Expansion, research and development of the eucalyptus in Africa
Wood production, livelihoods and environmental issues: an unlikely reconciliation?

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Introduction

In 1953, Aubréville wrote « *Who would believe that the eucalyptus can excite passions and sustain controversy, when in all the Tropical and Mediterranean world, they are today considered as a blessed genus for afforestation ?* ». More than half a century later, the debate is not yet closed: Wangari Maathai[3] recently stated that the eucalyptus has been excessively promoted for commercial reasons at the expense of biodiversity and water resources; and Kenya is now felling these trees along water courses.

It thus does seem interesting to review the issue, and have a quick analysis of the situation in the light of: i/the many research works carried out on the species in Africa since its introduction - of which the considerable investment done in genetics, notably by the CTFT and CIRAD aiming at improving its productivity- ii/the still huge demand in wood (fuelwood and service wood, notably) and iii/ and the major challenges regarding the environment (deforestation, soil degradation, climate change…)

1. The interest of travelers and foresters in the eucalyptus

Men who have seen the eucalyptus during travel have always been fascinated. This genus, almost exclusively Australian is indeed remarkable by its great diversity which allows it to grow in varied climatic and soil conditions from semi-arid areas to highly humid dense forests, and from Mediterranean climate to tropical climate – thus in almost all environmental conditions in Africa.

Besides the fascination that the eucalypts elicit, their silviculture is simple: one can easily harvest a very large number of seeds from well formed seed mother trees, their preservation

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[3] The 2004 Nobel Peace Laureate, who founded the Green Belt Movement in 1977, under the auspices of the National Council of Women of Kenya; on the matter, see Maina Waruru's article in The Nation of 30 Sept. 2009 : « Thirsty eucalyptus trees get the chop in Kenya »

and their germination is easy, the transplanting and planting (in lumps, clumps, balls, pots or bare roots) do not present any particular difficulties except in hot and arid zones. The growth of trees, if the provenances and species are well chosen is fast. Moreover, regeneration by natural seeding is quite often observed, mostly after a bush fire.

The eucalyptus coppice very well and can support multiple successive rotations. It is therefore not surprising that the travelers brought seeds from Australia to sow in their countries of residence, because of their productivity, their capacity to coppice, and their hardiness, an advantage that gives the species certain resilience. Today, however, this resilience is considered a drawback by critics of the eucalyptus.

2. The rapid expansion of the eucalyptus in Africa

The first eucalyptus were introduced to Africa between the middle and the end of the 19th century: in Algeria in 1854 (Blue Gum or *Eucalyptus Globulus,* as reported by Ellwood Coper *et al*, 2009); in Madagascar, towards 1890-1895, in 1895 in Ethiopia (under the leadership of the Emperor Menelik II to satisfy population needs in fuel wood and timber), at the start of 1900 in Rwanda, and in 1901 in Burundi, mostly by missionary priests. Initially, the number of species tested in parks and gardens was very limited. In Madagascar, the first true plantings began as early as 1897, and the first afforestation of significant size in 1909, with 20 species, *Eucalyptus robusta*, (introduced in 1916), being the most used species on the eastern slopes and *Eucalyptus camaldulensis,* was it on the less humid central plateaus.

In Burundi, the introduction of eucalyptus in arboretums or in research stations started in 1930 with 16 different species, followed by 20 new species between 1934 and 1936, then after by 7 others at the end of the 1940s. In Rwanda, *Eucalyptus camaldulensis* and *E. tereticornis* were introduced in arboretum in 1933, then, the introduction of new species was sporadic.
In Ethiopia, among the 55 species of eucalypts identified and reported from cultivation (Friis, 1995), *E camaldulensis, E. citriodora, E. globulus, E. regnans, E. saligna* and *E. tereticornis* were the most widespread species at this time.

During the First Global Conference on eucalyptus organized by FAO in 1956, 170,000ha of Eucalyptus in South Africa, 135,000ha in Madagascar, 35,000ha in Rwanda-Urundi, 19,000ha in Congo (DRC), 9,600ha in Kenya and 4000ha in Ethiopia was taken stock of. In 1963, nearly 450,000ha of eucalyptus could be counted in sub-Saharan Africa.
Nowadays, only in Ethiopia, the area covered by eucalyptus could be more than 500,000ha (FAO, 2009)[4].

It should be noted that these areas do not include the numerous micro plantations of eucalyptus in the form of woodlots and alignments planted around the fields by the farmers or found along the roads and paths.

