.); and fruit trees - mango (*Mangifera indica*), citruses (*Citrus* spp.), avocado (*Persea americana*) (Molua, 2005). These crops are usually intercropped with vegetables. Cash crops such as cocoa (*Theobroma cacao*) and coffee (*Coffea arabica*) are, most of time, cultivated as a small-scale plantations mixed with fruit trees, medicinal plants and timber species (Degrande *et al.*, 2006).

Generally, in drier northern parts of the country, farmers are more involved in production of cereals and cattle herding (Epule *et al.*, 2014). A relatively new trend in Cameroon is keeping livestock as a form of saving - the dominant livestock are native species of sheep, goats, pigs and poultry (Molua, 2005).

Although, rural populations in southern Cameroon face times of shortages while awaiting a new harvest (from January to April), most households are food self-sufficient all year round (Degrande *et al.*, 2006). On the other hand, most of the farmers have to bear with the consequences of global climate change, e.g. late start of raining season or longer and more frequent dry spells. These situations contribute to the rise of lower crop yields and conclusive changes in traditional planting periods, operated for several generations (Yengoh & Brogaard, 2014).

2.2. Tree domestication

A review on information known about tree domestication, pointing out important trends and steps towards success in domestication of new species.

2.2.1. General information

There can be a lot of definitions found relating to the word ‘domestication’. According to Harlan (1975), crop domestication is man-induced change in the genetics of a plant to conform to human desires and agro-ecosystems. However, in the case of tree domestication the definition slightly changes:

a) A farmer-driven and market-led process, which matches the intraspecific diversity of locally important trees to the needs of subsistence farmers, product markets, and agricultural environments (Simons & Leakey, 2004; Ræbild *et al.*, 2011).

b) The socio-economic and biophysical processes involved in the identification, characterisation, selection, multiplication, and cultivation of high-value tree species in managed systems (Leakey, 1998; Garrity, 2008).

More specifically, the domestication of indigenous trees is aimed at producing traditionally and culturally important products for cultivation in low-input agroforestry systems such as food, medicine and other goods which are marketable in niche markets, that are socially, economically and environmentally sustainable (Leakey & van Damme, 2014; Leakey, 2014).

Agroforestry is the interaction between trees and agriculture. As defined by Raintree (1982): “Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboo, etc.) are deliberately used in the same land management units as agricultural crops and/or animals, in some forms of spatial arrangement or temporal sequence.”

Domestication of agroforestry trees builds on a use of symbiotic natural equilibria and mutualistic relationships to counter both abiotic and biotic stresses, to make the most of environment and natural (soil) resources. Agroforests that make no use of external (chemical) inputs are production options allowed in green marketing but are also highly beneficial as approaches to sustainable intensification of tropical agriculture systems (Leakey & van Damme, 2014).

The fact that, agroforestry tree domestication is an important process in maintaining the environment and ameliorating people’s livelihood, is supported by results from all around the world. *Table 2* presents a list of countries and their selected agroforestry tree species under domestication process.

Table 2: Preferences of agroforestry trees according to studies made in selected regions worldwide

Region, countries	**Species involved in domestication process**
West Africa – Cameroon, Nigeria	*Dacryodes edulis, Irvingia gabonensis, Allanblackia, Ricinodendron heudelotii, Garcinia kola, Cola nitida, Chrysophyllum albidum*
Southern Africa – Malawi, Zambia, Zimbabwe, Tanzania	*Uapaca kirkiana, Parinari curatellifolia, Strychnos cocculoides, Sclerocarya birrea*
Eastern Africa – Ethiopia, Kenya, Sudan, Tanzania, Uganda	*Adansonia digitata, Cordeauxia edulis, Sclerocarya birrea,Tamarindus indica, Vitellaria paradoxa, Parinari curatellifolia, Ziziphus mauritiana*
Peruvian Amazon	*Inga edulis, Bactris gasipaes, Calycophyllum spruceanum, Guazuma crinita, Myrciaria dubia, Uncaria tomentosa*
Melanesia – Papua New Guinea, Vanuatu, Solomon Islands	*Canarium indicum, Barringtonia procera, Inocarpus fagifer, Santalum austrocaledonicum*
Indonesia	*Manglietia glauca, Parkia speciosa, Durio zibethinus, Gmelina arbórea, Sandoricum koetjape*
Australia	*Santalum lanceolatum*
Thailand	*Tectona grandis*

Source: Villachica et al., 1996; Kjaer et al., 2000; Akinnifesi et al., 2004; Akinnifesi et al., 2007; Leakey et al., 2009; Clement et al., 2010; Narendra et al., 2013.

2.2.2. Tree domestication steps

There are several stages in a process of crop and tree domestication. Species might be rated as: managed, semi-domesticated or full-domesticated (Leakey & Newton, 1993) or else incipiently domesticated, semi-domesticated and domesticated (Clement *et al.*, 2010).

An incipiently domesticated population has gone through human selection of a small sample of the wild population and propagation of descendants from this sample; this process reduces its genotypic diversity whereas its phenotypic diversity differs only from the ancestral wild population in the traits selected by man (Clement *et al.*, 2010).

A semi-domesticated population has reduced genotypic diversity, but its phenotypic diversity is enhanced by accumulation of diverse alleles for traits selected by man. Semi-domesticated populations tend to have more ample geographic distributions, which may permit introgression with other wild, incipient or semi-domesticated populations of the same species; in turn, such introgression may offer additional alleles for selected traits, thus somewhat enhancing genetic diversity (Clement *et al.*, 2010).

A full-domesticated population is usually else selected for adaptation to man-modified landscapes, especially cultivated gardens and fields. It has lost its original ecological adaptations for survival without human care, especially its original dispersal mechanisms (Clement *et al.*, 2010).

At first, products from wild trees are extracted in an uncontrolled manner from the natural forest. In a further instance, a change from uncontrolled utilization of wild tree products to their controlled exploitation takes place. The third phase consists of protection and managing of naturally regenerated individuals of valuable tree species in semi-natural forests (Wiersum, 1997). According to Wiersum (1997), the domestication process is described like this:

Uncontrolled, open access gathering of forest product → Controlled gathering of wild tree products → Systematic collection of wild tree products with protective managing of valuable tree species → Selective cultivation of valued trees by artificial in-situ regeneration of native trees → Cultivation of selected native tree species in artificially established plantations → Cultivation of domesticated tree crops in intensively managed plantations

According to ICRAF, tree domestication consist of five steps (Akinnifesi *et al.*, 2007; Franzel & Kindt, 2012; Leakey, 2014):

1) Selection of priority indigenous fruit tree species based on farmers' preferences and market orientation
2) Identification of superior or elite trees based on established criteria by users, marketers and market preference (tagging and naming trees for purpose of ownership and property right recognition)
3) Development and applying efficient vegetative propagation and nursery management techniques for producing quality propagules of on-farm dissemination
4) Integration of improved germplasms into farming systems
5) Post-harvest handling, processing and marketing research of fresh and processed products from domesticated species

As written above, every successful domestication has to firstly start with a systematic priority setting. Farmers are deciding which traits are later on incorporated within a selection program (Leakey, 2014). According to Franzel *et al.* (1996) the guidelines for priority setting involves:

1) Team building among stakeholders to agree on approaches and refine method to local conditions
2) Identifying clients and assessment of users' needs (farmers, marketers, etc.)
3) Inventory of all species used by clients, including potentially useful ones

4) Identifying the most important products in the target region, considering only those with the greatest importance

5) Selection of smallest number of species with highest benefits

6) Estimating the production value of key species to set priorities

7) Synthesizing previous results, reviewing the process and selecting the final choice of species

2.2.3. Vegetative and generative propagation

One constraint to tree domestication is that agroforestry trees are most of time difficult to domesticate, because they are predominantly out-breeding. This means that gains in selected traits are on the average small resulting from the wide range of intra-specific variation in the progeny arising from controlled pollinations. What more, generation time of trees could be really long: 10-20 years (Leakey *et al.*, 2009; Leakey, 2012). Thus vegetative methods of tree propagation are crucial to the domestication strategy of agroforestry trees (Leakey, 2014).

Vegetative propagation is based on totipotency of living cells in plant, i.e. capacity of a tissue to regenerate to a whole and identical plant as the mother tree - clones produced from the same mother plant are genetically identical, unless some rare somatic mutations occur (Scianna *et al.*, 2001; Akinnifesi *et al.*, 2004). Improved fruit trees are typically vegetative propagated using buds, grafts, marcots (air-layers) or cuttings (Simons & Leakey, 2004). By using these relatively simple techniques, it is possible to rapidly capture and multiply selected individuals as clones or cultivars. While these techniques have been known and used for thousands of years, they have been just recently applied to tropical and subtropical tree species (Leakey & van Damme, 2014). The use of vegetative propagation has naturally got some disadvantages too – it is an easy way for transmission of diseases, clonal trees have weaker root system and cloning is more expensive than seedlings production (Akinnifesi *et al.*, 2008).

On the other hand the seed-based breeding (generative, sexual) is important for a conservation of genetic variability for future use in selection programs as well as for broadening the genetic base of cultivars (Leakey, 2014). Generative propagation of plants involves male and female reproductive organs, reciprocal meiotic cell division and the creation of progeny with genetic information different from parents (Scianna *et al.*, 2001). That is the reason why it provides significant opportunity for variation and evolutionary advancement (Akinnifesi, 2004).

According to Leakey (2014) there are three actions contributing to genetic conservation:

• Establishing a Gene Bank (ex situ conservation)

•Wise utilization of the genetic resource in cultivation (circa situ conservation)

• Protection of wild populations (in situ conservation)

Generally, foresters are using seed-based tree breeding, on the contrary, horticulturalists have mostly adopted clonal vegetative propagation and cultivars development (Akinnifesi *et al.*, 2008).

2.3. Agroforestry trees

Chapter focuses on variety of highly important agroforestry tree species planted in Cameroon. These trees are divided into four groups according to their major utilization.

2.3.1. Fruit trees

Fruit tree species belong to the most popular and widely utilized tree group in Cameroon. Due to their vitamin richness and nutritional value they stands as an important source of balanced diet, medicine, create an additional income for local farmers and could play an important role in export too (Schreckenberg *et al.*, 2006; Tchoundjeu *et al.*, 2010; Leakey & Van Damme, 2014).

Nowadays priority setting among Cameroonian fruit and nut trees, exotic as well as indigenous, is shown in *Table 3*. All the indigenous species are further characterized in chapter 'Results'.

In addition to the these species, there are other exotic fruit trees often grown among local farmers: papaya (*Carica papaya*), guava (*Psidium guajava*), passion fruit and Adam's fruit (*Passiflora* spp.).

Highly discussed topic nowadays is the case of oil palm (*Elaeis guineensis*), native palm to the African Gulf of Guinea. For centuries, farmers in the forest zone of Cameroon have been harvesting wild oil palm groves with the purpose of producing palm oil, kernel oil and palm wine. Cameroon, with a total production of 230,000 tons of crude palm oil per year, is currently ranked as the 13th country in terms of oil production worldwide (Raymond *et al.*, 2014).

Table 3: Fruit trees ranked highly for promotion in Cameroon, according to farmers preferences

Indigenous origin	**Exotic origin**
Allanblackia spp.	Avocado (*Persea Americana*)
Bitter cola (*Garcinia kola)*	Citruses (*Citrus* spp.)
Bush mango (*Irvingia gabonensis*)	Mango (*Mangifera indica*)
Kola nut (*Cola nitida*)	
Njansang (*Ricinodendron heudelotii*)	
Safou, African plum (*Dacryodes edulis*)	

Source: Franzel & Kindt, 2012

2.3.2. Forest trees

Cameroon has, after Democratic Republic of Congo, the second largest forest estate among all African countries (Movuh, 2012). The forest is a part of Congo basin and covers about 42% of the land area. It is an environment for nearly 300 forest tree species with 40 – 80 being commercially exploited (Saha *et al.*, 2013).

Forest also plays a crucial role in local economy, providing 45,000 - 70,000 workplaces and accounting for more than 10% of the country's GDP (Alemagi & Kozak, 2010). Cameroon is the sixth largest tropical wood exporter in the world, 74% of its exports value come from the timber products sold in European markets (Alemagi & Kozak, 2010; Eba'a Atyi *et al.*, 2013). List of the most important forest tree species is presented in *Table 4*.

