Promises and Problems of Agroforestry

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As this article goes to press, thirteen million people in Southern Africa are on the verge of starvation. The United Nations Food and Agriculture Organization reports that drought, civil strife, flooding, and population displacement are to blame for this crisis (FAO 2002). Must the citizens of developing African countries, and developing regions around the world, continue to face starvation during years of drought or flood? How can food production be made more efficient and more reliable?

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The world's forests are disappearing at an unprecedented rate, at a time when we need them more than ever to stabilize our climate, clean our air, protect our soil and preserve biodiversity. Every year, millions of hectares of forests are cleared to make room for crops and to provide fuelwood for cooking. Tropical forests are in especially bad shape, with a rate of loss greater than 1% per year (Palo 1999). Is this loss an inevitable consequence of our expanding population, now over six billion and growing? How can trees and humans coexist with mutual benefit?

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Agroforestry has the potential to help solve both of these problems, and many more. Agroforestry, defined as land-use systems in which trees are grown in association with agricultural crops, pastures or livestock, has been used by humankind for thousands of years (Young 1997). For example, in Roman times, Mediterranean farmers used to grow grape vines and olive trees in alternating rows (Williams 1997). Central American farmers have for centuries grown "home gardens" around their houses with a complex mixture of

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fruit trees and annual crops. But despite its long history and widespread occurrence, the scientific study of agroforestry only began in the 1970's (Nair 1996). Interest in agroforestry is fast increasing, and it is now on its way to becoming a well-developed scientific discipline.

But what are the benefits of growing trees and crops together? After all, hasn't modern agriculture has achieved great success with high-productivity, high-efficiency monocultures? Unfortunately, despite their benefits, monocultures are prone to catastrophic failure in bad years and vulnerable to pest and disease outbreak, as well as requiring inputs of chemical fertilizer and pesticide in order to maintain their productivity. Subsistence farmers often cannot afford these inputs, nor can they afford the consequences of crop failure (Kidd 1992). Agroforestry systems, by mimicking the complexity of natural ecosystems (Figure 1), can provide farmers with reliable, sustainable food production while protecting the environment.

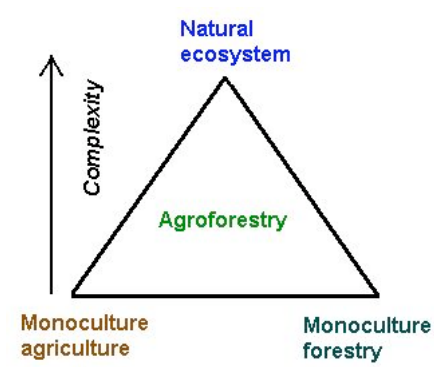

Figure 1. The "agroecological triangle" (adapted from Wojtkowski, 1998).

Agroforestry: A closer look

It's difficult to discuss the benefits of agroforestry without taking a closer look at the bewildering variety of agroforestry systems. In general, there are three different types of agroforestry (Nair 1989):

- Trees with crops ("agrosilvicultural")
- Trees with livestock ("silvopastoral")
- Trees with both crops and livestock ("agrosilvopastoral")

The trees and the other components can be separated in space or in time, but they must *interact* for the system to be truly considered an agroforestry system (Gordon 1997). Ideally, the interaction provides both ecological and economic benefits.

One common type of agroforestry system is the "alley-cropping" or "hedgerow intercropping" technique, in which rows of trees are alternated with rows of crops (Figure 2). Farmers in Africa often modify this method by planting individual trees or small clusters of trees among their crops (Kerkhof 1990). In mountainous regions, the tree rows can be planted along contour lines to prevent erosion.

In alley-cropping systems, the trees stabilize the soil and provide nutrient-rich mulch for the crops. The deep roots of trees allow them to reach to water and nutrients that crops cannot reach, and bring these to the surface. Trees may also increase soil moisture by shading the ground, provide protection from wind, and act as natural insect repellents . One of the most successful examples of alley-cropping is the combination of *Leucaena leucoceophala*, a nitrogen-fixing tree, with maize. A trial in Central America resulted in an 80% increase in maize yields, reduced soil erosion by thirty times, and also provided abundant and much-needed fuelwood (Kidd 1992).

Figure 2. Alley-cropping. An annual crop (here, maize) is grown between rows of leguminous trees.

