APPLICABILITY OF AGROFORESTRY SYSTEMS

Gerardo Budowski

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SUMMARY

It is argued that agroforestry is presently suffering from oversale and wishful thinking, rather than based on objective analysis of potentialities and limitations. To build up scientific credibility and provide a useful instrument for those who want to better promote agroforestry practices, it is proposed that a comparison between agroforestry and monocultures as a valid alternative should always be made. Such comparison must carefully weigh the advantages and disadvantages of each system, both from biological and socio-economic angles. To facilitate such a comparison a lengthy recapitulation of qualitative and a few quantitative assessments are presented, based on practical experiences, literature review and discussions with practising "agroforesters". It is hoped that these assessments - to be refined on a continuous basis - can serve as guidelines to research themes, for promotion and extension campaigns and for evaluations a posteriori.

APPLICABILITY OF AGROFORESTRY SYSTEMS*

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Agroforestry: The distinction between false premises, wishful thinking and realities

In the recent ICRAF consultative meeting on plant research and agroforestry held in Nairobi and which concluded only 3 days before the initiation of this workshop, I had the privilege of participating in one of the four working groups, with the aim of producing an appraisal as well as guidelines on topic "plant management in agroforestry systems". The discussions and the resulting conclusions, soon to be published, together with the background papers, all proved to be extremely useful to the subject that had been assigned to me by the organizers of the present workshop and it was inevitable that it moved me to rewrite the paper prepared in Turrialba, Costa Rica, in March 1981.

The lesson is of course that agroforestry is in a dynamic state of knowledge, of reappraisal, full of pitfalls and often grossly overrated in its role to help rural populations. As the draft conclusions of the Nairobi working group forcefully state: "agroforestry should not be considered as a panacea to cure all evils of land management, nor is it of uniform applicability. In specific areas agroforestry is useful, e.g. in reclaiming land which has been degraded by defective other uses, or in augmenting production on good land in high input systems, by managing suitable plant associations. In other areas, other land use systems are to be preferred "(ICRAF, 1981)".

A similar word of caution was voiced in a recent paper by the new director elect of ICRAF, Dr. Bjorn Lundgren, when he wrote at another ICRAF meeting (Lundgren, 1979, p. 526). In the promotion of the agroforestry concept, there has been no limit to the alleged positive influence of trees. Sometimes this has achieved almost mystical dimensions - the frequent talk about "miracle trees" is one aspect of this. Although it may sound like lack of imaginative thinking, it must be flatly stated that there exist no miraculous influences of trees on soils. It is often mistakenly supposed

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that any tree crop has the same stabilizing effect on the soil as the natural forest. This is as wrong as to say that a managed maize field is ecologically equivalent to a savanna."

Moreover there are other stereotyped images that must be clarified, concerning agroforestry. Is agroforestry only practiced by the rural poor? Is it restricted to marginal land? Can it be true, as stated in a famous report to IDRC (Bene *et al*, 1977), that ".... more than half of all land in the tropics, although too dry, too steep, too rocky to be classified as arable land, is suitable to the practice of agroforestry" (and this statement was placed in an emphasis box on p. 43)?

The more we learn about agroforestry, the more we discover that it includes productive and stable systems on all kinds of climate, soils and under varying social conditions. Many of these systems are very old, covering centuries of empirical knowledge. People who have been exposed to various agroforestry practices as a result of training in this field are actively reporting (or rather "discovering") systems, along routes they had previously travelled, without ever noticing them before (Budowski, 1981).

Although agroforestry has mostly been reported to be practiced by the rural poor (Michon, 1981; Tran van Nao, 1981; Avila *et al*, 1979; Bishop, 1979; Fuentes Flores, 1979; Wilken, 1977), good case studies are also coming forth concerning highly productive systems by small farmers (Beer, 1979; De las Salas, 1979). Afterall, coffee, tea and cocoa, when cultivated under one or several strata of "shade trees" (that also produce timber, add organic matter, recycle nutrients, diminish weed growth and provide a variety of other products and services), can be legitimately regarded as agroforestry systems, whether they involve small or large tenants or in some cases very huge enterprises such as for instance Jari Florestal in Amapá, Brasil (Briscoe, 1981).