Table 4: Most common forest tree species harvested in Cameroon

Latin name	Local name	Family
Azadirachta indica	Nim	Meliaceae
Baillonella toxisperma	Moabi	Sapotaceae
Canarium schweinfurthii	Canarium	Burseraceae
Combretum micranthum	Kenkeliba	Combretaceae
Cordia africana	Cordia	Boraginaceae
Distemonanthus benthamianus	Movingui	Caesalpiniaceae
Entandrophragma cylindricum	Sapelli	Meliaceae
Entandrophragma utile	Sipo	Meliaceae
Guibourtia tessmannii	Bubinga	Fabaceae
Mansonia altissima	Beté	Malvaceae
Milicia excelsa	Iroko	Moraceae
Piptadeniastrum africanum	Atui	Fabaceae
Pterocarpus soyauxii	Padouk	Fabaceae
Terminalia ivorensis	Chev	Combretaceae
Terminalia superba	Frake	Combretaceae

Source: Norgrove & Hauser, 2002; Onguyene & Kuyper, 2005; Jolivet & Degen, 2012; Saha et al., 2013; Banfi et al., 2014.

2.3.3. Medicinal trees

Millions of African people rely on medicinal plants for their primary health care. These traditional utilization plays also an important role in economics, providing income for large numbers of people involved in collecting, processing, transporting and selling of plants (Antwi-Baffour *et al.*, 2014).

In Cameroon, there are at least two very important tree species used as a medicine, both are utilized for their bark and being over-exploited in the wild. These species include: *Prunus africana* and *Pausinystalia johimbe* (Leakey, 2012).

Prunus africana (Rosaceae), also known as pygeum, is the only member of the *Prunus* genus on African continent. The genus implies well-known species such as peach (*Prunus persica*), plum (*Prunus domestica*) or almond (*Prunus dulcis*)

(Stewart, 2003). It is a widespread canopy montane tree (30-40 m high), reported from 22 African countries, occurring mainly as a secondary forest species (Muchugi *et al.*, 2006). Due to the over-exploitation, it is now part of IUCN Red List and in CITES Appendix II (Stewart, 2003; Stewart, 2009).

The reason for its progressive disappearing from wild is bark, which is an interest of pharmaceutical companies (Leakey, 2012). In the 1960s, bark extracts were found to be effective in the treatment of benign prostatic hyperplasia (Stewart, 2009), and it is Cameroon having the longest history of the bark harvest among West African countries. Commercial harvest started in 1972, when Plantecam Medicam began harvesting in the Northwest and West Region, however, the company was closed in year 2000. Worldwide exports of dried *P. africana* bark in the year 2000 have been estimated to 1,350–1,525 tons, down from its peak of 3,225 tons in 1997. The most popular product is the capsular form called *Pygeum africanum* (Stewart, 2003).

The bark collection could be done in a sustainable way, but that is an occasional case. For example, trained harvesters use a frequency of no more than one harvest in 4–5 years and utilize the trunk only. They cut the bark with a blunt tipped machete and then peel it approximately at the vascular cambium. After the bark removal, tree re-grows its bark through an initial callous bark, if the vascular cambium has not been disrupted (Cunningham and Mbenkum, 1993; Stewart, 2009). These methods have never been scientifically tested and appear to be followed only in strictly controlled community forests. Outside of these areas, trees are usually girdled, side branches are stripped, or the entire tree is felled (Stewart, 2009).

Pausinystalia johimbe (Rubiaceae), known as yohimbe, is an evergreen tree native to the Gulf of Guinea, distributed in closed-canopy forests from Southern Nigeria to Congolese Mayombe. It is exploited for its bark to supply both export and local medicinal plant markets (Tchoundjeu *et al.*, 2004; Raman *et al.*, 2013).

The bark contains an alkaloid johimbine used to treat cardiac disease and male impotence. According to Leakey (2012), the bark's extracts are the nature's equivalent to Viagra and are also used by body-builders for loosing fat.

In 2010, yohimbe was one of the twenty top-selling herbal dietary supplements in the USA (Raman *et al.*, 2013). But is a widely important species for

Cameroon as well, annually yohimbe generates about 640,000 $ (Tchoundjeu *et al.*, 2004).

2.3.4. Nitrogen fixing and fodder trees

In response to the increasing population pressure, agricultural production is intensifying across West Africa. This goes hand by hand with soil nitrogen depletion, which is also a threat to local food production (Sanginga, 2003). In the past, a long period of natural fallow was the general practice for maintaining soil fertility. Nowadays, shortened fallow periods and intensive harvests caused an inability of natural fallows to restore the soil fertility and suppress weeds (Harmand *et al.*, 2004).

A potential solution to the declining soil fertility, is using planted tree fallows to restore agricultural productivity more rapidly than natural fallow. Nitrogen-fixing trees, sometimes called 'fertilizer trees' or 'leguminous trees', are through nitrogen-fixing bacteria, able to increase the nitrogen budget of soil system and move the valuable nutrients from depth to higher soil horizons for their easier utilization (Harmand *et al.*, 2004; Vaněk *et al.*, 2012). Apart from the leaf manure, these species can also provide timber, fodder, fuelwood or serve as a shade trees or windbreaks. They are efficient in erosion control, improve the water infiltration into the soil and could be used to attract bees as well (Asaah *et al.*, 2014).

However, leguminous trees have greater demands on the supply of phosphorus in the soil, which is need for the optimal growth, nodule development and N_2 fixation function. Therefore it is recommended to use P fertilizer or select genotypes or provenances tolerant to low amount of P in soil (Sanginga, 2003). What more, establishment period of sufficient green leaf manure production varies usually between three-four years (Chirwa *et al.*, 2003).

These fertilizer tree species are grown in Cameroon (mainly in arid northern parts): *Calliandra calothyrsus*, *Gliricidia sepium*, *Faidherbia albida*, *Leucaena leucocephala*, *Acacia* spp., *Sesbania sesban*, *Tephrosia vogelli* (Leakey, 2012; Asaah *et al.*, 2014). Most of these trees are being intercropped by staple crops such as corn, sorghum or finger millet (Sanginga, 2003; Mokgolodi *et al.*, 2011). Despite the repeated demonstrations of usefulness of green manures in enhancing soil fertility, and the fact that tree fallows are better in accumulation of organic matter than herbaceous fallows (Harmand *et al.*, 2004), adoption of nitrogen-fixing trees is still limited (Sanginga, 2003).

Regards to fodder trees, it was found that a 400 m *Calliandra* hedge could produce enough fodder to feed two cows (90 kg of leaves per day) in the dry season (Leakey, 2012). This is possible due to the protein and mineral contain, which is much higher in nitrogen-fixing trees compared to grasses (Pamo *et al.*, 2006).

Another example is a project held at Dschang University on West African dwarf goats. Leaves of *Calliandra calothyrsus* and *Leucaena leucocephala* were used as supplementary feeding for these animals. As a result, the incidence of abortion was reduced and adult goats were able to gain more weight during the dry season (Pamo *et al.*, 2006).

2.4. World Agroforestry Centre

The World Agroforestry Centre (ICRAF) is one of the 15 centres of the Consultative Group on International Agricultural Research (CGIAR) Consortium. It was founded in 1978 as an autonomous non-profit making organization called 'International Centre for Research in Agroforestry'. In 2002, ICRAF acquired a new name - 'World Agroforestry Centre', which may reflected the position of international leader in agroforestry research and development (FAO, 1996; World Agroforestry Centre, 2015).

In 1996, ICRAF has been active in 20 countries (FAO, 1996), in the year 2013, the number of countries involved in centre's projects raised to more than 30 (World Agroforestry Centre, 2013). ICRAF's headquarters are in Nairobi, Kenya, with five regional offices located in Cameroon (Yaoundé), India, Indonesia, Kenya and Peru (World Agroforestry Centre, 2015). Regions and countries involved in ICRAF projects are listed in *Table 5*.

The key element in ICRAF's future vision is a rural transformation in the developing world, when smallholder households increase their use of trees in agricultural landscapes to improve food security, nutrition, income, health, energy resources, social cohesion and environmental sustainability. The mission is to generate science-based knowledge about the diverse roles that trees play in agricultural landscapes and its later implementation for the benefit of poor and environment (World Agroforestry Centre, 2013; World Agroforestry Centre, 2015).

Table 5: Places where ICRAF works

East and Southern Africa	**West and Central Africa**	**SE and East Asia**	**South Asia**	**Latin America**
Regional network office: Nairobi, Kenya	*Regional network office:* Yaoundé, Cameroon	*Regional network office:* Bogor, Indonesia	*Regional network office:* Delhi, India	*Regional network office:* Lima, Peru
Etiopia	Burkina Faso	China	Bangladesh	Brasil
Kenya	Cameroon	Indonesia	Bhutan	Costa Rica
Malawi	Côte d'Ivoire	Philippines	India	Peru
Mozambique	Democratic Republic of Kongo	Thailand	Nepal	
Rwanda	Ghana	Vietnam	Sri Lanka	
Tanzania	Mali			
Uganda	Niger			
Zambia	Nigeria			
Zimbabwe	Sierra Leone			

Source: http://worldagroforestry.org/regions

3. OBJECTIVES

The main objective of the study was to collect and summarize information known about agroforestry tree domestication in Cameroon, with special focus on indigenous fruit tree species. This was partly achieved by an extensive literature review and partly by a series of field trips and farmers survey in Cameroon during my intership at ICRAF. The outcome of this thesis could be considered as a summary report on tree domestication status, supported by results of semi-structured questionnaires focused on farmer's preferred species in crops and trees.

The aim was also to re-asses the tree species preferences among local farmers and to find out how were these preferences influenced by ICRAF domestication programme run in the country.

Up to now there was no thesis or fieldwork done in Cameroon under auspices of Faculty of Tropical AgriSciences, CULS. This study should thus also contribute to future cooperation between Czech University of Life Sciences and ICRAF Cameroon - headquarters for West and Central Africa.

4. METHODOLOGY

Methodology consist of a theoretical part (literature review) and a practical part carried out in Cameroon during July - September 2014.

4.1. Literature review

Most of the information was gained from scientific papers found through databases such as Scopus (http://www.scopus.com/home.url), Science Direct (http://www.sciencedirect.com), Web of Knowledge (http://apps.webofknowledge.com) or Google scholar (https://scholar.google.com/). These sources were followed by reviewing several scientific books, ICRAF internal papers, as well as BSc., MSc. and PhD. thesis focused mainly on agroforestry and ICRAF preferred tree species in Cameroon, appended by FAO and World Bank statistic information. All these sources are listed in 'References'.

4.2. Study site characteristics

Field data was collected within two regions presented in – Northwest Region (English speaking) with the capital Bamenda; and Centre Region (French speaking) with the capital Yaoundé, which is also the capital city of Cameroon (*Figure 2)*. The farmer survey was done in four villages (two representing the Anglophone part and two representing the Francophone part) belonging to humid forest zone.