[4] As mentioned in this study of the eucalyptus in East Africa, it is difficult to determine the exact coverage of the species ; in Ethiopia, according to other sources, it could be about 250,000 ha (Demel T., 2000), the country having by far the largest coverage in the sub-region; in all the countries, small (farmers') plantations (micro-woodlots, linear plantations, etc.) are highly under-estimated, when not accounted.

3. Experimentation and diffusion of eucalyptus species, from provenance trials to the production of clones: the contribution of CTFT and CIRAD

The introduction of the eucalyptus was done much later in a numerous other African countries. They began in 1953 in Congo, in 1963 in Niger and Burkina Faso (then known as Upper Volta) under the impetus of the Centre Technique Forestier Tropical[5]. Soon after this introductory phase and selection of species, tests of the provenances were initiated for the most promising species and genetic improvement programmes were put in place according to different countries, then started the selection of hybrids and production of clones for the purpose of industrial forestry production.

In Congo, 70 species were introduced, 18 were selected along with many comparative trials of provenances and progenies, the selection of hybrids and the production of clones through successive programmes of genetic improvement – axed on wood production (pulp wood, fuel wood, poles). As reported by Leakey in his summary of CTFT works in Congo (2004): *E. tereticornis, E. urophylla, E. cloeziana, E. torelliana* and *E. alba* appeared to perform best in the savannahs around Pointe-Noire. Extensive provenance trials *(eg.* one with 102 provenances of *E. urophylla)* were then established, in which phenotypic variation between individual trees was found to be very considerable (Delwaulle, 1983). Progenies from these trees included some inter-specific hybrids, (*E. tereticornis* x *E. saligna* and *E. alba* x *E. urophylla*). Plus-trees were then selected within plantations, felled and multiplied using cuttings from coppice shoots, so that clonal trials could be established. The selection programme in Congo had, by 1980, identified 174 superior genotypes of *E. alba* x *E. urophylla* and 256 of *E. tereticornis* x *E. saligna,* using tree height, form, yield ha-1, rooting ability and pulping quality as the criteria for selection.

In Niger, 101 species including 11 hybrids were tested, most without success, and the rest with variable results according to whether they were irrigated or not. There were 85 species in Burkina Faso. In Madagascar, in 1968, 173 species were introduced in 37 arboretums and country stations, and only 24 were finally retained as promising and 68 completely failed.

In Burkina Faso as well, *Eucalyptus camaldulensis* – for a certain number of provenances- turned out to be the most performing species, at the time in terms of hardiness (adaptation to poor soils and aridity) and in growth, the fastest and most homogenous among all the species of Eucalyptus tested (Mialhe & Piot, 1979).

The trials of provenances have been able to be multiplied thanks to seed harvesting done jointly by CTFT and CSIRO in the 1970s. Many programmes in selection and genetic improvement have developed from this time, and led to highly productive clone plantations as in Pointe-Noire in the Congo Republic.

In this country, the research initiated and led by CTFT and UAIC (Unité d'Afforestation Industrielle du Congo) have brought major results, from propagation methods (mainly by cuttings) to the transfer from Research to Development of the techniques designed and their adaptation to industrial scale – by 2003 the total area of clonal *Eucalyptus* was about 42,000 ha, consisting mainly in *E. urophylla* x *E. grandis* clones planted in monoclonal blocks of 20-50 ha at a density of 800 stems/ ha (Martin, 1971 and 1987; Delwaulle, 1980 ; Delwaulle *et al*, 1988; Leakey, 2004; Saya *et al*, 2008).

[5] CTFT, which was created in 1947, was integrated to CIRAD as its Forest Department by the beginning of the 1990's.

During the 70s, in the Sahelian zone, and more specifically in Upper Volta (Burkina Faso), trials on various propagation methods were developed by CTFT, with good results on the preparation and plantation of bare rooted stock (stumps) of *Eucalyptus camaldulensis,* for large scale planting – then, the most common pilot species of the afforestation programmes in the sub-region (Mhiale & Piot, 1979). Nevertheless, its real success was its adoption by the farmers and its extension through small scale plantations.

