Agroforestry

Parkland in Burkina Faso: sorghum grown under Faidherbia albida *and* Borassus akeassii *near Banfora*

Agroforestry or **agro-sylviculture** is a land use management system in which trees or shrubs are grown around or among crops or pastureland. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy, and sustainable land-use systems.[1]

1 As a science

The theoretical base for agroforestry comes from ecology, via agroecology.[2] From this perspective, agroforestry is one of the three principal land-use sciences. The other two are agriculture and forestry.[3]

The efficiency of photosynthesis drops off with increasing light intensity, and the rate of photosynthesis hardly increases once the light intensity is over about one tenth that of direct overhead sun. This means that plants under trees can still grow well even though they get less light. By having more than one level of vegetation, it is possible to get more photosynthesis than with a single layer.

Agroforestry has a lot in common with intercropping. Both have two or more plant species (such as nitrogen-fixing plants) in close interaction, both provide multiple outputs, as a consequence, higher overall yields and, because a single application or input is shared, costs are reduced. Beyond these, there are gains specific to agroforestry.

2 Benefits

Further information: Ecoscaping

Agroforestry systems can be advantageous over conventional agricultural, and forest production methods. They can offer increased productivity, economic benefits, and more diversity in the ecological goods and services provided.[4]

Biodiversity in agroforestry systems is typically higher than in conventional agricultural systems. With two or more interacting plant species in a given land area, it creates a more complex habitat that can support a wider variety of birds, insects, and other animals. Depending upon the application, impacts of agroforestry can include:

- Reducing poverty through increased production of wood and other tree products for home consumption and sale
- Contributing to food security by restoring the soil fertility for food crops
- Cleaner water through reduced nutrient and soil runoff
- Countering global warming and the risk of hunger by increasing the number of drought-resistant trees and the subsequent production of fruits, nuts and edible oils
- Reducing deforestation and pressure on woodlands by providing farm-grown fuelwood
- Reducing or eliminating the need for toxic chemicals (insecticides, herbicides, etc.)
- Through more diverse farm outputs, improved human nutrition
- In situations where people have limited access to mainstream medicines, providing growing space for medicinal plants
- Increased crop stability
- Multifunctional site use i.e crop production and animal grazing.
- Typically more drought resistant.
- Stabilises depleted soils from erosion

- Bioremediation

Agroforestry practices may also realize a number of other associated environmental goals, such as:

- Carbon sequestration
- Odour, dust, and noise reduction
- Green space and visual aesthetics
- Enhancement or maintenance of wildlife habitat

2.1 Adaptation to climate change

There is some evidence that, especially in recent years, poor smallholder farmers are turning to agroforestry as a mean to adapt to the impacts of climate change. A study from the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) found from a survey of over 700 households in East Africa that at least 50% of those households had begun planting trees on their farms in a change from their practices 10 years ago.[5] The trees ameliorate the effects of climate change by helping to stabilize erosion, improving water and soil quality and providing yields of fruit, tea, coffee, oil, fodder and medicinal products in addition to their usual harvest. Agroforestry was one of the most widely adopted adaptation strategies in the study, along with the use of improved crop varieties and intercropping.[5]

3 Applications

Agroforestry represents a wide diversity in application and in practice. One listing includes over 50 distinct uses.[2] The 50 or so applications can be roughly classified under a few broad headings. There are visual similarities between practices in different categories. This is expected as categorization is based around the problems addressed (countering winds, high rainfall, harmful insects, etc.) and the overall economic constraints and objectives (labor and other inputs costs, yield requirements, etc.). The categories include :

- Parklands
- Shade systems
- Crop-over-tree systems
- Alley cropping
- Strip cropping
- Fauna-based systems
- Boundary systems
- Taungyas
- Physical support systems
- Agroforests
- Wind break and shelterbelt.

3.1 Parkland

Parklands are visually defined by the presence of trees widely scattered over a large agricultural plot or pasture. The trees are usually of a single species with clear regional favorites. Among the benefits, the trees offer shade to grazing animals, protect crops against strong wind bursts, provide tree prunings for firewood, and are a roost for insect or rodent-eating birds.