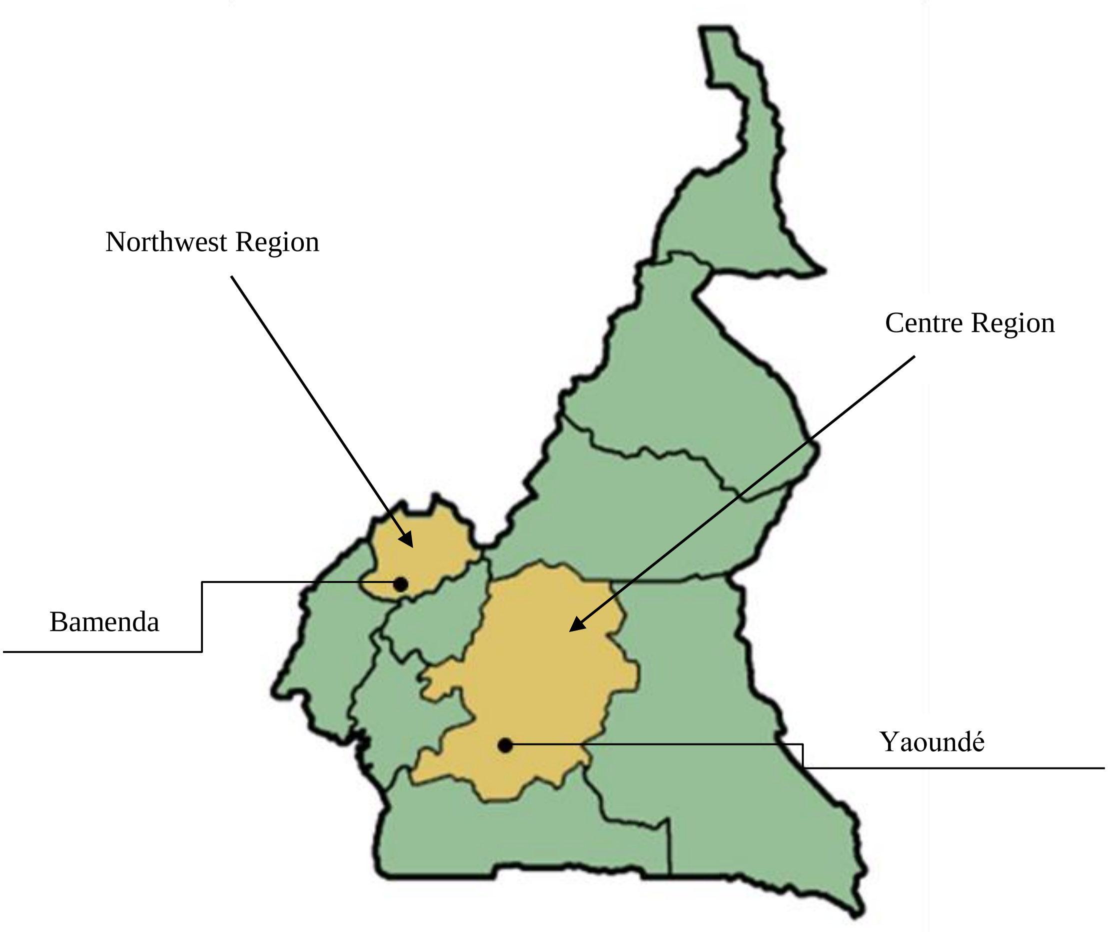

Figure 2: Location of targeted regions, adapted from Wikimedia commons

4.2.1. Northwest region

Figure 3: Location of Big Babanki and Abong-Phen, adapted from maps.google.com

Big Babanki and Abong-Phen are part of the Northwest region and situated close, around 20 km, to the capital Bamenda (*Figure 3*). They belong to a forest humid zone with fragments of highly valued primary montane forest (afromontane vegetation) and secondary grasslands. Annualy the rainfall varies between 1,300 and 2,000 mm (Takoutsing *et al*., 2014).

Big Babanki (Kedjom Keku in native language) is located between latitudes 6° 07' 03.67" N and longitudes 10° 15' 00.55" E, the approximate altitude is 1,150 m.

Unlike Big Babanki, Abong-Phen resembles more a farming zone than a proper village. Local farmers consider this area as an alternative, or another cropping opportunity, outside of Big Babanki, the main village. Contrary to the village, Abong-Phen lies in the mountain area between 6°03' 38.11" N and 10°18' 25.77" E, where the altitude varies around 2,000 m. As a consequence, Abong-Phen offers a completely different range in cultivated species (e.g. carrot, cabbage, irish potatoes).

4.2.2. Centre region

Figure 4: Location of Lekiasi and Nkenlikok, adapted from maps.google.com

Lekiasi and Nkenlikok are part of the Centre Region, situated approximately 35 km from the capital city Yaoundé (*Figure 4*). They belong to a humid forest zone (drier types of Guineo-Congolian rain forest in the case of Lekiasi, and wetter types of Guineo-Congolian rain forest in the case of Nkenlikok). The annual rainfall is usually 1,200 – 1,800 mm (Jagoret *et al*., 2011).

Lekiasi is located between latitudes 4°07' 30.27" N and longitudes 11° 20' 28.42" E, with altitude varying around 500 – 600 m.

Nkenlikok is situated between 3°48'01.64 N and 11° 11' 59.77" E and the altitude varies around 700 m.

4.3. Data collection and evaluation

The field data, mainly qualitative, were collected in four villages mentioned above, using a simple semi-structured questionnaires - see Appendix A. "Semi-structured interview is defined as a verbal interchange where one person (the interviewer) attempts to elicit information from another person (the interviewee) by asking questions. Unlike structured interviews, this conversational manner offers participants a chance to explore issues deemed as important" (Yengoh & Brogaard, 2014). The methodology was inspired by Huml (2011) who has done a similar research on tree species preferences in Peru, Ucayali region. Before interviewing the farmers, questionnaires were translated into French and updated according to the advices of socio–economic scientist Ann Degrande (ICRAF). Interpreters were used in both Northwest and Centre region.

Altogether 40 farmers were interviewed, 15 from Big Babanki + 9 from Abong-Phen (Northwest region, Anglophone part) and 10 from Lekiasi + 6 from Nkenlikok (Centre region, Francophone part). Firstly they listed up all crops and trees they grow, after that they selected and rank five most important ones in a descending order – the first with the highest priority received five points, the fifth with the lowest priority received one point. To complement this information, farmers were asked to name three most important crop/tree species for the whole region they lived in, as well as to specify some plants they would like to cultivate in the future. Each answer to these two questions was marked with one point. Next part of the survey was focused solely on trees. Farmers were requested to list all the tree species planted, or at least tolerated, within their compounds. After that, we talked about ways of species utilization e.g. food, firewood, medicine. Once again, every tree mentioned and either its usage has gained a point. All the points received were afterwards summed and evaluated for each village separately. Presented results were processed in Microsoft Excel spreadsheet.

Seven of the interviewees were also involved in ICRAF’s projects, hence the last part of the questionnaire was used as a feedback sheet, giving the farmers a chance to describe their satisfaction with ICRAF cooperation and propose some future suggestions or upgrades. Due to the small number of participants, these data were simply tabulated.

Tree identification was firstly carried out on the basis of local names and farmer’s identification. Assignment of the local names to the appropriate scientific ones was reviewed with a help of ICRAF and local botanists from Northwest region, namely Ernest Vunan and Kenneth Kumecha Tah.

4.4. Thesis limitations

There are two main limitations connected generally with the practical part of the thesis. At first, 40 farmers were interviewed using a ‘snowball’ sampling method, meaning that the spectra of people involved do not necessary cover all inner-village differences. Secondly, there is an altitude contrast between the selected villages in Northwest region, which further influences the data comparison with Centre region, where the villages are of about the same elevation.

5. RESULTS

This chapter composed of literature review aimed at six ICRAF preferred tree species (photo gallery of targeted species is placed in Appendix B) and also presents the data obtained during farmers' interviews.

5.1. Regionally planted crops and trees

These results are based on collected and evaluated data stated in questionnaires. The data were analysed separately for each region trying to show differences between them. *Figure 5* and *Figure 6* consist of a list of planted crops and trees with maximum of three columns for each species. These columns represents three statements from the questionnaires:

1) Regionally most planted crops/trees according to farmers' opinions ('past')
2) Most planted crops/trees in farmer's compounds ('present')
3) Farmers' future planting intentions in crops/trees ('future')

As we can see from the graphs, there are notable differences in planted crop and tree species between Northwest region (Anglophone part) and Centre (Francophone part) region. This variability is primarily based on diverse altitude of targeted villages, but might be influenced by different social environment as well.

Dominant species grown in Northwest region are: corn (*Zea mays*), beans (*Phaseolus* spp.), irish potatoes (*Solanum tuberosum*), plantains (*Musa* × *paradisiaca*) and njama njama (*Solanum scabrum*). These species match almost completely with crops and trees considered by farmers as regionally most important.

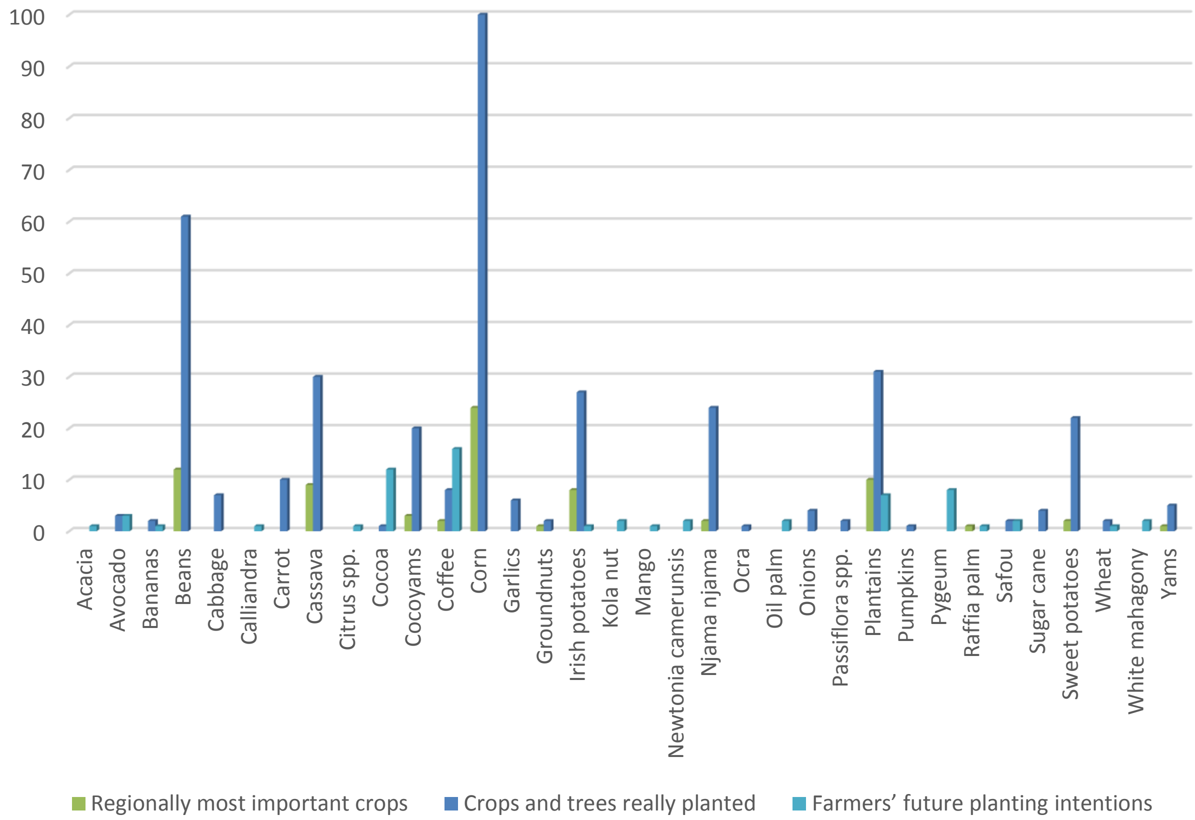

Figure 5: Score comparison between regionally most important crops and trees due to farmers' opinions; crop and tree species really planted according to farmers' preferences; farmers' future planting intentions in crops and trees in Northwest region

In Centre region, the most planted species include: cocoa (*Theobroma cacao*), cassava (*Manihot esculenta*), safou (*Dacryodes edulis*), cocoyam (*Colocasia esculenta*) and plantains. However, compared to regional most important crops and trees selected by farmers, there is a significant difference – cocoa and safou are replaced by groundnuts (*Arachis hypogea*) and sweet potatoes (*Ipomea batatas*). This contribute to our theory that the species thought as regionally most important in fact correspond with food crops grown mainly in past.

Considering farmers' future planting intentions, there is a strong focus on cash crops in both regions. Leading cash crop in Centre region is undoubtedly cocoa (*Theobroma cacao*), which is currently also the most preferred planted species there, followed by safou. Farmers from poorer Northwest region are, up to now, not growing cash crops regularly, therefore they would like to focus more on coffee (*Coffea arabica*), cocoa and pygeum (*Prunus africana*), which has an ample export potential to Nigeria.

