

Conservation Agriculture With Trees, a form of Agroforestry - an institutional perspective

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Historically agriculture in many parts of the world was compatible with the retention of valuable trees in cropped fields. It used only superficial soil tillage, usually in combination with a controlled fire that cleared the land but did not kill the larger trees¹. In temperate zones with relatively mild climates, however, a different approach to growing crops emerged, “non-conservation agriculture without trees”, which had success as it was readily scaled up with horse-drawn ploughs replacing human tillage, and tractors with ever-more horse power drawing ever-deeper ploughs through a soil that responded by mineralizing a substantial part of its organic matter, feeding the crops. This yield benefit, however, was not sustainable as it depleted the resource base – chemical fertilizer had to become the basis of plant nutrition. As tillage had killed many of the worms and other minute soil engineers, tillage became “necessary” to create a structure compatible with crop roots. The trouble started when this tree-less tillage-addicted form of agriculture became the norm, became known and taught worldwide as what agriculture is and should be, and was extended to parts of the world with less benign climates.

The term agro-forestry was coined in the mid 1970's when the “green revolution” experience and debate had made clear that its perspective on intensifying crop production worked well in some (particularly irrigated) environments, but not elsewhere. A parallel approach to large-scale forestry had success in some limited areas, but it ran into major social conflicts and issues over land rights elsewhere.

The idea that crops and trees are not necessarily incompatible was revolutionary for academically trained agronomists, while trained foresters had a hard time in seeing local people as partners, not as their major problem. In many parts of the tropics, these perspectives appeared to be self-evident, if only one opens one's eyes. Trees and crops, farmers and forest could typically work together.

¹An anecdote worth retelling is about a young British agronomist in charge of an integrated multi-donor Project Development Unit around 1980 in Southern Sudan, who asked and got permission from a Chief to carry out field experiments to compare new crop varieties with those locally used. When his team proceeded to clear the land of all trees a major conflict arose, and he was lectured by the Chief: permission to grow crops does not imply permission to remove trees... The agronomist later served on the Board of Trustees of the World Agroforestry Centre and recalled this as his initiation rite.

Yet, the advances in understanding the biophysical, ecological, social and economic aspects of tree-soil-crop interactions were slow to get mainstreamed in the world of “development” and “modernization”. New forms of agroforestry, compatible with mechanization and focussed on trees of high value finally emerged in Europe, North America and Australia – challenging² the rules and regulations that had been made on the concept of segregating trees and crops. “Conservation agriculture with trees” (CAWT) is a terminology that seeks to augment the conservation agriculture body of praxis and science, by (re)introducing trees. Yet, conservation agriculture is not without challenges. Replacing soil tillage by herbicide use as primary weed control strategy has its drawbacks – not the least of which is that tree roots if not regularly disturbed, can become too competitive for the crops. Cropped fields with trees can benefit from tree pruning and root pruning, a form of deep tillage adjacent to the trees.

Conservation Agriculture with Trees is Now Making Headway on the Ground

A key question in most CA systems is how to increase biomass production to enhance surface cover and generate more organic nutrients to bolster the long term sustainability of the systems. Recently, both the CA and agroforestry communities have mutually recognized the value of integrating fertilizer trees into CA to dramatically enhance both fodder production and soil fertility. Practical systems for intercropping fertilizer trees in maize farming have been developed and are being extended to hundreds of thousands of farmers in Southern and Western Africa. One particularly promising system is the integration of the leguminous tree *Faidherbia albida* into crop fields. This indigenous African acacia is widespread on millions of farmer’s fields throughout eastern, western, and southern Africa. It is highly compatible with food crops because it is dormant during the rainy season, while enhancing yields, improving soil health, and providing additional livestock fodder.

CAWT systems have demonstrated the ability to adapt crop productivity to climate variability and climate change, and provide greater yield buffering under increasing temperatures and more frequent and severe droughts. They should be attracting much more research and extension attention than has been the case so far. Depending upon which woody species are used, and how they are managed, their incorporation into crop fields and agricultural landscapes may contribute to:

- maintaining vegetative soil cover year-round
- bolstering nutrient supply through nitrogen fixation and nutrient cycling
- enhanced suppression of insect pests and weeds
- improved soil structure and water infiltration
- greater direct production of food, fuel, fiber and income from products produced by the intercropped trees
- enhanced carbon storage both above-ground and below-ground
- greater quantities of organic matter in soil surface residues
- more effective conservation of above- and below-ground biodiversity

² Experiments with agroforestry in France in the 1990’s were deemed illegal, and major efforts were needed to change policies so that trees could be grown in cropped fields

About half of all agricultural land in the world now has greater than 10% tree cover (Zomer et al 2009). In some regions tree cover on farm lands averages over 30%. In many countries the agroforestry area is steadily increasing.

Since the early 1990s, the World Agroforestry Centre and its partners in eastern and southern Africa have been developing a range of agroforestry systems that would improve soil quality and significantly boost crop yields, providing high returns on both land and labour.