Source: www.cgiar.org

However, alley-cropping doesn't always work as planned. One ecologist referred to it as "playing with fire" because it involves such strong positive and negative interactions (Sanchez 1995). Many alley-cropping projects have resulted in no productivity gains, or even lower productivity than if individual species were grown alone. When *Leucaena*, the tree that worked miracles in Central America, was planted in Ethiopia, it completely failed to grow (Kerkhof 1990). The same tree-crop interactions that can make agroforestry systems so productive can also make them unpredictable in new locations.

A basic principle of any agroforestry system is that *competition* between the plants must be minimized, and *complementarity* must be maximized (Sanchez 1995). This depends on the root systems of the trees and the crops. If both the trees and the crops have shallow roots, they can end up competing fiercely for water and nutrients, and productivity will suffer as a result. But if the trees have deep roots, and the crops have shallow roots, they can actually benefit from each others' presence (Wojtkowski 1998).

Another way of minimizing competition is to pay careful attention to the phenology (timing) of the plants, so that they are not all demanding resources at the same time. Of course, it's possible to plant trees on a field one year, and crops the next year – but then many of the benefits of interaction are lost. An example of a pair of plants with compatible timing is black walnut trees and sorghum in the United States (Williams 1997). Black walnut trees don't leaf out until late in the spring, when sorghum is nearly fully grown – so sorghum can take advantage of the spring sunlight. Then, during the hot dry summer, the walnut trees shade the ground and increase soil moisture for the sorghum. It's a partnership that's as remarkable as it is profitable.

Many agroforestry systems include livestock as well as – or instead of – crops (Figure 3). For example, many African farmers cultivate *Faidherbia albida* (acacia) trees on their land in order to feed their cattle with the protein-rich pods. (*F. albida* is another species with good timing – it loses its leaves during the millet growing season (Sanchez 1995), so it is often grown in combination with cattle *and* millet.) Also, rubber plantations in Malaysia may include sheep grazing in the understory. This not only provides additional outputs – mutton and wool – but it also helps the rubber trees grow, because the sheep eat the weeds and turn them into manure for the trees (Ismail 1989). Farmers' costs are thereby reduced, and their profits increased.

Figure 3. A silvopastoral system in Ireland, in which sheep graze among young trees (note protective sleeves around tree trunks).

Source: www.afsni.ac.uk

Pest control is one area where the benefits of agroforestry are not so clear. In general, intercrops are thought to have fewer problems with disease and pest outbreaks than monocrops, because they can disrupt insect movement, provide habitat for natural predators, and create a better microclimate for the plants (Wojtkowski 1998). However, the reverse can also occur: trees can provide habitat for pest species as well as beneficial species (Williams 1997).
In parts of Africa where tsetse fly outbreaks are a problem, the combination of trees, crops and livestock has proven to be a dangerous one (Okafor 1989). Each system is different – no assumptions can be made about the pest-control properties of agroforestry.

Despite the variability in results, agroforestry systems show great promise for increasing yields, providing greater ecological stability and sustainability than monocrops, diversifying outputs and increasing profits for small farmers. As we continue to develop our understanding of the scientific principles of agroforestry, no doubt its applications will enjoy greater success. However, a technical understanding isn't enough. Perhaps more than any other science, agroforestry can't be effectively applied until its social and cultural implications are understood.

Agroforestry, a social science

A group of agroforestry extension agents in Kenya was very puzzled. The tree seedlings they were handing out to villagers simply weren't popular – no one would take them. Were the villagers not interested in conservation? Did they not know how to plant trees? Finally they learned the reason for the villagers' reluctance: according to local legend, that particular tree species was known to promote disharmony among neighbors and attract snakes! Whatever the origin of the belief, there was no point trying to argue with it – the extension agents were forced to give up and try a different species of seedling (Hoagland 2002).

> **" We should always remember that people are the key elements in agroforestry."**
>
> *- Thomas Huxley, agroforestry scientist*

This is just one example of a resounding theme in agroforestry: culture and knowledge of the local people is just as important as the local ecology. Time and again, agroforestry projects have failed because they failed to take local knowledge into account (Kidd 1992). There is little point in coercing farmers to use techniques that they don't believe will work. On-farm demonstrations, along with a two-way exchange of knowledge, are essential for agroforestry to realize its full potential (Kerkhof 1990).

One agroforestry initiative that has nearly always failed is the cultivation of woodlots in Africa to provide wood for cooking fuel. At first glance, one would expect these projects to be very successful: biomass fuel accounts for 60% of Africa's energy use, and in some parts of Africa, wood is more expensive than food (Mgendi 2000). Women and children often spend the majority of their time collecting fuelwood (Figure 4). If Africa needs all the fuelwood it can get, why wouldn't woodlots be a success?

One reason is that African farmers value other functions of trees more than they value fuelwood. If food is scarce, better to have uncooked food than none at all. Due to the demands of farmers, the Rural Afforestation Project in Zimbabwe changed its goal from providing fuelwood trees to providing fruit trees (Kerkhof 1990). Best of all are trees that provide *multiple* benefits: timber for construction, fruit and nuts, shade, and livestock fodder, as well as fuelwood. Farmers are simply not willing to invest ten years in growing trees for fuelwood, with no benefits in the meantime (Schroeder 1999). With the help of ongoing dialogue, agroforestry systems are being developed that better meet farmers' needs for fuelwood and for other products.

Figure 4. An Eritrean boy carries a load of fuelwood. Biomass makes up 60% of Africa's energy use.

Source: www.fao.org

All too often, however, a crucial group of people is left out of these dialogues: women. In developing countries, women are taking on an ever-increasing share of farm labor (FAO 1995), but are often forbidden to take part in discussions and decision-making. Although community forest management is more successful when a greater diversity of people is involved (Banerjee 1999), there are many obstacles to the involvement of women in agroforestry.

Figure 5. A woman in Niger waters a newly planted seedling. In some countries, planting trees is exclusively men's work.

Source: www.arbex.ca

Strict division of labor between the sexes can lead to unexpected difficulties in implementing agroforestry projects. In parts of Kenya, women are told that if they plant a tree they will become barren (Kerkhof 1990). When men are in charge of planting and harvesting trees, and women are in charge of carrying water (Figure 5), the women may refuse to carry water for the men's trees (Kidd 1992): after all, what benefit will the women get?

In some cases, the pendulum has swung the opposite way. Richard Schroeder, in his book *Shady Practices*, reports that some agroforestry programs in The Gambia have been so successful for women that their husbands feel resentful and left out. Women in The Gambia are expected to be subservient and dependent, so when an agroforestry program that allows women to grow cash crops and earn an income greater than their husband's, social chaos results (Schroeder 1999). Agroforestry can be a potent tool for the empowerment of women, but it must be used with caution.

Completing the recipe for success

Even if an agroforestry system is ecologically harmonious and socially beneficial, it will fail unless it meets two more criteria: favorable economics, and favorable policy. Economic analysis of agroforestry projects can be complicated (Kidd 1992), due to numerous long-term hidden costs (extra labor, inconvenient timing of harvests, etc.) and benefits (soil conservation, shade production, aesthetic value, etc.) It would be nice to be able to report that agroforestry's ecological benefits always led to economic benefits, but the truth is that many agroforestry projects fail when subsidies are withdrawn (Kerkhof 1990). To avoid this, it is essential to develop low-input agroforestry systems for use in developing countries (Nair 1989).

Appropriate policy is the final condition necessary for agroforestry to succeed (Sanchez 1995). Perhaps the most important policy consideration is *land tenure* (Nhantumbo 1999): who owns the land? Who owns the trees? What are their rights? Farmers will only be willing to work hard to improve the land if they know their investment will be protected. Even something as simple as fencing – which can be very hard to come by in rural areas – can make a huge difference to the success of an agroforestry program (Schroeder 1999).

Agroforestry experience all over the world has shown that it's important to be open-minded about what constitutes "success" (Kerkhof 1990). Each environment has a unique combination of ecological, social, economic and policy conditions that makes it almost impossible to transplant a ready-made agroforestry system (Michon 1989) (Dawkins 1998). For this reason, *flexibility* is the final crucial ingredient in successful agroforestry. Though our understanding of the science behind agroforestry has improved tremendously, we are still not always able to predict which systems will work in which environments. This means that local knowledge and field trials will play a key role in agroforestry for the foreseeable future.

The future of agroforestry

Agroforestry will continue to be a profitable and sustainable way of using the land, as it has been (almost unnoticed) for thousands of years. It shows the potential for great benefits – soil and water conservation, increased yields, enhanced biological diversity, reduced need for pesticide and fertilizer, and greater economic stability for farmers. However, those benefits are not always realized in practice, underscoring the need for more research (Huxley 1999). Agroforestry is still a very young science, and as with all sciences, we can expect greater returns as we learn more.

Agroforestry won't replace large-scale monocropping any time soon. But it is precisely the vulnerability of these large-scale systems that makes agroforestry systems urgently needed (Kidd 1992). Because of its greater diversity of species, and its ability to stabilize the landscape, it can provide insurance to subsistence farmers during years of drought or flood. It also offers a solution to the ongoing battle between forest land and agricultural land. In short, agroforestry is one of the most promising local solutions to our global problems.

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