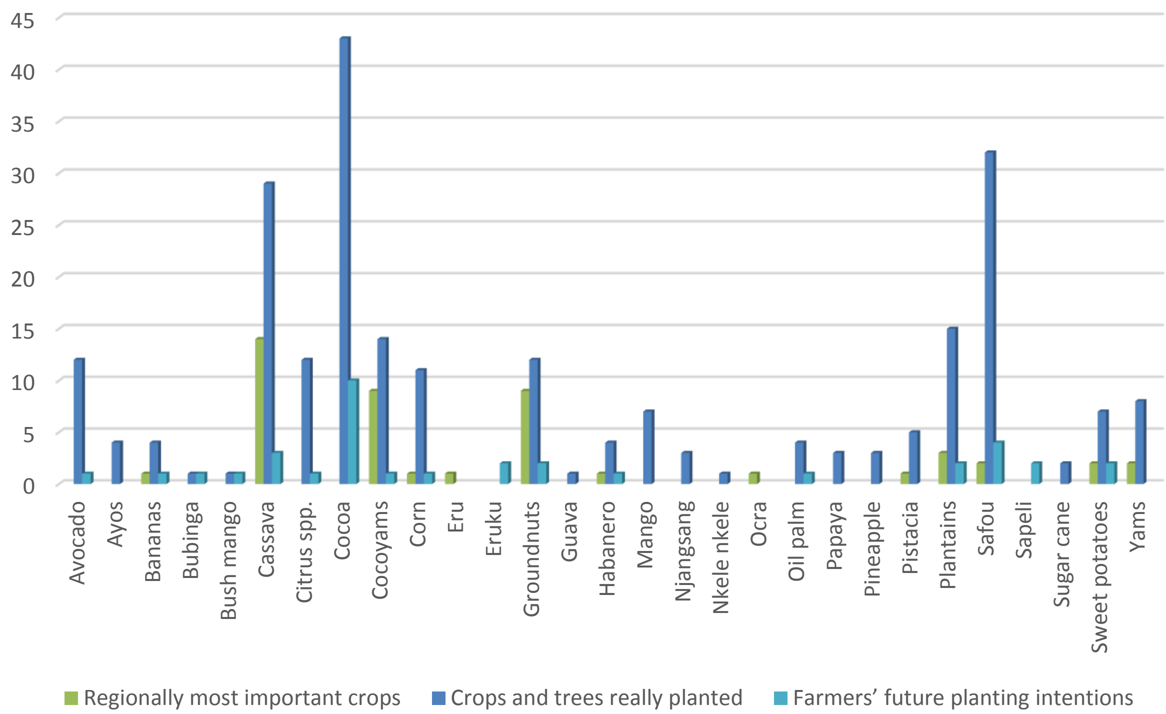

Figure 6: Score comparison between regionally most important crops and trees due to farmers' opinions; crop and tree species really planted according to farmers' preferences; farmers' future planting intentions in crops and trees in Centre region

5.2. Farmers' tree species preferences

Data are based on a total sum of all trees planted or leastwise tolerated by farmers in their compounds. *Figure 7* compares amount of planted tree species between Northwest and Centre region. All the planted species, with their names, origin, score and utilization, are then listed in *Table 6*.

Even though, farmers from Northwest region do not rank trees that high in preferences as farmers from Centre region do, they still value them as a necessary part of their homegardens and agroforestry systems. There are some differences in a composition of tree species between Abong-Phen and Big Babanki, where the species diversity is richer due to various altitude. The most planted tree species in Northwest region are: avocado (*Persea americana*), kola nut (*Cola* spp.), mango (*Mangifera indica*), pygeum (*Prunus africana*) and safou (*Dacryodes edulis*). Contrary, farmers from Centre region are, in both villages, growing citruses at most. Major tree species planted in Centre region are: citruses (*Citrus* spp.), safou, mango, avocado and kola nut.

Table 6: All tree species planted in Northwest and Centre region of Cameroon ordered by their total score

Position	Scientific name	Common name	Family	Origin	Total score	Score in NW region (Big Babanki/Abong-Phen)	Score in Centre region (Lekiasi/Nkenlikok)	Uses*
1.	*Citrus* spp.	Orange, lemon, lime, grapefruit, mandarin	Rutaceae	E	38	10 (6/4)	31 (19/12)	C, F, M
2.	*Persea americana*	Avocado	Lauraceae	E	37	25 (15/10)	12 (9/3)	F
3.	*Cola* spp.	Kola nut	Sterculiaceae	I	29	18 (11/7)	11 (8/3)	C, F, M, W
4.	*Dacryodes edulis*	Safou/African plum	Burseraceae	I	27	13 (13/0)	14 (8/6)	C, F
5.	*Mangifera indica*	Mango	Anacardiaceae	E	26	15 (12/3)	12 (9/3)	F, M, W
6.-7.	*Carica papaya*	Papaya	Caricaceae	E	15	5 (5/0)	11 (8/3)	F
6.-7.	*Psidium guajava*	Guava	Myrtaceae	E	15	8 (5/3)	8 (4/4)	F, M
8.	*Theobroma cacao*	Cocoa	Malvaceae	E	13	6 (6/0)	7 (7/0)	C
9.-10.	*Coffea arabica*	Coffee	Rubiaceae	E	12	12 (9/3)	0	C
9.-10	*Passiflora* spp.	Adam's/ passion fruit	Passifloraceae	E	12	12 (7/5)	0	F
11.	*Prunus africana*	Pygeum/ Plantecam	Rosaceae	I	9	14 (5/9)	0	M
12.-13.	*Acacia* spp.	Acacia	Fabaceae	E + I	8	3 (2/1)	5 (4/1)	B, Fe, Fo, W
12.-13.	*Ricinodendron heudelotii*	Njangsang	Euphorbiaceae	I	8	2 (2/0)	6 (5/1)	F
14.-15.	*Garcinia kola*	Bitter kola	Clusiaceae	I	7	0	7 (5/2)	F
14.-15.		Pistacia			7	0	7 (5/2)	F
16.-19.	*Raphia africana*	Raffia palm	Arecaceae	I	6	6 (6/0)	0	W
16.-19.	*Elaeis guineensis*	Oil palm	Arecaceae	I	6	6 (6/0)	0	O
16.-19.	*Irvingia gabonensis*	Bush mango	Irvingiaceae	I	6	0	6 (4/2)	F
16.-19.	*Milicia excelsa*	Eruku/Iroko	Moraceae	I	6	0	6 (5/1)	W
20.	*Mansonia altissima*	Biti/Beté	Malvaceae	I	4	0	4 (4/0)	W
21.-22.	*Eucalyptus* spp.	Eucalyptus	Myrtaceae	E	3	3 (1/2)	0	W
21.-22.	*Entandrophragma cylindricum*	Sapelli	Meliaceae	I	3	0	3 (2/1)	W
23.-26.	*Canarium schweinfurthii*	Canarium	Burseraceae	I	2	2 (1/1)	0	W
23.-26.	*Calliandra calothyrsus*	Calliandra	Fabaceae	E	2	1 (1/0)	1 (1/0)	B, Fe, W
23.-26.	*Baillonella toxisperma*	Moabi	Sapotaceae	I	2	0	2 (1/1)	M, W
23.-26.	*Combretum micranthum*	Kenkeliba	Combretaceae	I	2	0	2 (0/2)	M
27.-36.	*Tephrosia vogelii*	Tephrosia	Fabaceae	I	1	1 (1/0)	0	B, Fe,

								W
27.-36.	*Entandrophragma angolense*	White mahagony	Meliaceae	I	1	1 (1/0)	0	W
27.-36.	*Cordia africana*	Cordia	Boraginaceae	I	1	1 (1/0)	0	W
27.-36.	*Triplochiton scleroxylon*	Ayos	Malvaceae	I	1	0	1 (1/0)	W
27.-36.	*Azadirachta indica*	Nim	Melieaceae	E	1	0	1 (1/0)	M
27.-36.	*Phyllostachis*	Bamboo	Poaceae	E	1	0	1 (1/0)	W
27.-36.	*Piptadeniastrum africanum*	Atui	Fabaceae	I	1	0	1 (0/1)	W
27.-36.	*Lovoa trichilioides*	Bibolo	Meliaceae	I	1	0	1 (0/1)	W
27.-36.	*Irvingia wombolu*	Bitter bush mango	Irvingiaceae	I	1	0	1 (0/1)	F
27.-36.	*Dacryodes macrophylla*	Matom	Burseraceae	I	1	0	1 (0/1)	F

* Origin: E = exotic, I = indigenous; *Uses: B = beekeeping F = food, Fe = fertilizer, Fo = fodder, C = cash crop M = medicine, O = oil W = wood

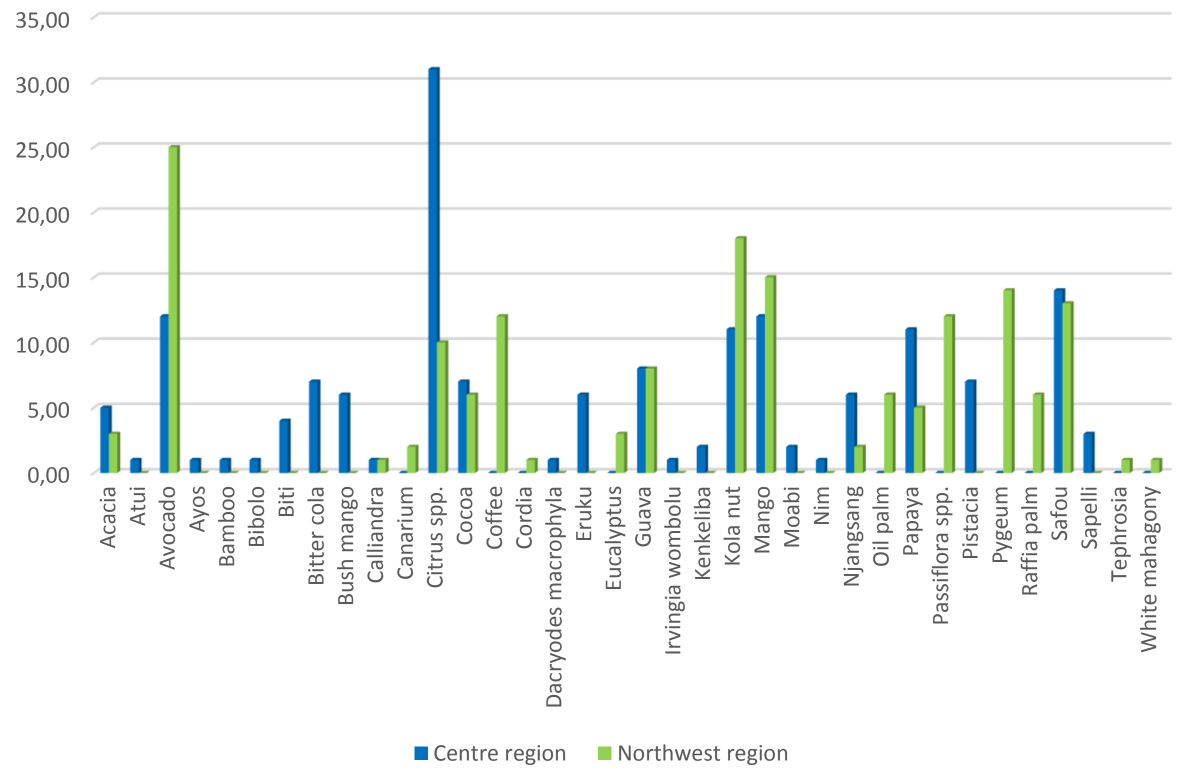

Figure 7: Score comparison between planted tree species in Centre and Northwest region

More trees, in the total sum of 31 species, are planted in Centre region, including mainly fruit trees and cocoa. Altogether 25 tree species were recognized in Northwest region with a considerable difference between Big Babanki and Abong-Phen, as mentioned above.

Results in *Figure 8* show that tree products are intended primarily for home consumption. Medicine, firewood or construction material stand as an additional way of utilization.

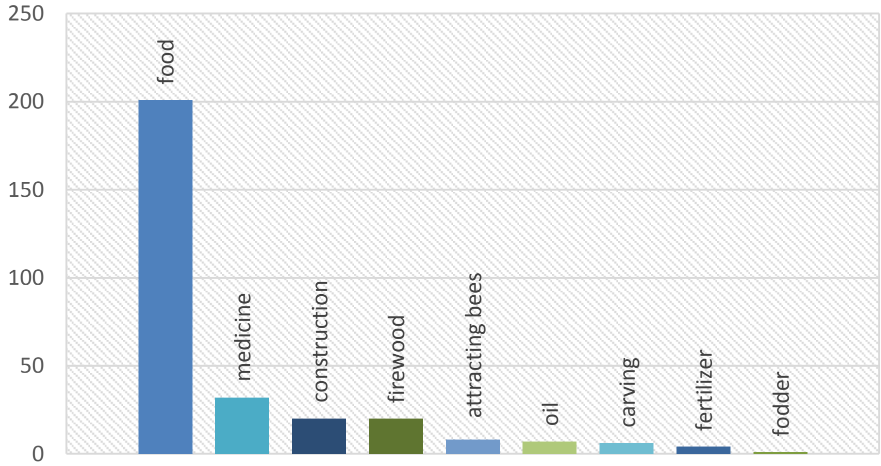

Figure 8: Utilization of tree products

5.3. ICRAF preferred agroforestry tree species

5.3.1. *Allanblackia spp.*

Allanblackia is a dioecious multipurpose tree genus of the family Clusiaceae found in the equatorial rainforests of West, East and Central African regions extending from Tanzania to Sierra Leone. It has several uses including shade, timber, and medicine, but the main practise is the production of edible oil from its seeds (Ofori *et al.*, 2013). The oil contains 52–58% stearic acid and 39–45% oleic acid (Asaah *et al.*, 2011a) and has been used traditionally for cooking or soap making. Recently, new uses of *Allanblackia* seed oil at industrial scale have been discovered by a Netherland company Unilever for the margarine and cosmetic products. Moderately high melting point of the *Allanblackia* seed oil makes it superior to other alternative oils such as palm oil (Ofori *et al.*, 2013).