Private or communal woodlots of eucalyptus have grown rapidly under the impetus of governments, NGOs or individuals such as the Bamileke people and the Bamoun of Cameroon who started making small individual plantations in 1950. They have grown rapidly in farming because of the hardiness of the species, its growth rate, its ability to coppice, its resistance to fire and its multiple uses (firewood, poles, sawn wood, and pharmacopoeia). This success is partly due to legislation that allows farmers to operate freely - they planted eucalyptus as it does not require a permit to cut them down as it is the case for the local species. The high price paid for the poles of *Eucalyptus camaldulensis* has made this species very productive and the favorite tree of thousands farmers who grow it on a few acres, near their villages, for commercial purposes (Njoukam et al. 1996 Bonnerat *et al*., 2003, Njoukam et al., 2008). These micro-woodlots as well as the linear plantations made around the cultivated plots marked increasingly rural landscape in many African countries. This is particularly clear in Madagascar where spontaneous and successive farmer plantations were observed for nearly a century, around Antananarivo in the highlands; and such dynamics at such a level of development seem not to have occurred elsewhere in Africa (Bertrand, 1999).

4. The Eucalyptus, a genus to be dreaded or promoted?

The Eucalyptus dilemma, based on arguments against or in favour of the species, is not new; and the debate has often reached a high emotional level, beyond any scientific evidence from its detractors.

As fast growing tree species, eucalyptus are highly productive and champions of biomass, providing many benefits, notably to the small scale farmers or planters and having a considerable potential for generating income. Meanwhile, they may exert severe competitive effects on soil, water and associated plants, and the blame is usually placed on the eucalyptus because they consume a lot of water and nitrogen, have a negative impact on the local flora, exert allelopathic effects on neighboring species, including crops that are constrained in their growth and yield, and promote erosion. Finally, their leaves do not decompose easily, thus adding little humus to the soil.

According to Chin Ong (2006), fears that eucalyptus will deplete water supply, affect wildlife habitats and soil fertility in undesirable ways, and cause soil erosion seem to be valid in arid and semi-arid lands (ASALs). And one may add that effects of climate change along with an increased scarcity of water resources, locally, do not militate in favor of the eucalyptus. The same author indicates that fears that it will affect wet zone biodiversity adversely appear unfounded.

Beyond this climatic determinism based appreciation, the scale of the plantation (e.g. small vs. large/industrial) and the management of the species are certainly to be considered.

But finally, as for many dilemmas, there is no unique answer, and it is a matter of trade-offs and case by case answer. And in this respect, past experiences – including research results should serve the reflection and any decision to be made regarding an appropriate development and use of the eucalyptus.

Thus, large eucalyptus plantations have had the initial goal of pulp wood production for paper in humid zones and firewood and service wood in drier areas. Factories for paper pulp were never built and often large plantations in dry areas did not meet the expected productions.

Small scale plantations of eucalyptus are currently considered as more appropriate, both for satisfying local needs and integrating them in rural landscape, in good balance with other species, and notably not at the expenses of indigenous species – which may provide other and complementary product and services (fruit trees, fodder trees, N fixing trees, etc).

As the eucalyptus is at the very heart of the debate which opposes indigenous species against exotic ones, which are accused of contributing to the loss of biodiversity and degradation of habitats and natural resources, it is important to remind here that agricultural development along with demographic pressure are the major causes of such troubles, through overexploitation or poor management of forest, land, soil and water. That is typically the case of Kenya where forest cover has dropped to1.7 % of the country area, viz. about 1.40 millions ha (Njuma *et al*, 1999), whereas the commercial tree plantations (dominated by *Pinus spp*.) are accounting for about 10% of these forests – the eucalypts covering only 60,000ha, as per FAO figures, 2009.

And nevertheless, not all is as negative for the Eucalyptus; here are some examples:

In Ethiopia, by the end of the 19th Century -when the kingdom of Emperor Menelik was reduced to the Choa region - the capital was regularly displaced when all woody vegetation of the area was depleted, having been used to build houses and for fuel wood. In 1889, the new capital of Addis Ababa, was founded, and like the preceding capitals promised to disappear after one or two decades. Mondon-Vidalhet, an adviser to the Emperor, introduced the first *Eucalyptus globulus* towards 1894, so as to use eucalypts when the natural vegetation would begin to be over-exploited. This supply of wood was sufficient to avoid the movement of the capital which was definitely settled down. Eucalyptus plantations were encouraged by exempting re-afforested land from taxes. Planted very close together, these eucalyptus were able to reduce soil erosion, but they dried up certain sources (Berlan, 1951).

Nowadays in Ethiopia, the eucalyptus continue to be planted and used by many farmers in various ways: mainly grown in small woodlots for building materials and fuel wood - and charcoal making, locally- they are also found in shelterbelts, shady groves in and around the villages, churches and other dwellings; they also constitute a major source of honey and their leaves are traditionally used as a medicine to fight flu and fever (*E. globulus*) –just to mention few products and services of the eucalyptus to be considered as a major multipurpose tree in Ethiopia.

