Agroforestry can improve food security, farm diversification and income generation in Zambia

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OVERVIEW

Fifteen years of research and development work by the World Agroforestry Centre (ICRAF) and its partners in Zambia have refined agroforestry technologies that can have a huge impact on food security and income generation at low cost and while protecting the environment. Current policies are failing to take advantage of these new technologies. Minor policy changes could bring about much greater adoption of these proven technologies with major benefits to farmers and the Zambian economy. Some of the key issues raised in this paper are:

- Using fertilizer trees to complement mineral fertilizers could save national expenditures on nitrogen mineral fertilizers by 25% to 50% annually. Farmers could use cheap combinations of K and P fertilizers to supplement N that is adequately supplied by fertilizer trees rather than expensive compound fertilizers.
- Only 20% of smallholder farmers use fertilizer in Zambia - it is too expensive or unavailable for most farmers.
- One hectare of fertilizer trees can fix up to 150 kg N/ha to crops, i.e. an equivalence of between ten and fourteen bags (25-kg size) of formulated inorganic (urea) fertilizer.
- At current average size (0.2 ha) of land grown to fertilizer trees, the technology can provide between 57 and 114 extra person days of maize consumption, i.e. cuts seasonal hunger period by between two to four months per household.
- Fertilizer trees return more than three times their investment cost – better than the returns per unit of investment on mineral fertilizers.
- Fertilizer trees improve soil quality and water holding capacity, ensuring better yields in drought years.
- Using leafy material from fertilizer trees to boost vegetable production can more than double farm returns to between $700-1000 per hectare in the dimbas and wetlands.
- Fertilizer trees can provide up to 10 tons of wood biomass per hectare, greatly reducing the burden of carrying firewood over long distance and the time spent searching for wood energy (especially by women).
- Fertilizer trees provide “live barns” and alternative source of stakes for curing tobacco and, contributing to reduce deforestation of the miombo which is currently being deforested at between 200,000 and 300,000 hectares annually in Zambia.
- With the right supportive policies these agroforestry innovations that were first developed in Eastern Zambia could be easily scaled up to benefit millions of farmers across the country.
AGROFORESTRY: OPPORTUNITIES FOR AND RELEVANCE TO THE ZAMBIAN AGRICULTURAL POLICY

Over a period of 15 years of research and development activities, the World Agroforestry Centre (ICRAF) and national partner institutions have developed and evaluated different agroforestry technologies that are now ready for wider adoption. Through its promotion of “an efficient, competitive and sustainable agricultural sector, which assures food security and increased income”, agroforestry provides a means for attaining the vision set for the Zambian agricultural sector as promulgated in the Zambia government’s National Agricultural Policy (2004-2015). In addition, agroforestry is consistent with three of the four specific thrusts of NEPAD for improving Africa’s agriculture as outlined in NEPAD’s Comprehensive Africa Agriculture Development Program (CAADP) programme. These technologies include the following:

A. “Fertilizer tree” system for soil fertility replenishment

Nitrogen is the main nutrient that plants need which is short supply in the soil. But it is abundant in the atmosphere, and “fertilizer trees” can capture it from the atmosphere and make it available to crops.

The system involves planting fast growing nitrogen-fixing, trees which can break down easily to provide nitrogen for the subsequent crop, increase soil organic matter and improve soil physical conditions.

Low doses of mineral fertilizers can have a major enhancing effect on the fertilizer tree system. Crop responses to mineral fertilizers are better where fertilizer trees are also present. Fertilizer tree species are well suited to the different environments of Zambia as the accompanying map shows.

The system contributes to food and environmental security as follows:

Fertilizer trees provide better food security

- Maize yields are up to twice as high as in crops grown continuously without any fertilizer.
- When fertilizer trees are added into the average maize field size of 0.20 ha. extra maize produced can feed a person for an additional two to four months.
Fertilizer trees save on buying nitrogen fertilizer

• One hectare of fertilizer trees can fix up to 150 kg N/ha to crops, equivalent bags (25-kg size) of formulated inorganic (urea) fertilizer.

• The system helps to save up to $2 million that would have otherwise been spent on mineral fertilizers to maintain soil fertility. This can be increased substantially depending on the level of adopters and land area under the fertilizer tree system.

Fertilizer trees produce a high return on investment

Fertilizer trees are financially profitable with the following attractive financial indicators:

• High returns per unit investment cost. Farmers obtain net profit ranging between 2.77 and 3.13 Kwacha for every Kwacha invested in fertilizer trees compared with 2.65 for mineral fertilizer and 2.01 for maize without additional nutrient supplement.