Allanblackia belongs to 'Cinderella' species (as well as *Cola* spp., *Dacryodes edulis*, *Garcinia kola*, *Irvingia gabonensis* and *Ricinodendron heudelotii*) overlooked by science, which provide nutritional, economic or environmental benefits, but have been neglected by mainstream domestication (Leakey & Newton 1993).

According to currently available information, *Allanblackia* genus consists of nine species, although the boundaries between taxa are sometimes indeterminate and multiple synonyms are apparent, there can be recognized: *A. floribunda*, *A. gabonensis*, *A. kimbilensis*, *A. kisonghi*, *A. marienii*, *A. parviflora*, *A. stanerana*, *A. stuhlmannii*, and *A. ulugurensis*. By cause of IUCN criteria, *A. gabonensis*, *A. stuhlmannii* and *A. ulugurensis* are considered to be vulnerable due to habitat loss, degradation or small initial population areas (Russell *et al.*, 2009).

In addition, significant domestication research has been undertaken in Cameroon, primarily on *A. floribunda* but with some work also done on *A. stanerana* and *A. gabonensis*. (Rusell *et al.*, 2009) Mature *A. floribunda* is a medium-sized forest tree species of about 30 m in height with a natural range from Cameroon to Democratic Republic of Congo. Trees are found in evergreen lowland deciduous forests and have 15-25 cm long brown fruits, weighing 1-2.5 kg, with 40-100 seeds per berry. The whole tree habitus is described in *Figure 9*. However, germination of this species is reported to be less than 5%. Its bark is thought to be locally used against coughs, dysentery, diarrhoea, toothache, and as an aphrodisiac or pain reliever (Atangana *et al.*, 2006).

Market value chains for *Allanblackia* seeds harvested from natural stands are currently under development of Unilever, who stands as the major buyer of *Allanblackia* oil and also provides a guaranteed price for the products in Cameroon, Ghana, Nigeria and Tanzania (Attipoe *et al.*, 2006). According to estimations, there is a market need for more than 100,000 t of *Allanblackia* oil annually. That was one of the reasons for the Novella partnership to arise, the partnership composed of Unilever, World Agroforestry Centre (ICRAF), World Conservation Union (IUCN), Netherlands Development Organization (SNV) and number of governmental organizations or NGOs in the African countries involved (Ofori *et al.*, 2013). However, with the recent *Allanblackia* yields it is really difficult for farmers to achieve a minimum requirements (240 t/year) set by Unilever. It is thought that with a support of domestication programmes and creation of special *Allanblackia* tree farms, this demand might be reachable (Ofori *et al.*, 2013)

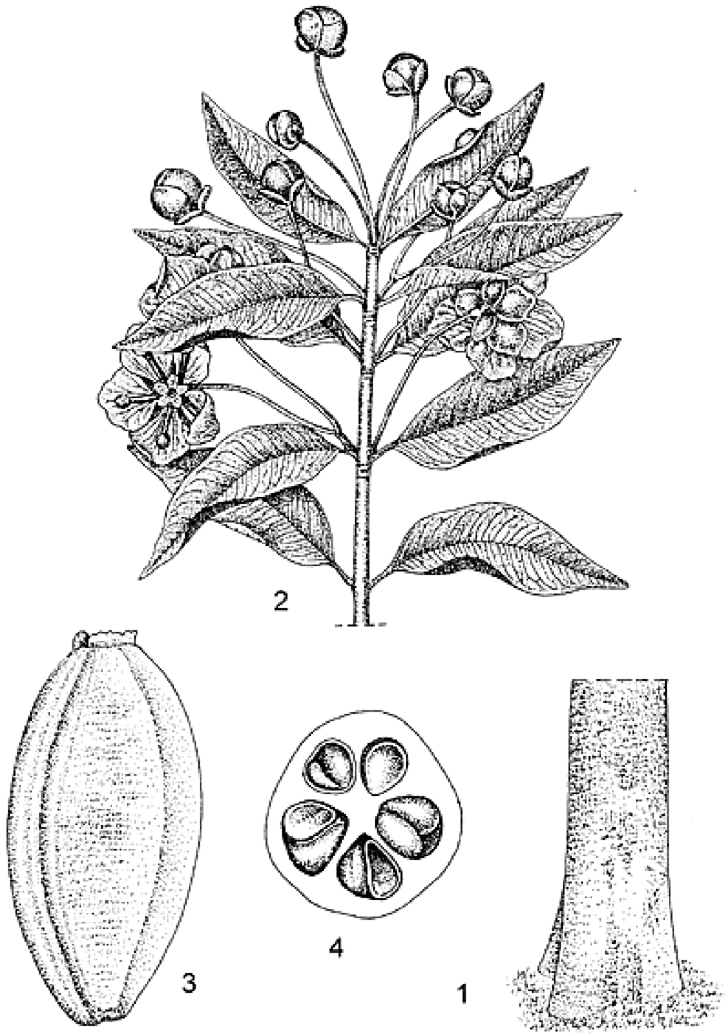

Figure 9: *Allanblackia florinbuda*, 1 - base of bole; 2 - flowering twig; 3 - fruit; 4 - fruit in cross section showing seeds. Redrawn and adapted by Achmad Satiri Nurhaman, PROTA

For the successful domestication of *Allanblackia* some knowledge gaps still need to be full-filled. This includes: lack of information on genetic structure within the genus and absence of data on gene flow within and between populations (Russell *et al.*, 2009). On the other hand some useful studies have already appeared, e.g. Attangana *et al.* (2010) reports a high within population and moderate among-population genetic diversity, while using eight informative microsatellite loci.

5.3.2. *Cola nitida*

Cola nitida, popular as kola nut, is a part of Sterculiaceae family. *Cola* genus comprises of about 125-140 species (depending on author) which are commonly grown in West/Central Africa and were introduced to South America as well. In the case of Cameroon, there are 39 *Cola* species reported among which *C. acuminata*, *C. anomala* and *C. nitida* are the most exploited (Facheux *et al.*, 2006; Niemenak *et al.*, 2008).

Cola nitida is an evergreen, allogamous, moderate-sized (reaching up to 25 m) and shade-bearing tree belonging mainly to secondary forest lowlands, see *Figure 10*. The trees are often cultivated as a shade crop in association with cocoa or coffee, however cultivation of *C. nitida* has been traditionally done in a more passive way - useful trees were simply retained during the forest clearing and more trees then naturally regenerated after fallowing the land (Tachie-Obeng & Brown, 2004).

Kola nut is the tree of multiple uses, e.g. bark extract works as a bacterial inhibitor, leaves or flowers are thought to be used as a remedy for dysentery and twigs are chewed to clean teeth (Tachie-Obeng & Brown, 2004). Though, it is the seed, commonly called kola nut, considered as the most significant part. The seeds consist of two cotyledons in case of *C. nitida* and of 3-6 cotyledons in case of *C. acuminata* (Niemenak *et al.*, 2008), which is reported to be smaller in seed size and preferred in northern Nigeria/Sudan rather than in Cameroon (Tachie-Obeng & Brown, 2004). Kola nuts are pink-brownish, about a size of chestnut with bitter astringent taste when eaten fresh (Burdock *et al.*, 2009). The flowering flush occurs usually in the middle of rainy season (July-August) with the fruiting season coming mostly from September to January (Tachie-Obeng & Brown, 2004).

Quick harvesting and storage quality are the key factors in processing of kola nut. Firstly, farmers have to climb the tree and cut the ripe fruits with a special harvesting tool, the pods are then cracked and seeds removed. For a simpler testa extraction, nuts are soaked in water or heaped into a large basket, where they are left to ferment for about five days. At the end of the process, the cleaned nuts are put into baskets and, while stirring regularly, kept there for three-four days. After this, nuts are ready to be either sold or consumed. Under the best conditions, kola nuts might be stored for months without any decline in quality, on the other hand most of the consumers still prefer the fresh variant (Tachie-Obeng & Brown, 2004).

Supply of kola nuts into markets is closely linked with seasonality of the product. There are significant periods of scarcity and abundance resulting in production and price fluctuations; furthermore, price of kola nuts varies each year. Despite, for the South region of Cameroon the income from kola nut sales is highly important and the nuts are also sold in great quantities there (Facheux *et al.*, 2006).

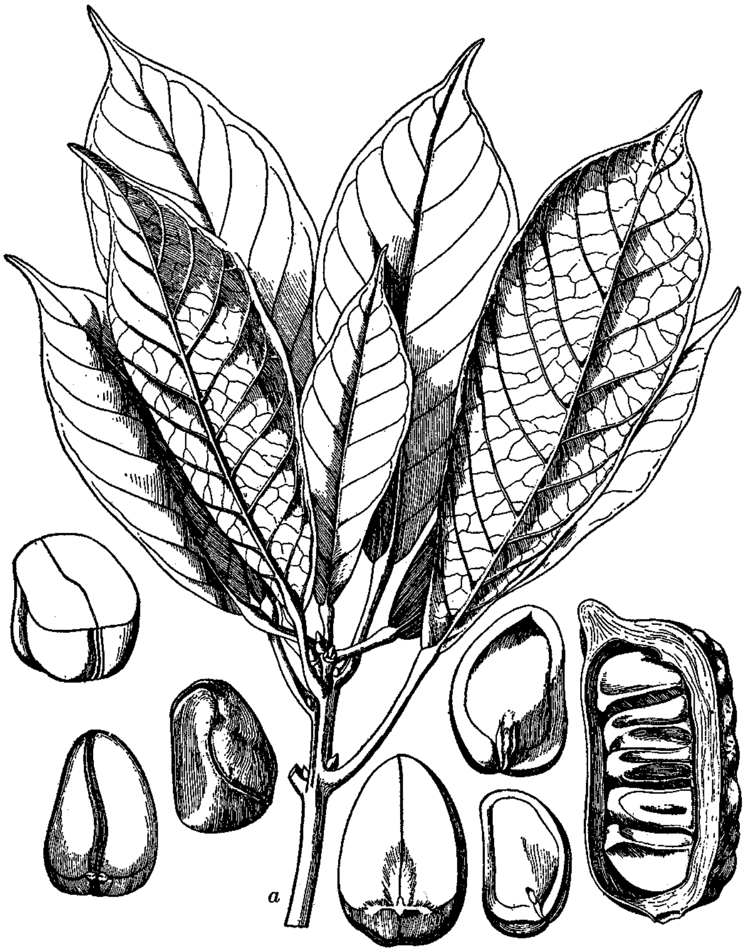

Figure 10: *Cola nitida*, a – leafy branch + longitudinal section of fruit, cross and natural kongitudinal section of seed showing embryo enlarged; source: PROTA

Caffeine, theobromine and catechin are the important constituents of kola nuts. Therefore are the seeds popularly chewed as a stimulant producing a strong state of euphoria and well-being, enhancing energy and suppressing hunger or thirst (Odenbunmi *et al.*, 2009; Burdock *et al.*, 2009). According to Niemenak *et al.* (2008), caffeine content in kola nut is between 100 and 200 mg per mature fresh seed, which is a higher amount compared to average cup (150 ml) of ground roasted coffee (85 mg), instant coffee (60 mg), leaf tea (30 mg) or hot chocolate (4 mg) (Niemenak *et al.*, 2008). However, it was found that mouth and gastro-intestinal cancers are prevalent in areas where the chewing of kola nuts is a common practice (Tachie-Obeng & Brown, 2004).