The same can be observed in other African countries, although the eucalyptus had a different story in its local development and way in its adoption by local populations.

Thus, in Madagascar, plantations of *Eucalyptus robusta* were set up along railway lines, to produce wood necessary for the locomotives. We are told that at the beginning, these plantations dried the rice fields, downstream, provoking dissatisfaction among the local populations. Today, the eucalyptus are still there and there is water in the rice fields. It seems that over time, a new balance was established. In the absence of fire, 10 years of experimentation confirmed zero erosion under the eucalyptus and higher rate of evapo-transpiration than that of a fallow, but run-off is significantly lower, leading to a strong reduction of water peak levels. (Bailly *et al*, 1974).
As they intercept the rains, and increase the biological life of soils which enables a better infiltration of rainwater, the eucalypts here contribute to the refill of the groundwater table, despite the high evapo-transpiration rate observed - and this appears valid in sufficiently humid regions, in contrast to drier regions or those where groundwater tables can dry up.

Regarding the allelopathic effects of the eucalyptus, they often appear marginal or not sufficient to prevent the development of undergrowth vegetation, even when plantations are set up on grassland savannas as in Congo. After a period where the cover of the Eucalyptus is dense, the former is progressively thinning as the trees grow up. They serve as perches for birds and shelter to mammals which bring the seeds of heliophilic and sciaphilic plants originating from the savanna and surrounding forests. They sometimes form a dense undergrowth in which more sciaphilic plants germinate and progressively recreate a forest environment with a plant biodiversity that is higher than that of the initial savanna. Similar examples can be found from South Africa to Ivory Coast.

The eucalyptus are also a source of revenue for the small farmers. In Madagascar, on the high plateaus, natural forests are rare, and in Antananarivo, 95% of coal comes from plantations of eucalyptus. These eucalyptus also provide a good part of the poles and perches used in construction.

In North-West Cameroun where indigenous trees are not enough to satisfy the local needs in wood, Bamileke people have developed extended plantations of eucalyptus (small woodlots) on large areas –replacing locally coffee plantations which appeared to be less profitable. The eucalyptus provides fuel wood for the kitchen, building materials, timber and act as windbreaks or shelterbelts around houses. Eucalyptus producers have grouped together to form cooperatives from which the National Electricity Company buys poles at a price.

In 2007, in East Africa, according to FAO, forests covered 19% of the land, which represented only 0.4ha per inhabitant. Between 2000 and 2005, these forests have decreased by 1% per annum in surface area. Therefore, plantations of fast growing tree species have become indispensable to substitute production of wood energy and service to those of natural forests, which are then subjected to lower pressure and may then be protected.

Conclusion

The Eucalyptus does therefore come across not as all good or all bad. It is to be used discerningly, so as to draw as much profit from it while doing the maximum to avoid the undesirable effects – it goes without saying that maintaining a natural forest or rehabilitating it with indigenous species when degraded is preferable to its felling down and replacement by exotic species such as the eucalyptus.

With few exceptions, like the replacement of large herbaceous savannas by tree plantations, the use of Eucalyptus for industrial purposes is out of the agenda of the investors, donors and development agencies. But the species is still essential for the small farmers and the rural poor, at least locally when woody resources have become rare and expensive. By its multiple products and services it provides and the incomes it generates, the potential of the eucalyptus in satisfying the basic needs of the local population and contributing in the improvement of their livelihood remains very high – and this should be reconsidered in a rationalized way beyond the emotional views and the total reject the species is currently the object

In this perspective and as suggested by Chin Ong (2006), there is a need for adequate information on the species and its management, from researchers and extension workers:

- better knowledge about the potential of the Eucalyptus (and express it) in generating income for the benefit of the small holders;
- establish clear scientific recommendations on how to manage Eucalyptus water consumption and possible effects on soil in various site specific conditions (appropriate clones could be tested for dedicated fragile environment, including drylands and riparian areas);
- guideline and map on where best to plant Eucalyptus - without excluding alternative tree species (see the development of *Grevillea robusta* in the Central Province of Kenya*)*, Kenya (and Eastern Africa) needs to assess critically the trade-off between the income eucalyptus generates and the water it consumes.

Learning from other's experience is also very important: rational use of eucalyptus in Eastern Africa should hinge on the South African experience[6], without ignoring important West and Central African experience.

[6] Although the eucalyptus in South Africa are nowadays considered as inappropriate species, sucking to much water from the ground, (notably in dominating dry areas) and often invasive, many works were carried out on the species in the framework of commercial plantations,intensified from 1930 onwards to meet the demand for wood destined for underground mining.

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