It is, therefore, possible to see agroforestry as a land use technique that applies to both low capital, low input farming where self supply is aimed at, as well as high input, capital intensive combinations where the highest possible yield, taking advantage of incoming energy is aimed at; both systems having in common that they must be sustained, that is, productivity must be maintained.

Actually as many authors have pointed out, notably Lundgren (1979),

"agroforestry as a form of land use is primarily considered as a desirable replacement or improvement of land use systems that are degrading under the pressure of increased population densities in areas with low inherent potential for intensive agriculture" and he adds: "In the humid tropics this is often synonymous with areas under various forms of shifting cultivation." In the American humid tropics one may reasonably substitute shifting cultivation with "extensive grazing" since this is, areawise, the principal cause of land degradation, as witnessed by millions of hectares of worthless secondary brushland that reinvaded abandoned pastures themselves carved out at the expense of the rainforests (Budowski, 1981).

Lundgren (1978) in a report for West Africa makes the additional point "that the economic and nutritional output from the land must not only be sustained at present low levels but must be substantially increased to meet the requirements of an increasing population and increasing demands for social and economic development", a generalization that is of course valid for all the low input agroforestry practices throughout the tropical world.

The present paper will therefore refer more exhaustively to the applicability of agroforestry systems as practiced by the rural poor, often under difficult conditions where the objective is primarily to feed the family (subsistence level) and hopefully increase the output, but always under the premise that the system, to be considered as such, must be sustained and whenever possible, should aim at increasing the productivity.

A yardstick to judge applicability

It can be reasonably assumed that in order to be justified, the practice of agroforestry must perform at least *equal* to any alternative, notably monocultures. This may apply to both economic and social short and long term aspirations, and depending on the feeding requirements and land use patterns, the areas devoted to agroforestry can cover a small or a large part of the land used by rural communities.

Basically this involves agricultural systems where trees are added in time or space or both to annual or perennial crops or grasses or combined with animals, resulting in a large number of agroforestry practices (see for instance, Combe and Budowski, 1979), and these to be compared with monocultures of either annuals or perennials without these trees, (or for that matter the same trees in monocultures). This may by no means be easy

since often the monocultures have no parallel in agroforestry or vice versa or if they exist, they may not be found side by side under comparable conditions. Moreover such evaluation is complicated by various short and long term economic projections concerning for instance the value of wood or the present and future estimations of environmental damage (for instance erosion, use of pesticides in monocultures) and even more so, by the appraisal of social and cultural factors, themselves complicated by a dynamic evolution in time that is difficult to forsee.

Nevertheless it is considered a most useful exercise for all those who want to promote agroforestry and eventually transfer various of its forms to other areas without unduly preaching on the basis of faith instead of careful scientific appraisal as explanied by Steppler and Raintree (1981) at the recent ICRAF consultative meeting on plant research and agroforestry held earlier in April, 1981 in Nairobi. "ICRAF considers itself as an honest broker in promoting agroforestry."* If other land use practices are better qualified, it implies that ICRAF will make this clear and refrain from introducing agroforestry practices where they are not warranted. This approach should become a credo for all those working in agroforestry. With this objective in mind an attempt in the form of a compilation, has been made to evaluate advantage and disadvantages of agroforestry practices, as a basis for discussion and future evaluations. The compilation is based on discussions with practical agroforesters and review of the literature (notably De las Salas, 1979; Chandler and Spurgeon, 1980; Beer, 1981; Mongi and Huxley, 1979; Raintree, 1981; and ICRAF, 1981).

The pro and contra of agroforestry systems, when compared with monocultures of economic crops, with emphasis on the humid tropics

1. Biological Aspects

a) Advantages

- A larger amount of solar energy is captured.
- A better utilization of the vertical space is achieved and up to a point, natural ecological models are simulated as to form and structure.
- There is greater resistance against adverse rainfall conditions (both excess and unseasonal droughts).