Cola trees have a strong cultural significance in West Africa. It is a gesture of hospitality and an inherent part of many traditional rituals or ceremonies. In North Cameroon, seeds of *Cola* are also used in dying clothes. What is more, in many Muslim areas where other stimulants such as alcohol are prohibited, kola nut acts as a substituent and thus plays an important social role (Facheux *et al.*, 2006).

In the food production, kola nuts often served as a popular flavouring ingredient and are used even recently. During slave trade in 17th century, *Cola* trees were introduced from Africa to Central and South America. This enabled John Stith Pemberton, in 1886, to discover a popular soft drink based on coca and kola extracts (Burdock *et al*., 2009). Nonetheless, these extracts are now completely excluded from the beverage process.

One of the major constraints in kola nut production are 'kola weevils', especially *Balanogastric kolae* and *Sophrorhinus* spp., attacking the dropped fruits (Facheux *et al.*, 2006). Hence more research need to be done on pests and diseases to secure a valuable kola nut production.

Scientific research on domestication of *Cola nitida* is still in its beginning. It is known that the seeds dispose a slow and uneven germination but vegetative propagation by cuttings has been reported as successful (Tachie-Obeng & Brown, 2004). Selective breeding program should be developed as well as field trials and training nurseries for farmers involved in *C. nitida* planting.

5.3.3. *Dacryodes edulis*

Dacryodes edulis, known as safou or African plum, belongs to the family Burseraceae. Its name derives from a Greek word 'dakruon' meaning 'tear' which refers to a resin appearing on the stem bark when the tree is injured (Ajibesin, 2011). There are around 70 species of *Dacryodes* distributed in the humid tropics – 22 species and 14 undescribed species in the forests of South America; 18 species in Africa; and 18 species in South-East Asia. Among these species, only few were detailed described (Tee et *al.*, 2014).

D. edulis, presented in *Figure 11*, is a dioecious evergreen and shade-loving tree, which can grow up to 40 m high in the forest but most of the vegetative propagated trees reached generally much lower highs (Tee *et al.*, 2014). The geographical area of this tree covers about 2/3 of the Cameroonian territory but its natural range extends from southern Nigeria into western Cameroon. Resulting from the anthropogenic transfer of planting material, safou can be recently also found in Gabon, Democratic Republic of Congo, Congo, Central African Republic and Equatorial Guinea (Anegbeh *et al.*, 2005; Youmbi *et al.*, 2010).

The fruit is large, cylindrical and elongated. When it is ripe, the fruit changes its colour from greenish-pink to dark blue, almost black (depends on variety) (Leakey, 2012; Tee *et al.*, 2014). In Cameroon the fruits are typically eaten roasted with cassava or plantain, in Nigeria fruits are traditionally boiled in salted water. Overall, safou is considered more as vegetable than fruit, with taste reminding a cross between avocado and olive. Major disadvantage is the inability to store raw fruits for more than a couple of days, however, this can be prolonged by drying (Anegbeh *et al.*, 2005; Leakey, 2012).

The trees are also important for a shade provision, therefore they are commonly a part of cocoa and coffee plantations. Especially in Cameroon, safou makes up 20-60% of all fruit trees in farmer's fields and homegardens (Leakey, 2012). Economically, safou stands on the third position among the most important fruits in Cameroon, coming after banana and kola nut. Fruits are not only traded regionally, a significant role also plays export, which was estimated to 2 million $ in 1999 (Anegbeh *et al.*, 2005). Approximately 4,500 t of safou is said to be annually exported to European Union (Youmbi *et al.*, 2010).

The fruits, which ripe during the rainy season (May – November) (Anegbeh *et al.*, 2005) with the best fruiting season around May - August (Leakey, 2012), are particularly important to women. The income allows them to pay school fees and other associated costs with education of their children (Schreckenberg *et al.*, 2006). Quite similar is the case of ICRAF's cultivar 'Nöel' fruiting during the Christmas time, which helps to pay the expenses on presents, special food etc. (Leakey *et al.*, 2003).

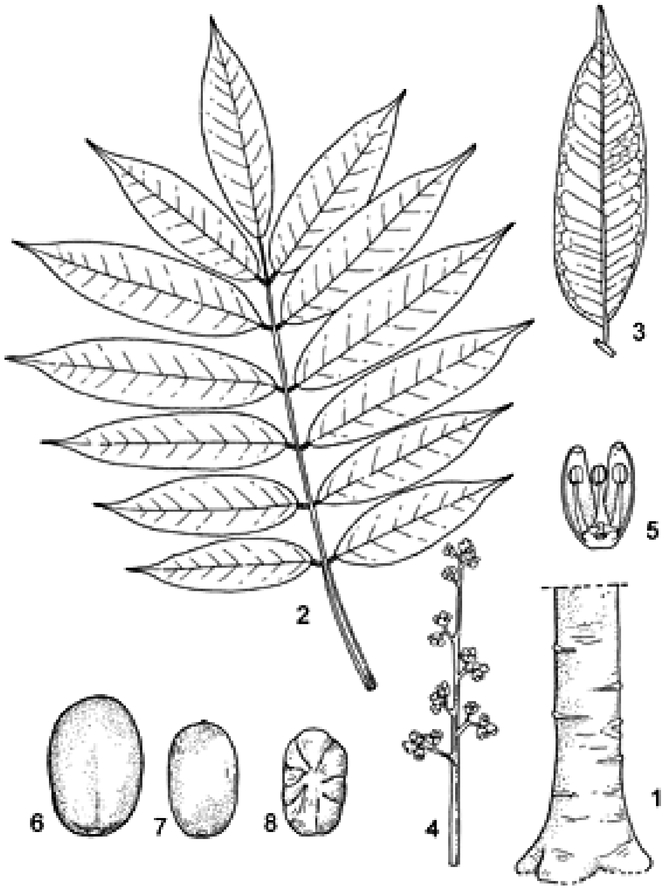

Figure 11: *Dacryodes edulis*, 1 - base of bole; 2 - leaf; 3 - leaflet; 4 - inflorescence; 5 - male flower in longitudinal section; 6 - fruit; 7 - endocarp; 8 – seed. Redrawn and adapted by W. Wessel-Brand, PROTA

In general, *Dacryodes* species are rich in lipids, proteins and minerals. Oils extracted from the fruits are high in unsaturated fatty acids. Therefore is safou considered as a valuable part of local diet. Concerning the nutrition value, lipids can form up to 73% of the entire fruit, 44% of the pulp and 27% of the seed (Tee *et al.*, 2014). Protein content is about 24%, which is a greater amount than in maize (10%), rice (8%), sorghum (11%) or wheat (8–13%), but lower than in groundnut (48%) and soybeans (40%). Both pulp and seeds of *D. edulis* contain essential and non-essential amino acids. The major essential amino acids are leucine, lysine, phenylalanine, and isoleucine - that makes the kernel of safou highly recommend for animal feeding (Anegbeh *et al.*, 2005).

Many studies are also reporting a medicinal value of safou (Ajibesin, 2011; Tee *et al.*, 2014), however my observation shows that Cameroonian farmers are using *D. edulis* just for the fruit, eventually wood, production.

In Cameroon, safou is the tree whose domestication process is more advanced compared to other multipurpose agroforestry species. A hypothesis suggests that quantitative morphological characteristics of safou's fruits are more influenced by genetic factors than the external factors such as soil and climate (Youmbi *et al.*, 2010). The reason for the advance in domestication of *D. edulis* is the use of homogeneous selected genetic material generally from marcotting and the precise selection of superior trees (Tchoundjeu *et al.*, 2006, Youmbi *et al.*, 2010).

One unexpected result from growing the safou was that some trees produced seedless fruits. This anomaly is often considered as a desirable trait (grapes, bananas), though in the case of safou, seedless fruits are socially unaccepted or tabooed. And that is a pity, because the kernel mass forms the majority of the fruit and is used just as a pig feed, if not directly thrown away (Leakey, 2012). On the other hand there is also an opportunity for future to develop *D. edulis* fruits as an oil crop (Anegbeh *et al.*, 2005).

5.3.4. *Garcinia kola*

Garcinia kola, common as bitter kola, is a part of Clusiaceae family. *Garcinia* is a tropical plant genus including several species in Africa, America or Asia. *G. kola* extends its distribution from Congo to Sierra Leone and is commonly found in evergreen lowland forest or coastal area plains up to 300 m above sea level, with average precipitation of 2,000-2,500 mm per year (Eyog-Matig *et al.*, 2007; Odenbunmi *et al.*, 2009).

Bitter kola is a medium-sized shade-tolerant tree growing up to 12 m (Indabawa & Arzai, 2011). It is highly preferred as a shading tree in cocoa plantations (Fondoun & Manga, 2000). Bark of the species is used for tanning leather, twigs serves as chewing sticks, while gum treats gonorrhoea and latex is applied to wounds (Leakey, 2012). Similarly to *Cola nitida*, the most valuable part of bitter kola is the seed.

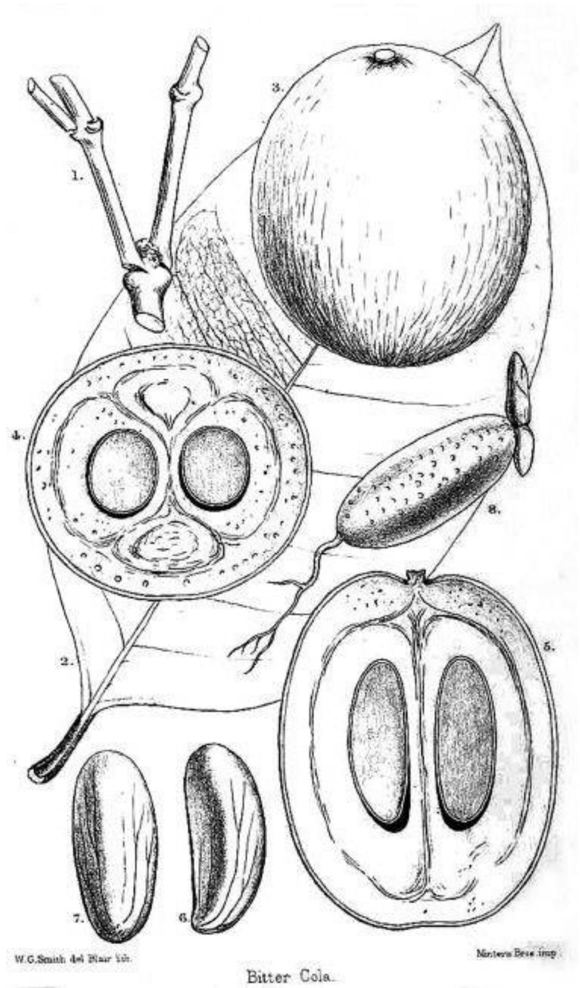

Figure 12: *Garcinia kola*, 1 - twig; 2 - leaf; 3 - fruit; 4, 5 - seeds disposition in the fruit; 6, 7 - seeds; 8 - germinated seedling, source: World Agroforestry Center

As presented in *Figure 12*, there can be one to five brownish compact seeds embedded in an orange endocarpic pulp (PROTA, 2015). The fruit is subgloose of reddish – yellow colour with a harvest period usually occurring during July - October (Indabawa & Arzai, 2011). The seeds have a bitter astringent resinous taste, suggesting the species local name, with a residual slight sweetness (Indabawa & Arzai, 2011). They are chewed as a stimulant but unlike in kola nuts, caffeine, theobromine or catechin were not detected (Niemenak *et al.*, 2008). However predominant compounds of this species are flavonoids and biflavonoids such as kolaviron, which supress its medical potential – the seeds are said to relieve bronchial problems, hoarseness and treat either urinary tract infections or liver disorders (Indabawa & Arzai, 2011). Odenbunmi *et al.* (2009) reports, that in folk medicine, bitter kola is dried, ground and mixed with honey to make a traditional cough mixture. Among all, it is a popular aphrodisiac and can be used both in palm wine fermentation as well as a substitute for hops in brewery (Fondoun & Manga, 2000; Leakey, 2012).

The major difficulty in domestication of *Garcinia kola*, as for several species of *Garcinia* genus, is the seed germination. The germination time, due to process of dormancy, was estimated to 18 months. Therefore it is necessary to create a solution overcoming this long dormancy time (Eyog-Matig *et al.*, 2007). Moreover, Kanmegne & Omokolo (2008) pointed out that the seed germination traits might be variable in the species. Even though some reports on the dormancy-breaking have been already released, more research is still required.