Table 1: Profitability of maize production (per ha) using fertilizer trees and mineral fertilizer over a five-year cycle in Zambia

<table>
<thead>
<tr>
<th>Production sub-system</th>
<th>Description of land use system</th>
<th>Net profit</th>
<th>Benefit Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous, NO Fertilizer</td>
<td>Continuous maize for 5 years</td>
<td>584,755 (Zambian Kwacha) 130 (US $)</td>
<td>2.01</td>
</tr>
<tr>
<td>Continuous + Fertilizer (subsided at 50%)</td>
<td>Continuous maize for 5 years</td>
<td>2,243,341</td>
<td>499</td>
</tr>
<tr>
<td>Continuous + Fertilizer (at non-subsidized market price)</td>
<td>Continuous maize for 5 years</td>
<td>1,570,500</td>
<td>349</td>
</tr>
<tr>
<td>Gliricidia sepium</td>
<td>2 years of Gliricidia fallow followed by 3 years of crop</td>
<td>1,211,416</td>
<td>269</td>
</tr>
<tr>
<td>Sesbania sesban</td>
<td>2 years of Sesbania fallow followed by 3 years of crop</td>
<td>1,390,535</td>
<td>309</td>
</tr>
<tr>
<td>Tephrosia vogelii</td>
<td>2 years of Tephrosia fallow followed by 3 years of crop</td>
<td>1,048,901</td>
<td>233</td>
</tr>
</tbody>
</table>

• The fertilizer tree system gives a good return to labor use. For every kwacha spent on labour to apply mineral fertilizer on trial plots the return in maize yield was worth 3.2 Kwacha, while it ranged between 2.5 and 1.9 Kwacha for the three fertilizer tree plots. By comparison, the returns to labour for the unfertilized maize system was only 1.1 Kwacha.

Over a five-year period, one hectare of maize field cultivated continuously using mineral fertilizer yields a net benefit of 1.57 million Zambia Kwacha (or 2.24 million Kwacha using subsidized mineral fertilizer) even allowing for inflation and the time value of money that may occur during the different years within the five-year period. This compares with a net benefit of 1.2 million Kwacha for Gliricidia sepium, 1.39 million Kwacha for Sesbania sesban, 1.04 million Kwacha for Tephrosia fallow and about half a million Kwacha for continuous cropping without fertilizer. The high benefit from mineral fertilizer system was however...
Agroforestry can improve food security, farm diversification and income generation in Zambia achieved through a high investment cost. The comparison of the ratio of benefit to cost (BCR) shows that for every Kwacha invested into maize production, the farmer gains an extra 1.01 Kwacha if no nutrient supplement is used, an extra 1.77 Kwacha for mineral fertilizer system, an extra 1.91 Kwacha in Gliricidia sepium plots, extra 2.13 Kwacha for Sesbania sesban field and 1.74 Kwacha in Tephrosia fallow fields.

Fertilizer trees have a positive environmental impact

The beauty of fertilizer trees is not just the increase in food production alone, but also in the conservation of the natural resource base and the protection of the environment.

- Fertilizer trees can provide up to 10 tons of wood biomass per hectare, greatly reducing the burden of carrying firewood over long distance and the time spent searching for wood energy (especially by women).
- Fertilizer trees provide “live barns” and an alternative source of stakes for curing tobacco. Thus, the system has great potential to contribute to reduced deforestation of the miombo which is currently being lost at between 200,000 and 300,000 hectares annually in Zambia.
- Fertilizer trees can sequester up to 2.5 to 3.6 tons of Carbon per hectare per year and hence contribute to mitigating the effects of climate change.
- Improved soil aggregation, enhanced water infiltration and water holding capacity which contribute to minimizing the risk of productivity loss during drought years
- The system has positive impact on biodiversity and enhanced ecosystem services rendered by soil invertebrates.
- Fertilizers trees suppress weeds and reduce soil compaction, thus reducing the burden of weeding. This aspect of fertilizer trees provides a big incentive for women who are traditionally responsible for weeding the family’s fields.

B. Biomass transfer for improved nutrition & production diversification

Farmers have been growing vegetables widely during the dry season in wetlands known locally as dambos in Zambia but declining soil fertility has posed a major challenge to many of them. Biomass transfer involves using the nutrient-rich leaves of agroforestry species (usually planted in the upland) as fertilizer for the production of high value vegetable crops and an extra maize crop in the dambos during the dry season. This offers many farmers the opportunity to supplement their incomes by growing cash crops that command high prices in urban markets. It also helps them to integrate agricultural production in upland and lowland areas. With an estimated 3,505,000 ha of dambos in Zambia, biomass transfer offers opportunity for enhanced food production and income diversification for farmers in this landform.