- Temperature extremes are mitigated (lower maxima and higher minima) particularly for the benefits of plants and animals) close to the ground. The lower maxima reduce the speed of decomposition of organic matter.
- The damage caused by strong winds and rain drops with high energy is reduced.
- A larger amount of biomass returns to the soil as organic matter through fallen leaves, fruits, flowers, branches.
- There is greater efficiency in recycling nutrients because tree roots "capture" nutrients that move through the soil profile or to areas far away from the annual or perennial crop plants. In this connection superficial long horizontal roots of trees may play an extremely useful role as was pointed out by Lundgren (1978) who stated that "the superficial root system (of trees) will reduce nutrient and soil losses by leaching and erosion and improve porosity infiltration and aeration properties, and their deeper roots will bring up nutrients from depth to be incorporated into the biomass."
- Trees and their roots also tend to improve the soil structure (see above) by producing a higher amount of stable aggregates and avoiding (also dismantling) various types of hard pans. Percolation is thus favoured and there will be less stagnant water on the soil surface.
- There will be less proliferation of weeds because of less light reaching the ground and the possible effect of mulching.
- Mulch production, particularly if trees are pruned or pollarded reduces water evaporation from soil, adds considerable organic matter and reduces (or eliminates) the need for tillage.
- Most trees are better able to extract available nutrients from the soil, through the activities of mycorrhiza. In the case of most legumes (and representatives of a few other families), nitrogen from the air can be fixed through the action of specialized bacteria, and incorporated in the plant tissues.
- Erosion is prevented (up to a point) by most trees particularly on slopes.

- Manipulation of the arboreal strata through pruning (particularly to control crown density) can become a tool for better control of phenological processes like flowering or fruiting, for the benefit of associated plants. Moreover the trees themselves can be selected for appropriate phenology (Huxley, 1981) particularly their decidiousness (Budowski, 1981b).

- A greater diversity of the fauna is promoted by providing a greater variety of niches and this can be advantageous (e.g. certain animals as a source of protein, birds and other beneficial predators of harmful insects or rodents).

- The diversity of plant species and their spatial arrangement can deter insect proliferation.

- Trees may serve as supports for climbers of economic value (see for instance Okigbo, 1981).

b) Disadvantages

- Trees compete for light with associated plants in the lower strata and this may lower the yields and the quality of crop plants.

- Trees may compete for space with associated plants, both above and under ground and this can be a handicap for either or both. components.

- Trees compete for nutrients and make them inaccessible to associated crops when they are stored in stems and branches (instead of being recycled).

- There is a loss of nutrients when the wood is harvested or "exported" from the area. This is of course equally true when fruits or seeds from the trees are harvested.

- Trees compete for water in the soil in times of water stress, the more so if they keep their leaves (and transpire) instead of shedding them.

- Trees keep part of the rain in their crowns. This can be important when there are light rains. Stemflow can adversely redistribute rainfall.

- The harvesting of trees may cause mechanical damage to the associated crops.

- Mechanization becomes more difficult or impossible.
- Microrelief manipulation of the soil surface (furrowing, building of mounds, etc.) to benefit certain crops is more difficult or impossible.
- Air moisture close to the associated crops may be increased (partly because of less air movement) favouring fungal diseases.
- Large water drops that coalesce and drop from the higher parts of the tree crowns may cause damage to the associated crops (for instance in times of flowering).
- The different environment produced by the addition of trees can favour the proliferation of noxious animals.
- Some trees have allelopathic effects on crops.