Overall, a lot has been done in the field of *G. kola* physiology, biochemical content or medicinal uses, though information on genetic intraspecific variation is lacking. More investigation also need to be conducted on the economic value and market chain development of bitter kola.

5.3.5. *Irvingia gabonensis*

Irvingia gabonensis, locally called bush mango or dika nut, belongs to a small family of Irvingiaceae with nine species occurring in West and Central Africa (Vihotogbé *et al.*, 2014). It is a large evergreen tree reaching up to 35 m in height and 120 cm in diameter, the whole tree habitus is described in *Figure 13*. Geographical distribution extends from Senegal to Angola with main sources in the humid lowlands of Cameroon, Nigeria, and Côte d'Ivoire (Ayuk *et al.*, 1999). There are two main varieties of *Irvingia* described by Okafor (1975): the bitter and the sweet one. Sweet one (*I. gabonensis*) is appreciated more in Cameroon contrasting to the bitter variety (*I. wombolu*) preferred in Nigeria.

Bush mango is popular mainly for its greenish-yellow fruits appearing from April to July and sometimes also in September (Ayuk *et al.*, 1999). The fruits consist of a stringy yellow flesh and a large woody seed. Even though it may remind a domesticated mango (*Mangifera indica*), the species are actually unrelated (Leakey, 2012). Fruits are consumed fresh and the juice has been recommended for a wine production. However the most valued part is the kernel inside (Anegbeh *et al.*, 2003).

The kernels are traditionally used as a food thickening properties in soups and stews, due to mucilaginous polysaccharides which are secreted during the cooking process (this characteristic is called drawability) (Atangana *et al.*, 2002). Moreover, the seeds figure prominently in trade between West African countries – it was estimated that between January and February 1995 had Cameroon exported 140 t of kernels to Gabon, Nigeria and Equatorial Guinea for an approximate income of 302,000 $ (Ndoye *et al.*, 1997).

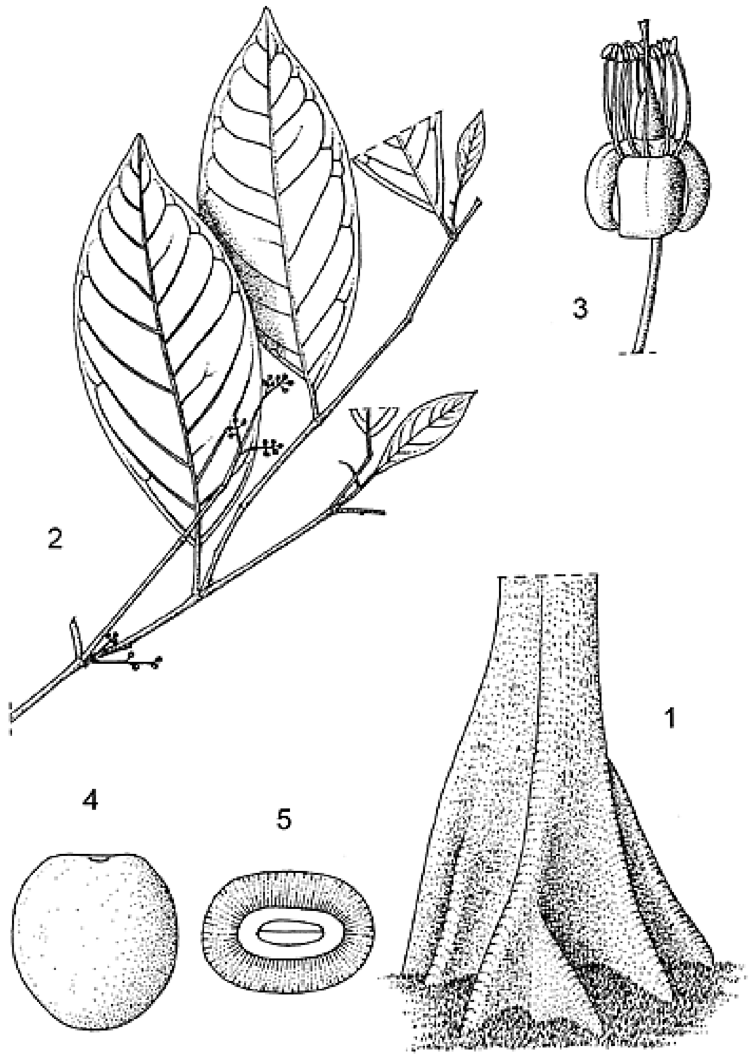

Figure 13: *Irvingia gabonensis*, 1 - base of bole; 2 - flowering twig; 3 - flower; 4 - fruit; 5 - fruit in cross section. Redrawn and adapted by Achmad Satiri Nurhaman, PROTA

It is a difficult task to remove the kernel from the pulp, usually a group of three or four woman has to undertake the procedure. Firstly, the fruit is split in halves with a machete and the split cotyledon is removed with a knife. Cotyledons are then sun-dried, so they contain no moisture and can be stored for a long time. Before cooking, the kernels need to be ground into a powder (Ayuk *et al.*, 1999).

Considering the other usages, bush mango is involved in a soap production (from the kernel oil) and its bark is recommended for treatment of diarrhoea, hernia or yellow fever. It is also hypothesized that the fruit has an ability to decrease blood sugar and is becoming popular as a weight loss supplement (Onakpoya *et al.*, 2013). In addition, the tree is sometimes preserved for a shade provision on cocoa and coffee farms (Ayuk *et al.*, 1999).

Despite the economic importance of *I. gabonensis* in Cameroon, the species still remains basically wild and undomesticated. (Atangana *et al.*, 2001; Vihotogbé *et al.*, 2014). Additionally strong relationships were found between some of the traits that characterise a good fruit for eating fresh, indicating that large fruits have more flesh rather than bigger nuts. On the other hand, weak relationships stands between the fruit and kernel mass, which means that big kernels are not necessarily found in big fruits. Therefore it is suggested to focus the domestication process on the two general ideotypes - one for the fruit flesh and the other for the kernel traits (Atangana *et al.*, 2002).

5.3.6. *Ricinodendron heudelotii*

Ricinodendron heudelotii, in Cameroon traditionally called njangsang, is a fast growing light-demanding tree belonging to Euphorbiaceae family. It can reach up to 50 m, but the average height varies between 20-30 m, with a trunk diameter of about 1.2 m (Cosyns, 2013; Oyono *et al.*, 2014). Njangsang, presented in *Figure 14*, is the typical tree of secondary forests, growing mainly at an altitude between 130 and 1030 m (Tchinda *et al.*, 2013), with a broad distribution ranging from Guinea to Angola, either Madagascar (Assanvo, 2015). The *Ricinodendron* genus is represented by two species: *Ricinodendron rautanenii* in southern Africa and *R. heudelotii* in West and Central Africa. *R. heudelotii* is then further divided into two subspecies: *R. heudelotii* subsp. *africanum* (which is the case of Cameroon) and *R. heudelotii* subsp. *heudelotii* (Plenderleith, 2004).

Njangsang is a tree of multiple utilizations – its wood is used for carving and furniture, bark extracts are thought to be considered as a traditional medicine against cough, intestinal diseases, malaria or yellow fever and can be served to pregnant women (Oyono *et al.*, 2014). However, the most significant part of the tree are fruits containing a seed kernel known for its unique thickening and flavouring features, which reminds a taste of groundnuts. It is a popular component of local soups or stews and is most commonly served in fish dishes (Leakey, 2012; Assanvo, 2015).

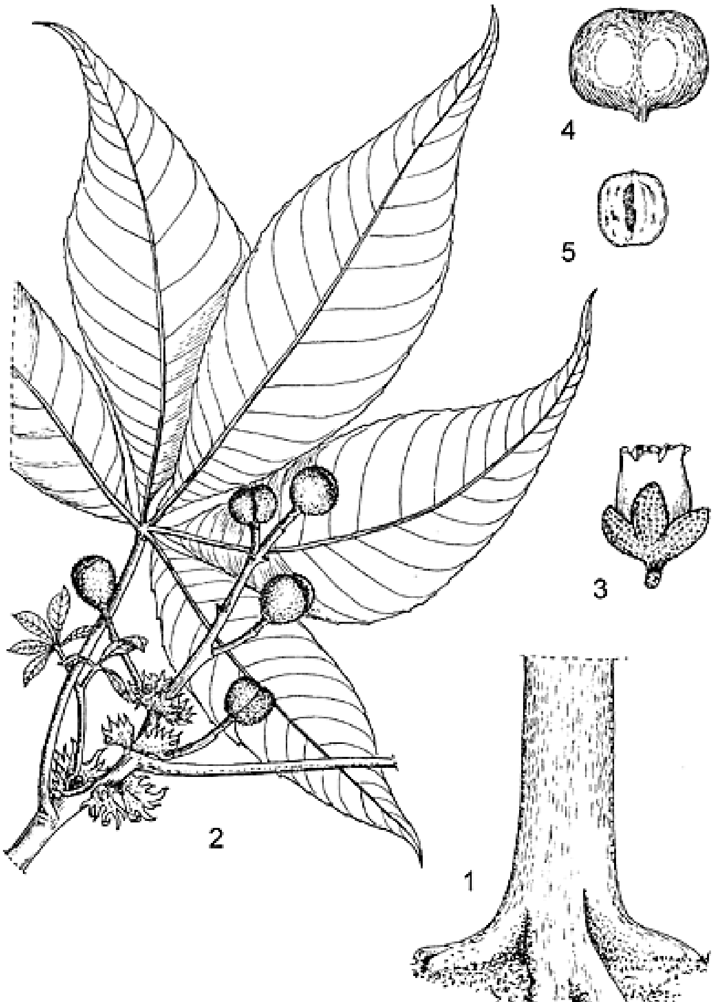

Figure 14: *Ricinodendron heudelotii*, 1 - base of bole; 2 - part of branch with young fruits; 3 - male flower; 4 - fruit; 5 - seed. Redrawn and adapted by Iskak Syamsudin, PROTA

The kernels have a high nutritional value because of the great amounts of proteins, which are often missing in the diet of tropical farmers (Cosyns, 2013). Apart from proteins, polyunsaturated fats are important as well. Oil content of the seeds differs from 49 to 63% and represents a possible future alternative in production of cooking oil, margarine, soaps or pharmaceutical preparations

(Plenderleith, 2004). Nonetheless, njangsang oil is not highly valued by local people and its extraction is still in an experimental phase (Cosyns, 2013).

The process of extraction is really demanding, especially in terms of time. After gathering, the fruits are left to rot for 5-8 weeks. Seeds are then washed and boiled in water (once or twice), which helps to crack the seed shell. Next step is to release kernels from the shells, using a knife or nail, and let them dry. Fruit pulp and endocarp are usually discarded. The time between fruit collection and eventual sale is generally 3-4 months, adding that the most trees are flowering during April - May and the fruits ripening occurs in September - October (Plenderleith, 2004; Cosyns, 2013).

Njangsang kernels are traded on local, national and regional market. In 1996, 1 kg of njangsang (250 seeds on average) was sold for 1.30–1.50 $, export amounted at least 980,000 $ in that year. Current trends show increasing njansang consumption in Cameroon as well as growing export quantities. Due to large number of immigrants coming from West and Central Africa, the export has also expanded to European cities such as Paris or Brussels (Plenderleith, 2004; Cosyns, 2013). For Cameroonian farmers, the kernels often ensure an additional income in times of cocoa price fluctuations (Leakey, 2012).

As a future recommendation, low input processing technologies are need to be developed for a simplification of the kernel extraction process. There is also a potential to focus more on products that could be derived from njangsang oil.

Regarding the domestication process, Cosyns (2013) reports a low adoption of vegetative propagation techniques among local farmers. Therefore, farmers should be steadily encouraged to adopt some of the propagation methods and njangsang domestication need to be promoted by several projects. Further research also has to be done on species' germplasm, including genetic variety, distribution or tree characteristics description.

5.4. Cooperation with ICRAF

Seven from the interviewed farmers had got an experience with ICRAF projects or training programmes. Therefore, they had been further asked four simple questions, to both review their satisfaction and to find out some future recommendations on the basis of ICRAF cooperation.

All of the farmers involved were men between 35 and 59 years. Two of them worked also as trainers of other farmers, so they were receiving a salary from ICRAF. Most of them came from Centre region except one from Northwest, however, he had taken his training in Centre region as well. This finding implies an option for ICRAF to implement some projects in Northwest region and start there a firm cooperation for the future.

As seen in *Table 7*, only with one exception, all of the farmers were involved in tree domestication programmes. They assessed ICRAF cooperation as very useful or rather useful. Support afforded to the farmers consist mostly of giving advice/instructions, provision of tools/materials and teaching new methods/technologies. As mentioned above, trainers were able to get some loan and money for their services. From the recommendations received, we would point out a need for more tools such as wheelers or machetes and a demand for encouragement to bring more people into the programmes. Although, half of the farmers would welcome a money provision, this recommendation does not correspond with ICRAF rules.

Table 7: Farmers involved in ICRAF programmes

Name	Village	Region*	Projects**	Cooperation rating	Provided support	Recommended upgrades
Ernest Vunan	Big Babanki	NW	Tree domestication, Project designing	yes, very useful	giving advice, instructions; teach new methods, technologies	support for extension work; identify more priority places to work
Tsala Nnomo	Lekiasi	C	Tree domestication (IFT)	rather yes	provide materials and tools; give advice, instructions; teach new methods, technologies	provide more chemicals (fungicides, pesticides), sprayers and wheelers
Mengue Eloundou	Lekiasi	C	Tree domestication, Tree nurseries	yes, very useful	provide materials and tools; give advice, instructions; teach new methods, technologies	provide medicines for people, more tools (wheelers, machetes), provide money
Eugéne Ombudu	Lekiasi	C	Tree domestication (IFT)	rather yes	provide materials and tools; give advice, instructions; teach new methods, technologies	provide money, encourage more farmers
Christophe Misse	Lekiasi	C	Tree domestication (IFT)	rather yes	provide materials and tools; give advice, instructions; provide a loan; provide money - trainer	financial support for building a training centre; provide some transportation-motorbikes
Jean Essomba	Nkenlikok	C	Cassava Project	rather yes	give advice, instructions; teach new methods, technologies	provide money
Luis Atangana	Nkenlikok	C	Tree domestication, Allanblackia	yes, very useful	provide materials and tools; teach new methods, technologies; provide a loan; provide money - trainer	encourage more farmers; build a warehouse with tools for everyone

6. DISCUSSION

Agricultural diversity among planted crop and tree species in Northwest and Centre region of Cameroon is primarily based on diverse altitude of targeted villages, but might be influenced by different social environment as well. The most valued trees are primarily fruit species followed by cash crops and trees used as a remedy. Interestingly, locals are not really involved in planting timber species, although there is a plenty of high-quality indigenous hard-wood trees. This can results from the influence of ICRAF's domestication programmes focused more on indigenous fruit trees, as well as from the fact that farmers are often used to get wood directly from the forest.

Main cash crops are cocoa (*Theobroma cacao*) in Centre region and arabica coffee (*Coffea arabica*) in Northwest region. Though, remarkable differences are found within the two villages in Northwest. Due to high altitude, cocoa was not historically settled among people from Bamenda highlands. However, a few members of Big Babanki (1,150 m) are nowadays trying to grow this cash crop and even other farmers would like to, in the future, plant cocoa more than coffee. In Abong-Phen (2,000 m), farmers are not able to grow cocoa at all, so they prefer to focus on growing coffee and pygeum (*Prunus africana*) instead. Growing cocoa in this region might be problematic and definitely less profitable than in regions of lower altitudes. Hence we would recommend to aim more at planting coffee which cannot be grown in lowlands and therefore presents a considerable potential for the future of Northwest region.

On the other side, Lekiasi and Nkelikok (500 – 700 m) in Centre region provide a perfect setting for cocoa and coffee is not grown there, except some remains of robusta coffee (*Coffea canephora*) plantations. When asked about their future preferences, farmers there had often answered that they would like to grow more cocoa in agroforestry systems with fruit trees or intercropped with tubers and vegetables. This conviction might be a sign of ICRAF influence.

ICRAF's goal is to promote domestication programmes focusing on indigenous fruit tree species. After years of investigation, researchers come up with species that has to correspond with farmer's needs: *Allanblackia* spp., kola nut (*Cola nitida*), safou (*Dacryodes edulis*), bitter kola (*Garcinia kola*), bush mango (*Irvingia gabonensis*) and njangsang (*Ricinodendron heudelotii*) (Tchoundjeu *et al*., 2006; Franzel & Kindt, 2012; Asaah *et al*., 2014). To compare, our results present that the most planted tree species in both Centre and Northwest region are: avocado (*Persea Americana*), mango (*Mangifera indica*), citruses (*Citrus* spp.), kola nut (*Cola* spp.) and safou (*Dacryodes edulis*), with differences in cash crops as discussed above. This shows that the majority of planted tree species are of an exotic origin, however indigenous species such as kola nut, safou, pygeum in Northwest and njangsang in Centre region have their stabile place in farmer's compounds (*Table 6*). The other ICRAF preferred species (*Allanblackia* spp., bitter kola and bush mango) are not considered to have strong importance for farmers in our survey. This fact is partly influenced by climate and environmental conditions and partly by different behaviour or customs of particular regions in Cameroon - to compare, Egbe *et al*. (2012) reported cocoa, bush mango, orange (*Citrus sinensis*), safou, njangsang and oil palm (*Elaeis guineensis*) as most planted tree species in Southwest region.

Surprisingly, we found that domestication of safou is on the highest level among the preferred species (Tchoundjeu *et al.*, 2006, Youmbi *et al.*, 2010), even though, for example, kola nut is reported to have much more importance within fruit trees (Anegbeh *et al.*, 2005). This could be the matter of species' utilization, kola nut plays a role of stimulant, energetic snack, on the other hand, safou provides a nutritional valuable meal rich in lipids and proteins, especially in the combination with cassava or plantains. Therefore, focusing on proper food production makes more sense in suppressing hunger than targeting on stimulant and that might be the reason for higher interest in the safou domestication.

7. CONCLUSION

Overall, we confirmed that the ICRAF preferred tree species generally correspond to actual farmers' needs in Centre and Northwest region of Cameroon. However, we have to consider the fact that domestication of most of important exotic tree species (such as avocado, mango, citruses, cocoa of coffee) has been already started in countries of their origin. So it is a logical direction to focus our attention on indigenous species, which play an important role in local culture, and try to amend their characteristics or production value.

Domestication involves series of human-induced and biophysical processes based on genetically profound changes. All the focused indigenous fruit tree species could be categorized as semi-domesticated – their phenotypic diversity is enhanced by accumulation of diverse alleles for traits selected by humans, but they are still able to survive in the wild. According to Wiersum (1997), the targeted species are in a second phase of domestication implying a change from uncontrolled utilization of wild tree products to their controlled exploitation. The most advanced level of domestication has been identified in safou (*Dacryodes edulis*), as a result of very well-established vegetative propagation methods and precise selection of superior trees.

The next step in the tree domestication consist in further development of efficient vegetative propagation methods, establishing tree nurseries and farmers' training centres, helping in an on-farm dissemination of selected species. This step has to be followed by an integration of improved germplasm into farming systems.

It is a long-term process to finalize the domestication of indigenous fruit tree species in Cameroon. To hasten the domestication progress, we would recommend to focus more deeply on the field of population genetics and plant protection, though these information are often missing in published studies.

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Appendices

Appendix A – Questionnaire

Village characteristics

Name of the village:

Region:

Altitude: GPS:

Personal data

Farmer's name:

Gender:

Age:

Number of household members:

Cash crops:

Cooperation with ICRAF:

yes	no

Are you involved in some other (non-ICRAF) projects? Is there any foundation supporting you? (local NGO's, Ministry of Agriculture)

Preferred species

What crops and trees do you plant? Please name all the species you grow or at least tolerate on your field/garden. Then pick 5 plants that are the most important for you. *(Ranking: 1- the most important, 5 – the least important)*

Please, name 3 crops that you consider as the most important for your region.

What tree species do you plant? Which part of the tree is important for you and how do you use it?

Tree parts: bark, trunk and branches, fruits and nuts, leaves, blossom…

Usage: medicine, traditions and rituals, oil, food, fodder, fuel wood, trade, shade, erosion control…

Species	**Parts**	**Usage**
Citrus spp.	Fruits, leaves	Food, medicine

What kind of troubles do you face often? *(you can choose multiple answers)*

a) Soil erosion
b) Pests
c) Weed
d) Lack of irrigation
e) Lack of fertilisers

Other:

What do you want to plant for the future? Please name crops and trees you would like to focus on.

ICRAF

(Please, answer only if you are in cooperation with ICRAF)

In which project of ICRAF are you involved?

Is cooperating with ICRAF useful for you? *(choose only one option)*

yes, very useful	rather yes	it depends	rather no	not at all

How do ICRAF support you? *(you can choose multiple answers)*

a) Provide materials and tools
b) Give advice, instructions
c) Teach new methods, technologies
d) Provide a loan
e) Provide money

Other:

What can do ICRAF better to support you and other local farmers?

Appendix B – Photo gallery of preferred tree species

Allanblackia floribunda


Fruits


Blossom and flower pods


Mature tree


Young tree

Cola nitida

Differences in cotyledons between cola species (Niemenak *et al.*, 2008)


Young tree


Seeds (PROTA)

Dacryodes edulis

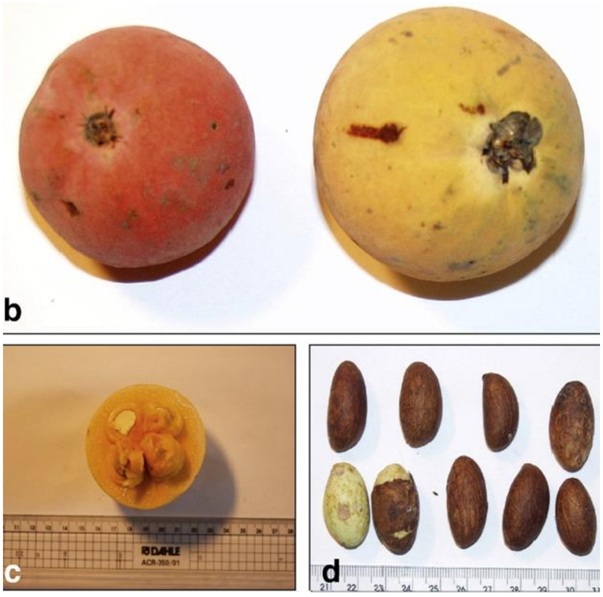
Unriped fruits

Young marcott

Ripening fruits

Garcinia kola

Mature tree (ICRAF)



Fruits and seeds (Niemenak *et al.*, 2008)

Harvest of bitter kola

Irvingia gabonensis

Fruit (PROTA)

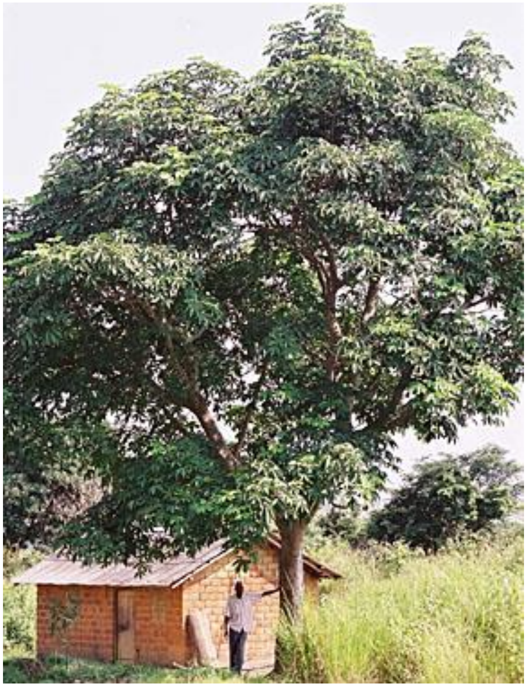
Fruits with seed kernels (Julius Atia)

Grafted mature tree (Julius Atia)

Seeds in detail (Julius Atia)

Ricinodendron heudelotii

Mature tree



Mature tree (PROTA)

Fruits and leaves (PROTA)

Appendix C – Agriculture systems


Agroforestry in Centre region


Cocoa planted with oil palm and fruit trees


Established farm on the expense of forest


Steep fields in Northwest region


Corn intercropped with njama njama


Field preparations