# Agroforestry Research Methodology used at CATIE

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A great variety of agroforestry research methodologies have been used at CATIE since the first agroforestry experiments were set up more than twenty years ago. The development of new research methodologies has been an evolutive process as errors were recognized in various experiments and social scientists became increasingly involved in agroforestry research. The movement of on-station research to on-farm research required a change in methodologies to suit the on-farm situation. Another important factor has been changes in the nature of agriculture and agricultural policy of the CATIE member countries over the twenty five years that CATIE has existed as an institution. Although food grains were a priority in the period from 1973 to 1986, in the past twelve years, increasing emphasis has been given to export crops (Rosset, 1991). Increasing concern over environmental factors and maintenance of biodiversity has also affected the nature and methodologies used in agroforestry research.

Various agroforestry systems have existed in the Central American region since Pre-Columbian times among the most significant being cacao grown under shade of Gliricidia sepium and other trees, qualtitative improvement of the floral composition of the secondary succession in the fallow phase of slash and burn agricuture, multistrata home gardens, and dispersed trees for timber and firewood in crop fields (Budowski, 1993). Although only the animals domesticated before the conquest were the turkey, llama, alpaca, and dog, it is still possible to see farmers feeding turkeys the leaves tsalam, (*Lysiloma latisiliquum* (L.) Benth. ) in the Yucatan so this might be a pre-Columbian agroforestry practice. Other non-domesticated animals might have been involved in seed dispersal of important agroforestry species such as the calabash tree (*Crescentia alba*) (Janzen and Martin ,1982). (Ovalle et al., 1990). The introduction of European grazing species—in the case of the horse, a reintroduction, made it possible for silvopastoral systems to develop throughout the Americas. The introduction of shade-grown coffee in the 18th century and exotic timber species in the 20th century increased the possibilities for agroforestry systems. Systems developed for the production of food grains have been modified for the production of higher valued vegetables and export crops.



## 1.Agroforestry Research under the Interamerican Institute for Agricultural Sciences (1942-1973)

Major trends in agroforestry research in CATIE are given in Table 1. Although agroforestry was only recognized as such at CATIE in 1976, there had been research activity in what was later recognized as agroforestry as part of the M.S degree program set up in Turrialba by IICA in 1954. Most of these theses concentrated on particularly aspects of agroforestry systems such as erosion control (Bermudez, 1980; Apolo, 1980; Amezquita, 1974) and light penetration to pasture grasses growing below tree canopies (Daccarett and Blydenstein, 1968). A summary of the work with soil conservation is given in Table 2.

## 2. The institutionalization of agroforestry at CATIE, 1973-1986; The Budowski era.

In 1970, CATIE was separated from the Interamerican Institute for Agricultural Sciences and began functioning as a separate entity dedicated to education and research

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In Turrialba in 1973. IICA was reconstituted as the Interamerican Institute for Agricultural Cooperation.

The first truly integral agroforestry experiments at CATIE were set up by Fassbender and others in 1977. This was part of a Latin-America wide network of coffee and cacao shade experiments begun in that year (Fassbender, 1993). The original experiment was a systematic design with a limited number of replicates in order to accommodate a great number of crops and cropping associations (Soria et al., 1975). Analysis of this experiment proved difficult and it was resolved that later experiments would not incorporate the design defects. However, the CATIE experiment produced considerable information about the most important Central American agroforestry systems with respect to nutrient cycling, biomass distribution, nutrient inflows and outflows, weed control, and long-term economic analyses.

Other on station trials were set up at CATIE over the next ten years. Two different designs were used. One, the first alley cropping trial planted in Central America used a split-plot design in randomized complete blocks (Kass et al., 1989; 1995). Because trees were only planted in some of the treatments, subplots which measured 18 m X 12m were too large for crop research and too small to have a sufficient number of trees To account for variability and completely offset edge effects although the presence of a large number of treatments without trees ensured that plots with and without trees were Sufficiently separated to reduce interference (Sanchez, 1995). A similar design was used in a coffee shade and fertilization experiment set up on a farm near CATIE by the Costa Rican Coffee Institute in collaboration with CATIE (Ramirez, 1993).

Another coffee shade experiment, utilizing two types of shade species, was set up at CATIE in 1983. This was the first use of a systematic design, in which density of one tree species , *Erythrina poeppigiana* (Walp.) O.F. Cook, principally valued as a shade tree, varied in one direction while that of another, *Cordia alliodora*, principally valued as a timber tree, varied in the other direction. Coffee population was constant throughout the experiment, which only measured 100m X 50 m. However, the uniform coffee planting permitted the development of a number of site covariate values which could be used to correct for site variability. A similar set of covariates was developed for the Erythrina planting (Beer, 1993).