The most popular system in southern Malawi, where land holdings are very small (<0.5 ha), is intercropping maize with nitrogen-fixing tree species of *Gliricidia sepium*, *Sesbania sesban*, *Tephrosia* species and pigeon peas. *Sesbania sesban*, *Tephrosia* (*T. vogelii* and *T. candida*) and pigeon peas are often relay-intercropped with maize. In these systems, farmers plant the trees in rows between their crops. *Gliricidia* is pruned back two or three times a year, and the leaves and the biomass are incorporated into the soil. Long-term experiments spanning more than a decade, involving the continuous cultivation of maize with *Gliricidia* in Malawi, have yielded more than 5 t/ha in good years, and an average of 3.7 t/ha overall, in the absence of mineral fertilizers. That compared with an average of 0.5–1.0 t/ha in control plots without *Gliricidia* or mineral fertilizer.

As the Zambian Conservation Farming Unit (CFU) worked to develop solutions to make conservation farming feasible for smallholders, they encountered the problem that more than two-thirds of their smallholder clientele couldn't afford inorganic fertilizers, and have little or no access to manure or other nutrient sources. This fundamentally limited smallholder maize yields, and further depleted their soil fertility each year. To address the problem the Zambian CFU investigated the incorporation of *Faidherbia albida* trees into maize production systems. Their studies found that maize yields were typically 2.5 times higher in association with the trees. The effects tend to be most remarkable in conditions of low soil fertility.

The Zambian CFU now recommends that *Faidherbia* seedlings be planted in a grid pattern at 100 trees per ha. Fields with *Faidherbia*-maize CA systems managed with such a planting pattern (10 m x 10 m) accommodate mechanization. The result is a maize farming system under an agroforest of *Faidherbia* trees. The trees may live for 70-100 years, providing inter-generational benefits for a farm family, with a very modest initial investment. As the trees mature, and develop a spreading canopy, they are gradually thinned down to about 25-30 trees per hectare. Currently, the departments of agriculture in Zambia and in Malawi are encouraging farmers to establish *Faidherbia* trees in their maize fields, the aim being to increase food production sustainably. The efforts are backed by national policy and supported by the Zambia National Farmers Union.

The majority of farmers in Niger do not use the plow or the hoe for land preparation on their typically sandy soils. Rather, they use a hand tool used for loosening the soil and undercutting weeds that is passed just underneath the soil surface without inverting the soil.

They have also integrated agroforestry into a minimum tillage conservation farming system. The trees improve their crop yields, and the foliage and pods provide much-needed fodder for their cattle and goats during the long Sahelian dry season. Tree densities and tree cover in Niger have increased over time.

There are now about 4.8 million hectares of *Faidherbia*-dominated farm lands. These croplands also harbor tree populations of a wide range of other indigenous trees with up to 160 trees per hectare. Many villages now have 10–20 times more trees than 20 years ago.

Current issues in agroforestry research

International agricultural research under the umbrella of the CGIAR has four major goals (system level outcomes). It seeks to increase 1) rural income, 2) food security, 3) access to healthy food, while 4) achieving sustainable use of natural resources.

In that context, international agroforestry research has taken on three main challenges: 1) the need for more productive land use linked in with local, national and global value chains that improve rural income, 2) the need to maintain and restore land health as a basis of productive landscapes that provide the environmental services society expects (but so far poorly rewards) in addition to food production, and 3) the need to link knowledge and action in more effective ways, breaking out of “boxed-in” paradigms of how the world should be, and allowing greater influence for local voices, traditional ecological wisdom and knowledge, and integrated perspectives on sustainable development.

A research agenda for Conservation Agriculture With Trees

In supporting this form of agroforestry for dryland conditions, a multistep research agenda is emerging, which includes work on:

- Understanding the diversity of farm strategies, gender and equity: roles of livestock, farmer assisted natural regeneration, land access
- Tree - soil - crop interactions on farm, linked to input-output accounting
- Soil biota, infiltration and land health: time course of recovery
- Market integration of tree products: options in relation to transport costs
- Tree diversity, domestication and delivery: utilizing diversity for risk reduction, being prepared for climate shifts, meeting multiple needs and expectations; tree seed and seedling systems in delivery of “right trees for right places and good reasons”
- Buffering by trees of climatic and other variability
- Agroforestry policy initiative: reform of land access rights

There are many critical research issues to be explored with CAWT. These include the choice of appropriate tree species for varied agroecologies, higher quality tree germplasm, better tree seed dissemination systems, and further improvements in tree propagation and establishment methods.

The optimum tree densities for different CAWT systems have yet to be fully understood, and the best practices in exploiting the soil fertility synergies between organic and inorganic nutrient sources need to be elucidated. Integrated CAWT systems pose a pioneering research agenda with enormous implications for Climate Smart agriculture.

The World Agroforestry Centre is working on this agenda with a number of key partners from national research, universities and NGO's in a number of projects across the developing world. It is part of broader ecological intensification efforts with CGIAR partners.