There are other gains. Research with *Faidherbia albida* in Zambia showed that mature trees can sustain maize yields of 4.1 tonnes per hectare compared to 1.3 tonnes per hectare without these trees. Unlike other trees, Faidherbia sheds its nitrogen-rich leaves during the rainy crop growing season so it does not compete with the crop for light, nutrients and water. The leaves then regrow during the dry season and provide land cover and shade for crops.[6]

3.2 Shade systems

With shade applications, crops are purposely raised under tree canopies and within the resulting shady environment. For most uses, the understory crops are shade tolerant or the overstory trees have fairly open canopies. A conspicuous example is shade-grown coffee. This practice reduces weeding costs and improves the quality and taste of the coffee.[7][8]

3.3 Crop-over-tree systems

Not commonly encountered, crop-over-tree systems employ woody perennials in the role of a cover crop. For this, small shrubs or trees pruned to near ground level are utilized. The purpose, as with any cover crop, is to increase in-soil nutrients and/or to reduce soil erosion.

3.4 Alley cropping

With alley cropping, crop strips alternate with rows of closely spaced tree or hedge species. Normally, the trees are pruned before planting the crop. The cut leafy material is spread over the crop area to provide nutrients for the crop. In addition to nutrients, the hedges serve as windbreaks and eliminate soil erosion.

Alley cropping has been shown to be advantageous in Africa, particularly in relation to improving maize yields in the sub-Saharan region. Use here relies upon the nitrogen fixing tree species *Sesbania sesban, Tephrosia vogelii,*

Gliricidia sepium and *Faidherbia albida*. In one example, a ten-year experiment in Malawi showed that, by using fertilizer trees such as *Tephrosia vogelii* and *Gliricidia sepium*, maize yields averaged 3.7 tonnes per hectare as compared to one tonne per hectare in plots without fertilizer trees or mineral fertilizer.[9]

3.5 Strip cropping

Strip cropping is similar to alley cropping in that trees alternate with crops. The difference is that, with alley cropping, the trees are in single row. With strip cropping, the trees or shrubs are planted in wide strip. The purpose can be, as with alley cropping, to provide nutrients, in leaf form, to the crop. With strip cropping, the trees can have a purely productive role, providing fruits, nuts, etc. while, at the same time, protecting nearby crops from soil erosion and harmful winds.

3.6 Fauna-based systems

Silvopasture over the years (Australia).

There are situations where trees benefit fauna. The most common examples are the silvopasture where cattle, goats, or sheep browse on grasses grown under trees.[10] In hot climates, the animals are less stressed and put on weight faster when grazing in a cooler, shaded environment. Other variations have these animals directly eating the leaves of trees or shrubs.

There are similar systems for other types of fauna. Deer and hogs gain when living and feeding in a forest ecosystem, especially when the tree forage suits their dietary needs. Another variation, aquaforestry, is where trees shade fish ponds. In many cases, the fish eat the leaves or fruit from the trees.

3.7 Boundary systems

There are a number of applications that fall under the heading of a boundary system. These include the living fences, the riparian buffer, and windbreaks.

- A living fence can be a thick hedge or fencing wire strung on living trees. In addition to restricting the movement of people and animals, living fences offer habitat to insect-eating birds and, in the case of a boundary hedge, slow soil erosion.

A riparian buffer bordering a river in Iowa.

- Riparian buffers are strips of permanent vegetation located along or near active watercourses or in ditches where water runoff concentrates. The purpose is to keep nutrients and soil from contaminating surface water.
- Windbreaks reduce the velocity of the winds over and around crops. This increases yields through reduced drying of the crop and/or by preventing the crop from toppling in strong wind gusts.

3.8 Taungya

Taungya is a system originating in Burma. In the initial stages of an orchard or tree plantation, the trees are small and widely spaced. The free space between the newly planted trees can accommodate a seasonal crop. Instead of costly weeding, the underutilized area provides an additional output and income. More complex taungyas use the between-tree space for a series of crops. The crops become more shade resistant as the tree canopies grow and the amount of sunlight reaching the ground declines. If a plantation is thinned in the latter stages, this opens further the between-tree cropping opportunities.

3.9 Physical support systems

In the long history of agriculture, trellises are comparatively recent. Before this, grapes and other vine crops

were raised atop pruned trees. Variations of the physical support theme depend upon the type of vine. The advantages come through greater in-field biodiversity. In many cases, the control of weeds, diseases, and insect pests are primary motives.

3.10 Agroforests

These are widely found in the humid tropics and are referenced by different names (forest gardening, forest farming, tropical home gardens and, where short-statured trees or shrubs dominate, shrub gardens). Through a complex, disarrayed mix of trees, shrubs, vines, and seasonal crops, these systems, through their high levels of biodiversity, achieve the ecological dynamics of a forest ecosystem. Because of the internal ecology, they tend to be less susceptible to harmful insects, plant diseases, drought, and wind damage. Although they can be high yielding, complex systems tend to produce a large number of outputs. These are not utilized when a large volume of a single crop or output is required.