On –farm experiments with alley farming were begun in 1983 and 1984. In one of these, a latin-square design was used in order to get a better measure of variability over the experiment area which was over one hectare. Conventional randomized complete blocks were used in experiments set up in farmers' fields in Puriscal, Costa Rica. Again, because trees only occupied one of the treatments, plots were probably too small to account for tree variability (Kass and Araya, 1987). Although these experiments were discontinued in 1988, data over a sufficient number of years was obtained to permit stability analysis (Kass et al., 1995a).

**3. Changes in Central American agricultural policy, designs for on-farm research, 1986-1994**

A second series of experiments utilizing the cacao shade system were begun in Costa Rica and Panama in 1986 to 1988. Every effort was made to avoid the errors of the CATIE Central experiment. The experiments were all on-farm, plot sizes were large enough to account for tree variability and avoid interference from plot to plot and a wider variety of shade species were used. Experiments involving other types of agroforestry systems, line-plantings and taungya, were also set up. These required a different set of designs. The large plot sizes, however, resulted in considerable soil variability especially as the experiments were frequently set up in alluvial areas where soil conditions could vary considerably over short distances. A careful selection process of farmers was also developed in order to ensure that the sites could be monitored over a long period. Criteria were developed for determining which farmers were most likely to make a long.-term committment to the research implanted on their lands (Beer, 1991;Lujan, 1994).

Other on-farm experiments were set up at CATIE in 1990. In one case, split plots were arranged in a Latin square design in order to avoid residual effects in a cropping rotation (Limon, 1993). Another utilized a conventional randomized complete block design but blocking was used to reduce variability due to differences in slope (Kass et al., 1995b).

In the mid-1980s there was a complete change in agricultural policies of most Central American countries. Instead of seeking self-sufficiency in food grain production, which had been a major policy objective since World War II, falling food prices and diminishing rural populations made importation of basic grains more important. In an increasingly globalized economy, export crops were considered to provide better possibilites for increasing incomes since there would be a greater cash inflow, a smaller percentage of which could be spent for food. However, export crops frequently needed larger inputs of imported inputs . The dependency model which had characterized Central American agriculture before World War II was reinstated in the guise of globalization although activities such as light manufacturing and tourism frequently replaced agriculture as principal sources of revenue in a globalized economy. Efforts of small farmers to enter export agriculture were generally not successful, however (Rosset; 1991). As more and more farmers moved out of small grain production, home gardens took on increasing importance and organic agriculture proved surprisingly cost-efficient as pesticides were the major cost of high value crop production.

**4. Globalization and Participation, 1994-present**

Increasing involvement of social scientists in agroforestry research led to the use of new methodologies in research activities. A wider number of surveys were used to study systems such as home gardems. Cluster analysis proved a valuable tool (Mendez and Lok, 1998) while conventional economic analysis continued to be used but was supplemented by the incorporation of parameters concerning gender and human health. (Marsh and Henandez, 1998). Correlations between socioeconomic and biophysical factors (Lok et al, 1998) proved valuable while special methods were developed for work with indigenous communities (Lok and Samaniego, 1998).

Increasing interest in participative methods resulted in the incorporation of participative methods in CATIE research, especially for on-farm experiments. The participative rural appraisal was developed to replace the rapid rural appraisal in order to Incorporate farmer participation in research designs (Lok, 1998). A summary of The characteristics of the participative rural appraisal is given in Table 4.
Other ways of incorporating economic and social factors into agroforestry research design have been given by Somarriba (1998). A comparison of the participative and rapid rural appraisals was given by Grenier (1998). She states that PARA places more emphasis than RRA on correct behavior and attitudes (The PARA researcher must be more flexible and willing to listen to rural people), the use of multiple research techniques, and visually shared information and ideas. The main advantages of PARA is that increases participation, supports independence, builds dignity, generates knowledge, and is practical and creative. Among the weaknesses that Grenier (1988) notes in participative research are its susceptibility to manipulation by local power structures, its requirement of greater training and committement from researchers utilizing it, and the possibility of creating unrealistic expectations among the participants.

Silvopastoral research has been a signficant element of agroforestry research at CATIE since 1986. As in the case of agroforestry systems with annual crops, research methods used for animal research have generally been adapted to use with tree based feeds. Split plot experiments in time are frequently used. Models have been developed to describe the results obtained. Some special methods have been developed for on farm research (Simon et al., 1998).

In Table 5, a summary of research methodologies used in CATIE agroforestry theses in 1997 is given. This table gives some idea of the variety of methods used. It can be seen that there is no set recipe for the best design for each case. The punishment will have to fit the crime, so to speak. According to the objectives of the research, the most appropriate design must be chosen. Participative research is supposed to increase the probability that farmers will adapt the treatments that are shown to be superior. On the other hand, a place remains for more conventional on-station research. Adoption is successful when both the technology and the methods of diffusion of the technology are superior.

It remains to be seen whether the research methods presently beign used by CATIE in agroforestry are an adequate response to the needs of its member countries. Coffee and cocoa producers are the most obvious clients for agroforestry research. Prices for these commodities have been maintained and have shown some increases in recent years. Prices for basic grains and cattle have declined, making agroforestry systems involving these components somewhat less attractive than they were twenty years ago. Efforts are now being made to establish timber trees in degraded pastures and use nitrogen fixing trees as supports for high value vegetables such as tomato, sweet peppers, and chayote (*Sechium edule*). There is also a great need for soil conservation practices on hillslopes where much of the food production has been relegated. Agroforestry systems have a definite role to play in such situations but the research methodology for dealing with these systems is only beginning to be developed. Participative methods have proved very successful in working with home gardens and indigenous farmers but these have only a limited participation in the cash economy (Lok and Mendez, 1998; Lok and Samaniego, 1998). Efforts are now being made to integrate an ecological with a sociological approach.

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## Table 1. Principal trends in CATIE and IICA agroforestry research, 1954-1998.

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|---|---|
| 1954-1973 | While IICA was located in Turrialba, there were several theses involving agroforestry systems, especially in erosion control in shaded coffee systems and light transmission in silvopastoral Systems. Universal soil loss equation was used to predict soil losses with different coffee shade systems. |
| 1973-1977 | In first years of CATIE, there was much interest in crop associations. Large long-term experiments involving annuals and shaded perennials were set up in Turrialba, Belém, Brasil, Itabuna, Brasil, and Venezuela. Lattice designs were used. |
| 1977-1986 | Beginning with UNU project, more emphasis was given to on-farm work. Annual crop systems and silvopastoral systems studied as well as shaded coffee and cacao which had received most attention previously. Although three long-term experiments were set up at CATIE in this period to study density of timber and shade trees in coffee and alley cropping for production of annual crops, partial replicates of these experiments were soon set up on farmers' fields to evaluate solutions in farm situation. Support from GTZ and IDRC (Canada) emphasized on farm work. |
| 1986-1994 | More emphasis given to adequately replicated designs, even for on-farm work. Some very large, long-term studies were set up on farmers' fields. Effect of management practices on agroforestry systems studied. IDRC and SIDA support for nitrogen-fixing-tree and silvopastoral systems research Large CIDA project for silvopastoral systems for dry areas. GTZ began demanding larger social science and extension aspect to Research activities. Period of maximum funding for agroforestry research. DANIDA support to agroforestry coordination begun: Revista Agroforesteriía en las Américas begun. |
| 1994-present | More emphasis given to social sciences and participative research. Competition studies renewed, especially root competition. Reduced priority given to fodder trees in silvopastoral systems, greater emphasis to recovery of degraded pastures. Greater integration of agroforestry into other CATIE research lines: conservation of biodiversity, ecological agriculture, silviculture, soil conservation and watershed management, enviromental socioeconomics |

**Table 2. Results of measurement of soil loss in different agroforestry systems. Carried out at CATIE.**

| Source | Site, soil, slope | Agroforestry system | Soil loss (t/ ha/ yr) |
|---|---|---|---|
| Ives, 1951 | CATIE, Serie Colorado (Acrudoxic melandudand) 45% slope | Grass | 0.0 |
| | | Bare | 18.79 |
| | | Crops | 12.41 |
| Bermudez, 1980 | CATIE, Serie Colorado | Coffee with Erythrina | 0.071 |
| | | Coffee, Erythrina, Cordia | 0.127 |
| | | Coffee alone | 0-439 |
| Apolo, 1980 | La Suiza, Haplohumult, 20-60% slope | Pasture alone | 1.47 |
| | | Pasture with Erythrina | 2.54 |
| | | Pasture with Cordia | 1.88 |

**Table 3. Objectives, ,methodologies, and commentaries on some components of the participative rural appraisal (from Lok,1997)**

| Objective | Method/Instrument | Commentaries/advantages |
|---|---|---|
| **Identification of existing agroforestry systems and their components** | **1.Transect on the level of farm or system** Although this has traditionally been done at the community level, it can also be used at the farm or system level, above all when the level of biodiversity is great | A transect is not a "transverse cut" but rather an overview of the most salient characteristics or species on the farm or within the system. The advantage of the transect lies in the fact that, with the help of the farmer, it is possible to place within a single design, all of the advantages and problems of the system and/or its components |
| | **2. Group interviews (complementary to the transect)** Having established the systems to be studied, their components, and their most relevant aspects (albeit on a reduced scale), their frequency of occurrence on a larger scale can be corroborated by means of group interviews. | The group interview permits obtaining representative information for a large segment of the population. Compared with the individual questionnaire, interviews of this type, when carried out correctly, considerably facilitate analysis of the information. |
| **Evaluation of components** | **Matrix of prioritization and establishment of hierarchies** (comparisons to express preferences) | See evaluation of methods. |
| **Establishment of local knowledge** | **1. Direct observation** | A good compilation of local knowledge requires the use of complementary methods and systematic efforts. Once the practices for different aspects of managementare established, the inforamtion can be corroborated on a larger scale by means of group interviews. |
| | **2. Seek local experts on the subject** | |
| | **3. Do it yourself** (researcher establishes matrix with the help of the local populace) | |
| | **4.Conferences and semi-structured interviews** | |
| **Evaluation of methods** | **Matrix of prioritization and establishment of hierarchies** (comparisons to express preferences) | Comparisons can be made in a group meeting, using simple matrices and comparing technologies (conventional vs. local) according to different criteria which the target population considers important (for example: labor, costs, effectiveness etc.) |
| **Profile of priorities and needs (by gender)** | **1. Chronologies and analysis of directions of change** | When working with groups, it is important to choose persons with similar characteristics (for example, women who plant a particular crop)<br><br>Establishment of group priorities and needs implies a particular process.<br>The methods discussed help the group to organize the information needed to formulate these priorities and needs |
| | **2. Seasonal calendars**(related to topics given importance by the target group, such as rainfall distribution, harvest activities, health, food availability, salaried off-farm work, use of family labor) | |
| | **3. Analysis of daily activities and allotment of time** | |
| | **4. Institutional or Venn diagrams** | |
| | **5. Levels of well-being (ordering of wealth)** | |
| | **6. Establishing hierarchies of present and future priorities** | |

**Table 4. Ways of increasing farmer participation in research activities ( Prins, 1998—In Press)**

1. Study the characteristics of the farm

2. Take into account the priorities and preferences of the family

3. Together with the farmer, analyze the bottlenecks and unutilized opportunities

4. Utilize technologies whose biophysical viability has already been demonstrated

5. Recover the knowledge of the farmers

6. Locate the forms of interchange of knowledge among the farmers

   a. How do farmers interchange ideas and knowledge
   b. Strengthen the scientific knowledge of the farmers
   c. Involve farmers in research design and experimentation

Table 5.Types of research and designs used in CATIE M.S. Agroforestry Theses in 1997

| Title | Site | Type of study | Research methodolgy | Method of analysis | Country of student |
|---|---|---|---|---|---|
| Knowledge of home gardens | Costa Rica | Survey | Interviews | Index of similitude | Honduras |
| Value of perception and local knowledge among Ngobe tribe | Panama | Pariticipa-tive survey | Interviews | Maps made by participants | Panama |
| Stability and risk analysis of cacao, plantain and Cordia systems | Panama | Prediction of risk with different populations | Analysis of existing data | Risk analysis | Brazil |
| Effect of diet supplementation with Morus alba | Costa Rica | On station | Cattle diets supplemented with Morus alba | Split plot in time | |
| Rumen degradation of Cratylia | Costa Rica | On station, labora-tory | Fistulated calves | ANOVA | Colombia |

Type of analysis used in M.S. Thesis research, CATIE 1997, ctd.

| Thesis | Country | Research type | Research methodology | Type of analysis | Country of student |
|---|---|---|---|---|---|
| Soil properties associated with legumes in pastures | Costa Rica | On station , laboratory | Laboratory analyses | ANOVA | Costa Rica |
| Fine root distribution in Costa Rican coffee plantatios | Costa Rica | On farm | Used sites with different times of coffee-Eucalyptus association | Root length density determined with scanner | Bolivia |

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|---|---|---|---|---|---|
| Effect of shade on coffee vigor | Costa Rica | On farm | Different types of shade and distances from tree | Parametric and non parametric methods | Bolivia |
| Growth of Cordia in different agroforestry systems | Costa Rica, Panama | On farm | Tree growth matched with site characteristics at 15 sites with different agroforesty systems | Corelations with site index: Predictive model | Bolivia |
| Effect of Acacia mangium on Vigna | Panama | On station | Replicated complete blocks, fractionation of soil P | ANOVA | Panama |
| Effect of cattle on tree regeneration | Argentina | On farm | Transects, tree growth before and after grazing | Grouped data | Argentina |