- Helps smallholder farmers to produce diverse & high value crops (ginger, garlic, cabbage and onion)
- Improves farm income and household nutrition.
- Production takes place during off season when farm

<table>
<thead>
<tr>
<th>Type of production method</th>
<th>Cabbage yield per ha</th>
<th>Net profit per ha</th>
<th>Net profit per average dambo plot (0.13 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no fertilizer, no biomass)</td>
<td>17 tons</td>
<td>2,714</td>
<td>366</td>
</tr>
<tr>
<td>Full mineral fertilizer application</td>
<td>58 tons</td>
<td>10,378</td>
<td>1,354</td>
</tr>
<tr>
<td>Fertilizer + manure</td>
<td>67 tons</td>
<td>12,365</td>
<td>1,614</td>
</tr>
<tr>
<td>Leucaena biomass</td>
<td>33 tons</td>
<td>5,469</td>
<td>714</td>
</tr>
<tr>
<td>Gliricidia biomass</td>
<td>43 tons</td>
<td>7,728</td>
<td>1,009</td>
</tr>
</tbody>
</table>

Table 2: Yield and net profit (US $) of cabbage production in the dambos
produce attracts higher prices.

• Highly profitable farm enterprise with net profit ranging between $700 and $1000 per ha compared with $366 for control plots (Table 2)

• Possibility of increasing production to 2-3 crops per season

• Potential integration with fish farming

C. Indigenous fruit trees: food and income from the wild

Indigenous fruit trees including Masuku, Maholoholo, and Masao provide food from the wild during periods of hunger because their fruits mature at the time when maize shortage is most critical. Several indigenous fruit tree species have been successfully domesticated and cloned; propagation techniques have been developed and, processing of marketable products have been developed through collaborative activities between ICRAF, partner institutions, the private sector and farmer groups. As a result:

• Indigenous fruits have changed from being a “snack” food to a main food source which helps reduce vulnerability during years of famine;
• Indigenous fruits provide opportunities for empowering rural women in processing and enterprise development through income generation activities

• Preservation and selection of Indigenous fruit trees avoids “eating up” the opportunities of future generations” in regions where they are being lost to deforestation.

D: Jathropha: the green fuel for income generation and cleaner environment

Jatropha is a “green” fuel that provides farmers with the opportunity to generate and diversify their income base and contribute to a cleaner environment. Some features of Jatropha are listed below:

• It is planted in hedges for crop protection, prevention of soil erosion and desertification
• Its seed contains 30 – 38 % oil
• Multi-purpose uses: The oil has a very high saponification value and is being used extensively for making soap. It can also be used as an illuminant; as an alternative to diesel; its bark provides raw material for dye; its oil cake is rich in nitrogen, phosphorous and potassium and can be used as organic manure; its leaves can be used as animal feed, and its latex contains an alkaloid known as jatrophone which has anti-cancerous properties.
• Potential turnover of $200/ha for a smallholder planter

Despite their excellent performance, the widespread adoption of agroforestry technologies by smallholder farmers is has been constrained by local customs, institutions and policies at the national level. This is because technological innovation is important for widespread adoption, but not in isolation. Some of the constraints are highlighted below:

Local and national policies

The widespread uptake of some agroforestry technologies have been constrained by local customary practices and institutions especially incidence of bush fires and browsing by livestock during the dry season, and absence of perennial private right over land. The animals destroy the trees after planting either by browsing the leaves and removing the biomass or by physically trampling over the plants. A community’s institutional regulations for fruit collection, land and tree tenure all affect individual farmer’s decision to invest in establishing an indigenous fruit tree field. The failure of existing local institutions to address the interests of the
different groups of farmers within the community creates a dilemma. World Agroforestry Centre (ICRAF) staff have been working in collaboration with traditional rulers, government officials, community-based organizations, NGOs, and national researchers partners to resolve these institutional bottlenecks. Some traditional authorities in Zambia enacted bylaws to prohibit these incursions but more need to be done on other parts of the country.

Training
Agroforestry generally relies on incipient technologies and it is a relatively new phenomenon compared with conventional land use practices which farmers have known, and have received training on for a much longer period. Unlike annual crop production technologies and conventional soil fertility management options, fertilizer trees require skills in terms of management of the trees. Capacity for doing this needs to be built at the national level. The costs of providing information greatly decrease over time, but investment is critical when helping farmers get started with the practice.