2. Economic and Social Aspects

a) Advantages

- Farmer obtain, at least in part, direct economic benefits from the trees that satisfy their needs for firewood, posts, poles, sawn wood, certain fruits, feed for cattle, flowers for honey, medicinal products, etc. They do not need to buy these products or transport them from far away.
- Trees that produce salable wood constitute "standing capital", an insurance to meet emergencies in case of immediate cash needs.
- Dependency and catastrophies associated with a single crop are overcome or mitigated, particularly in the case of irregular rainfall patterns, market fluctuations, pest outbreaks, difficulty in acquiring imported products such as pesticides, fertilizers, machinery and spare parts, concentrates for cattle, etc. Moreover, the price of such imported products may (and often does), drastically increase.
- There is less need to "import" and to pay for energy, particularly fuel and other products brought from outside.
- Economic investments to establish tree crops may be considerably reduced because of the benefits obtained from annual crops at the early stages of tree growth. In some cases the number of years

- devoted to annual crops can be increased by thinning, pruning or upper crown manipulation and additional economic benefits can be obtained (posts, firewood) at the early stages of tree development.
- The presence of trees usually reduces weeding costs.
- Trees can be used to mark property boundaries and constitute a safeguard device against land usurpation.
- There is more flexibility to distribute the work load during the course of the year.
- Wildlife can be favoured and may be harvested for protein.
- Some schemes allow a gradual change from destructive land use practices towards more stable systems without diminishing productivity.
- There is obviously considerable scope to improve on existing stable systems and to design new systems with higher production and productivity, by associating the most desirable plant species (and/or animals), in space and in time, by drawing on local and world-wide experience.

b) Disadvantages

- In some cases, over the same area, yields of crops (or pastures) can be lower than for monocultures. Even if the combined value of crops and trees may be higher, it may take a number of years for the trees to acquire economic value.
- More manual labour may be required, a negative factor where labour is scarce and expensive and mechanization appears to be a better alternative.
- Agroforestry is often associated with land use systems of poor people, where little effort is made to adapt improved agronomic practices such as selection of improved varieties, or use of fertilizers while there usually is a complete neglect of pest control. In this connection it is often argued that many current agroforestry practices do not stimulate farmers to abandon their present socio-economic status associated with poverty and subsistence levels.

- In depressed areas, economic recuperation may take a longer time (than profitable cash crops) because of the time lag in cropping trees.
- In areas of high population density and scarce land resources, where survival is based on the next crop, there may be considerable resistance in planting or tending trees. In the particular case of taungya when cheap labour is used to establish trees with the collaboration of itinerant farmers that do not own the land, this may be considered as socially inadequate or a vestige of "colonial" or other practices linked with exploitation of the poor.
- There is considerable scarcity of trained personnel to handle or improve existing agroforestry systems, and to devise new systems and install demonstration plots.
- Agroforestry is more complex and less understood than monocultures and this may be a handicap to attract scientists, extensionists or farmers with a higher agricultural education. Also any experimental designs involving complex associations (in space or in time) and subject to statistical analysis is likely to be much more difficult. It can hardly be done in existing plots such as those currently designed by farmers because of the impossibility of controlling, let alone manipulating the variables. Testing agroforestry practices and comparing them with monocultures may thus become a lengthy, difficult and costly task that apparently can only be carried out efficiently by selected experimental stations where appropriate land, funds and specialists of different disciplines, are available.
- There is lack of knowledge on the potentialities of agroforestry among decision-makers and this results in scarcity and lack of funds for land use planning, research and extension programmes. Backlashes resulting from false premises (e.g. "miracle" trees) may compound this rather depressing picture.

Conclusions

The foregoing appraisals of advantages and disadvantages are obviously incomplete. Moreover, they can scarcely pretend to cover the whole array of agroforestry possibilities. Not all of them may apply for one peculiar system but they cover a multitude of situations.

However, they can provide a framework for evaluating existing systems and for the design of new ones, particularly as concerns their applicability and the chances of success. They could constitute a basis for a series of questionnaires when the promotion of certain agroforestry practices is to be aimed at. Finally they offer a series of possibilities for research and for evaluations.

With new and more homogeneous descriptions of agroforestry systems entering the literature these appraisals may be considerably refined, enlarged and incorporated, at least in part and where applicable, in the quantification of those systems, their testing, validation and continuous evaluation, particularly where transference of techniques is aimed at.

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