4 Challenges

Agroforestry is relevant to almost all environments and is a potential response to common problems around the globe, and agroforestry systems can be advantageous compared to conventional agriculture or forestry.[11][4] Yet agroforestry is not very widespread, at least according to current but incomplete USDA surveys as of November, 2013.[12][11]

As suggested by a survey of extension programs in the United States, some obstacles (ordered most critical to least critical) to agroforestry adoption include:[12]

- Lack of developed markets for products
- Unfamiliarity with technologies
- Lack of awareness of successful agroforestry examples
- Competition between trees, crops, and animals
- Lack of financial assistance
- Lack of apparent profit potential
- Lack of demonstration sites
- Expense of additional management
- Lack of training or expertise
- Lack of knowledge about where to market products
- Lack of technical assistance
- Cannot afford adoption or start up costs, including costs of time
- Unfamiliarity with alternative marketing approaches (e.g. web)
- Unavailability of information about agroforestry
- Apparent inconvenience
- Lack of infrastructure (e.g. buildings, equipment)
- Lack of equipment
- Insufficient land
- Lack of seed/seedling sources

Some solutions to these obstacles have already been suggested although many depend on particular circumstances which vary from one location to the next.[12]

5 See also

5.1 Permaculture

Agroforestry is a key component of the Permaculture system.

- Sustainable agriculture
- Sustainable gardening
- Permaculture
- Permaforestry
- Orchard
- Climate-friendly gardening
- Farmer-managed natural regeneration
- Fertilizer tree
- Forest gardening
- Forest farming
- Analog forestry
- Wildcrafting
- Buffer strip
- Afforestation
- Deforestation
- Megaprojects
- Mycoforestry
- World Forestry Congress
- Agropastoralism
- Sylvopasture
- Deforestation and climate change

6 References

[1] "National Agroforestry Center". USDA National Agroforestry Center (NAC). Retrieved 2 April 2014.

[2] Wojtkowski, Paul A. (1998) The Theory and Practice of Agroforestry Design. Science Publishers Inc., Enfield, NH, 282p.

[3] Wojtkowski, Paul A. (2002) Agroecological Perspectives in Agronomy, Forestry and Agroforestry. Science Publishers Inc., Enfield, NH, 356p.

[4] "Benefits of agroforestry".

[5] Kristjanson, P; Neufeldt H, Gassner A, Mango J, Kyazze FB, Desta S, Sayula G, Thiede B, Forch W, Thornton PK, Coe R (2012). "Are food insecure smallholder households making changes in their farming practices? Evidence form East Africa". *Food Security* **4** (3): 381–397. doi:10.1007/s12571-012-0194-z.

[6] "Turning the tide on farm productivity in Africa: an agroforestry solution". July 8, 2009. Retrieved 2 April 2014.

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[11] "Agroforestry Frequently Asked Questions". United States Department of Agriculture. Retrieved 19 February 2014.

[12] Jacobson, Michael; Shiba Kar (August 2013). "Extent of Agroforestry Extension Programs in the United States". *Journal of Extension* **51** (Number 4). Retrieved 19 February 2014.

7 Further reading

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- *The Springer Journal*, "Agroforestry Systems" (ISSN 1572-9680) ; Editor-In-Chief: Prof. Shibu Jose, H.E. Garrett Endowed Professor and Director, The Center for Agroforestry, University of Missouri
- Robbins, Jim (November 21, 2011). "A Quiet Push to Grow Crops Under Cover of Trees". The New York Times. Retrieved November 22, 2011.

8 External links

- National Agroforesty Center (USDA)
- World Agroforestry Centre
- The Center for Agroforestry at the University of Missouri
- Online Masters Degree in Agroforestry University of Missouri
- Australian Agroforestry
- The Green Belt Movement
- Plants For A Future
- Ya'axché Conservation Trust
- Trees for the Future
- Free Distance Agroforestry Training Manual (from Trees for the Future)
- Vi-Agroforestry
- Agroforst in Deutschland

Media

- "Agroforestry makes sense for marginalised people in the Philippines uplands" (Erhardt/Bünner), article in the magazine D+C Development and Cooperation
- The short film *Agroforestry Practices - Alley Cropping (2004)* is available for free download at the Internet Archive
- The short film *Agroforestry Practices - Forest Farming (2004)* is available for free download at the Internet Archive
- The short film *Agroforestry Practices - Riparian Forest Buffers (2004)* is available for free download at the Internet Archive
- The short film *Agroforestry Practices - Silvopasture (2004)* is available for free download at the Internet Archive
- The short film *Agroforestry Practices - Windbreaks (2004)* is available for free download at the Internet Archive

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