Seeds:
One of the greatest constraints to some agroforestry technologies is farmers’ lack of access to quality seeds. Unlike the seeds of annual crops which are promoted by established institutions and are multiplied and distributed by private sector organizations, there is little or no institutional structure to make the seeds of agroforestry available “off the shelf”. Such structures and institutions need be developed and this process can be “kick-started” through a public sector investment (for a limited period) while allowing time for the private sector to spot the commercial opportunity of such ventures and eventually taking it over.

Awareness:
Over several years, there have been structural shifts towards “quick fixes” and technologies that render immediate benefits. The opportunity of agroforestry technologies to provide some medium and long term benefits to individuals and the public simultaneously is not as yet well communicated to many stakeholders.

Human resource capacity
The human capacity, infrastructures and institutional supports for agroforestry are not as well developed as for annual crop technologies. Such missing supports include well developed input and output markets to enhance the access of small-holder farmers to ensure that they get the price premium for their crop produce. In many cases, the widespread adoption of agroforestry requires appropriate policies at the national and local level.

WHERE DO WE GO FROM HERE?
The opportunities offered by agroforestry technologies have been shared with, and well received by several institutions and stakeholders in the Zambian food security and agriculture sector. Among others, these include the Select Committee on Agriculture and Land of the National Parliament, Paramount and Senior Chiefs in eastern Zambia, Agricultural Consultative Forum (ACF), and the KEPA NGO policy Roundtable. Key NGOs including the World Vision, PLAN international, HEIFER international, Womens’ Development Associations (WDAs) do appreciate agroforestry and have collaborated in the generation and implementation of the technologies highlighted above. Development partners including Canadian International Development Agency (CIDA), BMZ, Rockefeller Foundation, USAID, EU and DFID provide support for the programmes that have generated the technologies that are now available for improving agriculture, environment and food security. However for historical reasons, the development and impact of agroforestry is most emphasized in eastern Zambia where the generation of the technologies were first initiated. But the time has come to rethink policies and institutional support to facilitate the effective scaling up of agroforestry technologies to other parts of Zambia where they can also benefit farmers and create more impacts in these locations.
Agroforestry can improve food security, farm diversification and income generation in Zambia. The feasibility and potentials of agroforestry to contribute to improved food security, farm diversification and income generation in Zambia have been well demonstrated in this paper. Non-action on these potentials will constitute a great loss of opportunity to widen the range of options that could be available to achieve national policies and vision in the food security and natural resource sub-sectors. Among others, the cost of non-action mean a continued reliance on subsidized fertilizers (with its concomitant implications on national budget) to maintain soil fertility, a continued degradation of the nation’s woodlands, a compromise of the nation’s ability to simultaneously meet the challenges to achieve food security and simultaneously preserve the natural resources and environment for the future.

**We list below some policy action points**

**Suggested action points:**

- Subsidize mineral fertilizers under the Fertilizer Support Program (FSP) and integrate fertilizer tree seeds and improved crop varieties as integral parts of the inputs package under the Programme to ensure sustainable soil fertility replenishment
- Provide support for the development of a national agroforestry strategy and the targeting of priority scaling up areas in Zambia.
- Build on the synergy between fertilizer trees and mineral fertilizer to save national expenditures on nitrogen mineral fertilizers by 25% to 50% annually. Rather than buying compound NPK fertilizer, farmers may opt for a simpler and cheaper formulation consisting of P and K to supplement N that is adequately supplied by fertilizer trees.
- Institutionalize agroforestry as part of the mainstream official programme of activities in the Ministries of Agriculture and Natural Resources
- Given the knowledge and management intensive nature of some agroforestry technologies, active training of government agricultural extension staff on agroforestry technologies to enhance their competence to provide information and scale up the technologies to farm communities
- Institutionalize and support regular “science-policy forums” where updates on agroforestry research results and opportunities are presented to policy makers and stakeholders in Zambia. The forum would help to emphasize the need to examine food security through a sustainable development lens.
- Assess how existing national policy and institutional setups either facilitate or constrain the adoption of agroforestry.

**SUMMARY:**

The feasibility and potentials of agroforestry to technologies to contribute to improved food security, farm diversification and income generation in Zambia have been well demonstrated in this paper. Non-action on these potentials will constitute a great loss of opportunity to widen the range of options that could be available to achieve national policies and vision in the food security and natural resource sub-sectors. Among others, the cost of non-action mean a continued reliance on subsidized fertilizers (with its concomitant implications on national budget) to maintain soil fertility, a continued degradation of the nation’s woodlands, a compromise of the nation’s ability to simultaneously meet the challenges to achieve food security and simultaneously preserve the natural resources and environment for the future.

“Institutionalize and support regular science-policy forums”
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For further reading, see:


