129
B
LEARMONTH, J.; RABETTE, J. (1978)
THE ECONOMICS OF AGROFORESTRY: A PRELIMINARY ANALYSIS
In K. Howes and R. Rummery (eds) *Integrating Agriculture and Forestry.* Proceedings of a Workshop held at Bunbury, Australia. Perth: CSIRO, Division of Land Resources.
pp. 80-90 EN XP/AU
ICRAF acc. no: B1265

This paper presents an exploratory analysis of open-spaced pine plantations with sheep grazing between the trees in Ballarat District of Victoria, Australia. The first three years, only hay is produced and then the sheep are reintroduced with a gradual decline in stocking rate. The net present values of four systems are compared: 1) permanent wool production 2) pines integrated with wool production run on a 25 and 30-year rotation 3) a conventional pine plantation on a 36-year rotation. The amount of expenditure required is presented but overhead costs are excluded. Management details appear in an annex. Three possible timber prices are included in the analysis. Returns are discounted at rates of 0, 5 or 8%. The outcome shows that the agroforestry system is superior except under the highest discount rate and the lowest price for timber.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Pinus spp*
TREE/SHRUB PRODUCT: timber
TREE/SHRUB SERVICE: shade
LIVESTOCK: sheep
DATA SOURCE: estimates

130
B
LEE, K.A.; NG, L.H.; GOH, C.L. (1976)
ECONOMICS OF POULTRY UNDER RUBBER
Proceedings of the seminar on Integration of Livestock with Plantation Crops. Kuala Lumpur: Rubber Research Institute of Malaysia
pp. 230-240 EN XP/MY
ICRAF acc. no: 1760

Intercropping can be done during the first years of rubber cultivation. After that, owing to the shading effect of the canopy, it is not economically feasible. In this paper, the costs and benefits of poultry rearing under these circumstances are examined. The effect on the rubber trees is not quantified. It is concluded that it is a profitable enterprise for smallholders. Data are drawn from three poultry projects in Malaysia.

ECOZONE: semi-arid
TYPE OF ANALYSIS: linear programming, economic concepts/methodology
ANALYSIS LEVEL: farm, region
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch
CROP/GRASS: maize, cowpea, pigeon pea, beans
DATA SOURCE: farm survey, research plot

134
B
MACBRAYNE, C.G. (1982)
AGROFORESTRY FOR UPLAND FARMS?
Scottish Forestry
Vol. 36 No. 3 pp. 195-206 EN XE/GB
ICRAF acc. no: 3118

A system of planting hybrid larch trees (spacing 3.5x1.5 meter) on pasture in the Scottish Highlands is examined. Averaged over a 16-year rotation period, the 'agricultural value' of the pasture is estimated as 40% that of open pasture. The agricultural value is higher than the value resulting from the grazing capacity due to shelter benefits of the trees. The trees are assumed to be used for poles and firewood. Discounted costs and benefits are given resulting in an internal rate of return of 7%.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture, windbreak
TREE/SHRUB SPECIES: *Larix heterophylla*
TREE/SHRUB PRODUCT: poles, fuelwood
TREE/SHRUB SERVICE: shade, wind protection
LIVESTOCK: sheep
DATA SOURCE: estimates, unspecified

135
A
MAGRATH, W. (1984)
MICRO-ECONOMICS OF AGROFORESTRY
In K. Shapiro (ed) *Agroforestry in Developing Countries.* Ann Arbor, USA: University of Michigan
pp. 73-144 EN XZ
ICRAF acc. no: B2371

This paper provides a comprehensive review of the major problems and potential solutions to valuing inputs and outputs in agroforestry and social forestry projects. Topics covered include demand for tree products and services, supply and market structure, a summary of existing information on profitability of projects, and

methodological issues of agroforestry project appraisal. The latter discusses estimating values of environmental benefits, and shadow pricing of domestic consumption in terms of market prices, commercial or dung/residue replacement, cost of production and time spent gathering wood products. Summary data are presented from 78 studies on agroforestry and social forestry projects, including estimates of present net worth per hectare, internal rate of return, and type of analysis. Of these studies, 75% are ex-ante analysis. Most refer to plantation, taungya, or shelterbelt projects, but the analysis presented is largely applicable. The author places agroforestry project analysis firmly within the established micro-economic literature on project evaluation.

TYPE OF ANALYSIS: economic concepts/methodology, production function analysis, agroforestry sector analysis, cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: project
DATA SOURCE: unspecified

136
A
MARY, F.; MICHON, G. (1987)
WHEN AGROFORESTS DRIVE BACK NATURAL FORESTS: A SOCIO-ECONOMIC ANALYSIS OF A RICE - AGROFOREST SYSTEM IN SUMATRA
Agroforestry Systems
Vol. 5 pp. 27-55 EN XP/ID
ICRAF acc. no: 7470

Damar agroforests in southern Sumatra, Indonesia are one element of farming systems which include irrigated or rainfed rice cultivation, and coffee plantation. Detailed description of crop succession and historical evolution of cropping systems is presented, showing the trend towards replacement of natural forests with damar agroforests. The value produced in agroforests can be as high as 50% of total farm production value, and provide income throughout the year. The economic characteristics of the land tenure system are also discussed. Recent changes in the farming systems leading to a reduced role for damar agroforests are ecological limitation to damar growing, transportation problems, shrinking of the land base and increased uncertainty in land tenure, migration characteristics, negative changes in terms of trade between damar resin and rice, declining rate of growth in market demand, and increasing attractiveness of speculative cash crops such as clove. The authors point out the need to evaluate agroforestry systems at different levels - both as an individual system, and as part of the larger farming system.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis, whole-farm budgeting ex-post
ANALYSIS LEVEL: farm, community, region
TECHNOLOGY: trees in homegarden, taungya afforestation, trees mixed in perennial cropland
TREE/SHRUB SPECIES: *Shorea javanica, Durio zibethinus, Lansium domesticum*
TREE/SHRUB PRODUCT: fruit, fuelwood, poles

CROP/GRASS: rice, coffee, clove
DATA SOURCE: farm survey, case studies

137
B
MATHES, D.T. (1986)
ECONOMICS OF INTERCROPPING: COFFEE, CACAO AND PEPPER UNDER COCONUT
Coconut Bulletin
No. 3 pp. 9-11 EN XP/LK
ICRAF acc. no: 7679

This paper presents the relative costs and returns from tree crops of coffee, cacao and pepper, interplanted with coconut at Sirikandura estate, Dodanduwa, Sri Lanka. The brief report measures labour and material costs in relation to returns over a period of seven years and concludes that smallholders get good returns from the intercropping systems. There are no adverse effects on the yields of the coconut palm. Several cost factors are aggregated into two items: labour and material.

ECOZONE: humid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in perennial cropland, trees mixed in annual cropland
TREE/SHRUB SPECIES: *Cocos nucifera, Theobroma cacao*
TREE/SHRUB PRODUCT: fruit, nuts
CROP/GRASS: coffee, pepper
DATA SOURCE: case studies

138
A
MATHUR, R.S.; SHARMA, K.K.; ANSARI, M.Y. (1984)
ECONOMICS OF EUCALYPTUS PLANTATIONS UNDER AGROFORESTRY
The Indian Forester
Vol. 110 No. 2 pp. 171-201 EN XP/IN
ICRAF acc. no: 4460

The economic potential of plantations in Uttar Pradesh and Punjab/Haryana, India are calculated using different spacing and harvest rotations. The economic feasibility of eucalyptus hybrid both with and without agriculture under varying spacing, i.e. 2.5x2.5 meter, 3x1.5 m, 4x2 m and 6x1 m, is worked out. Planting of eucalyptus in combination with agricultural crops at 6x1 m spacing with 8-year rotation gave the highest net present value in both areas. For small farmers, planting of eucalyptus on bunds is economically viable and is thus recommended by the authors.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: contour planting, woodlot
TREE/SHRUB SPECIES: *Eucalyptus tereticornis*
TREE/SHRUB PRODUCT: fuelwood, timber
CROP/GRASS: wheat, rice, sugarcane
DATA SOURCE: research plot, estimates, case studies

139
B
MAY, P.H.; ANDERSON, A.B.; FRAZAO, J.M.; BALLICK, M.J. (1985)
BABASSU PALM IN THE AGROFORESTRY SYSTEMS OF BRAZIL'S MID-NORTH REGION
Agroforestry Systems
Vol. 3 pp. 275-295 EN XL/BR
ICRAF acc. no: 6050

This paper discusses the use of babassu palm in pastoral and shifting cultivation systems in northern Brazil. The palm is used for cash income, fuel, fibre, edible oil and food, especially by tenant farm households. The structure of the system is described including components, arrangements and interactions. Land, labour, capital and other input data obtained from a household survey are presented, showing the importance of babassu in cash flow. However, ranchers receiving subsidies for pasture establishment are encouraged to clear babassu. Other babassu stands are being felled to make way for mechanized rice operations, and plantations of sugarcane and bamboo. The authors predict that in the more fertile parts of the zone babassu's continued dominance of the landscape appears to be seriously threatened. But in drier, less fertile areas, the palm will remain an integral part of traditional land use systems. Priority research needs and development potentials for babassu are identified.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis, partial budgeting ex-post
ANALYSIS LEVEL: farm, region
TECHNOLOGY: improved tree fallow, trees in pasture
TREE/SHRUB SPECIES: *Orbignya spp*
TREE/SHRUB PRODUCT: fruit, fodder, oil, poles, charcoal
TREE/SHRUB SERVICE: soil-fertility improvement, soil conservation
CROP/GRASS: rice, maize, cassava, beans, *Hyparrhenia rufa, Panicum maximum, Brachiaria spp, Pennisetum purpureum*
DATA SOURCE: farm survey

140
A
MAY, P.H. (1986)
A MODERN TRAGEDY OF THE NON-COMMONS: AGRO-INDUSTRIAL CHANGE AND EQUITY IN BRAZIL'S BABASSU PALM ZONE
Unpublished PhD thesis. New York: Cornell University
432 pp. EN XL/BR

This thesis concerns the economic role of successional babassu palm forest in northeast Brazil. The study compares babassu's importance to rural producers by enterprise and social organization between two agro-ecological regions. Different chapters provide detailed analysis of babassu use, markets, and farm enterprise analyses for traditional babassu production systems, babassu-pasture systems, and alternative systems. The author concludes that if development is combined with industrial innovation in babassu fruit processing where peasants already exploit most palms, employment will be severely curtailed. However, where babassu exploitation rates and agro-pastoral potential are low, industrial innovation may generate new employment. Technical and institutional innovations are suggested to protect the peasant producers of babassu.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis, partial budgeting ex-ante and ex-post
ANALYSIS LEVEL: farm, region, plantation
TECHNOLOGY: improved tree fallow, woodlot
TREE/SHRUB SPECIES: *Orbignya spp*
TREE/SHRUB PRODUCT: fruit, oil, fiber, fuelwood
TREE/SHRUB SERVICE: soil-fertility improvement
DATA SOURCE: farm survey

141
A
MCDERMOTT ASSOCIATES (1984)
EVALUATION OF AGROFORESTRY AT REGIONAL AND NATIONAL LEVELS
In G.W. Bilbrough (comp) *Proceedings of a Technical Workshop on Agroforestry.* New Zealand Forest Service
pp. 89-95 EN XP/NZ
ICRAF acc. no: 10963

The authors present a review of earlier investigations into agroforestry options for the Northern Hawkes Bay, New Zealand (Central North Island Planning Study Findings, 1983). It draws upon a simulation-based analysis of regimes of 100 and 200 trees per hectare of pasture. Tree growth has been simulated using SILMOD which simulates tree growth on the basis of measured site parameters. The opportunity cost of tree production has been measured by foregone pastoral output based on Ministry of Agriculture & Fisheries farm models for the area, as well as results of research at Whatawhata. The cost-benefit analysis confirms positive returns for agroforestry as an attractive alternative to existing afforestation practices. However, under the updated cost, price and production assumptions only

the system with 100 trees per hectare showed a positive net present value at the 10% discount rate. This results from higher opportunity costs and higher costs for sawing timber. A sensitivity analysis confirms this finding under all assumptions. Policy changes evolving from agroforestry are discussed. These concern finance, extension service, and collective organisation of farms to prevent diseconomies of scale due to the scattered pattern of tree-growing.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: farm, region
TECHNOLOGY: trees in pasture
TREE/SHRUB PRODUCT: timber
LIVESTOCK: sheep
DATA SOURCE: biological models, research plot, estimates

142
B
MCGOWAN, L. (1986)
POTENTIAL MARKETABILITY OF CHARCOAL, POLES, AND PLANKS PRODUCED BY PARTICIPANTS IN THE AGROFORESTRY OUTREACH PROJECT
Maine, USA: University of Maine, Agroforestry Outreach Project (financed by USAID)
61 pp. EN XL/HT
ICRAF acc. no: 7373

The study tries to determine the market for wood products of the Agroforestry Outreach Project (AOP) in Haiti. Will peasants be able to sell the harvest from their trees for cash? The determinants of farm gate prices for poles, planks, and charcoal are discussed in this report. Among price determinants common to all three of these wood products are quality, local supply and demand levels, distance of the producer from the market, and bargaining skill and personal relationships of the merchant and producer. Each product also has specific market structures. It is found that the charcoal market is and will remain good, but that the demand for poles and planks will be met soon. The study contains useful data on marketing costs and market structures in Haiti.

TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: country
TREE/SHRUB PRODUCT: poles, timber, charcoal
DATA SOURCE: farm survey, estimates

143
B
MEINSTOCK, J.; VERGARA, N.T. (1987)
LAND OR PLANTS: AGRICULTURAL TENURE IN AGROFORESTRY SYSTEMS
Economic Botany
Vol. 41 No. 2 pp. 312-322 EN XP/ID/PG
ICRAF acc. no: 7508

The distinction between the right to land and rights to plants is often overlooked when viewing agricultural tenure in developing countries. These different types of rights are evaluated in two Asia-Pacific agroforestry systems: one in Indonesian Borneo and the other in Papua New Guinea. Conflicts are discussed between the traditional dichotomy of land and plant rights and government policy. It is concluded that the perceptual separation of land and plant ownership needs to be explored if agroforestry practices are not only to be ecologically and economically feasible but also culturally acceptable.

ECOZONE: humid
TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: region
TECHNOLOGY: boundary planting, trees mixed in annual cropland, trees mixed in perennial cropland
TREE/SHRUB SPECIES: *Hevea brasiliensis, Cocos nucifera, Durio zibethinus*
DATA SOURCE: farm survey, case studies

144
A
MENDOZA, G.A.; CAMPBELL, G.E.; ROLFE, G.L. (1986)
MULTIPLE OBJECTIVE PROGRAMMING: AN APPROACH TO PLANNING AND EVALUATION OF AGROFORESTRY SYSTEMS. PART 1: MODEL DESCRIPTION AND DEVELOPMENT
Agricultural Systems
Vol. 22 pp. 243-253 EN XZ
ICRAF acc. no: 11060

The authors present a conceptual framework for planning and evaluating agroforestry systems through multi-objective programming (MOP) to identify optimal allocation of land to alternative agroforestry systems. These alternatives are classified on the basis of management regimes, with activities occurring in particular planning periods. Land is stratified by site quality. In MOP, the 'optimization' technique leads to a set of solutions which are non-dominated, non-inferior or pareto-optimal, rather than a single 'best' solution. Five major types of MOP techniques are classified: a) generating techniques, b) techniques that require the a priori articulation of preferences, c) techniques that rely on the progressive a posteriori articulation of preferences, d) techniques that accommodate multiple decision-makers and e) techniques designed to generate selected alternatives. A MOP mathematical formulation for agroforestry is

presented. The author notes that one feature of agroforestry not adequately considered in the model is the ecological and economic interaction of woody components and other crops/livestock.

TYPE OF ANALYSIS: economic concepts/methodology, linear programming, non-linear programming
ANALYSIS LEVEL: farm

145
A
MENDOZA, G.A.; CAMPBELL, G.E.; ROLFE, G.L. (1987)
MULTIPLE OBJECTIVE PROGRAMMING: AN APPROACH TO PLANNING AND EVALUATION OF AGROFORESTRY SYSTEMS. PART 2: AN ILLUSTRATIVE EXAMPLE AND ANALYSIS
Agricultural Systems
Vol. 23 pp. 1-18 EN XN
ICRAF acc. no: 7037

The authors present a case study to illustrate the use of multiple objective programming (MOP), using black walnut intercropped with soybeans and winter wheat, fescue seed and hay, fescue hay, and grazing. Data are taken from earlier studies of such systems. A hypothetical forest area is divided into four strata based on site quality. Four cropping systems are evaluated. Objectives are maximization of net present worth (NPW) of each management regime, and maximization of black walnut timber volume. 75 distinct management regimes are analysed and 11 area constraints are identified. This problem is addressed by using four different MOP approaches. The generating technique generates too large a number of potential solutions. The non-interactive method required a prior value judgement by the decision-maker in numerical values. The interactive methods were found to come closest to a desirable decision-making process due to active input from the decision-maker. The 'Modelling of Generating Alternatives' method generates 'useful' or 'practical' alternatives, rather than 'optimal' solutions.

TYPE OF ANALYSIS: economic concepts/methodology, linear programming, non-linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, trees in pasture
TREE/SHRUB SPECIES: *Juglans nigra*
TREE/SHRUB PRODUCT: nuts, timber
LIVESTOCK: cattle
CROP/GRASS: soybean, fescue, wheat
DATA SOURCE: estimates

146
B
MENDOZA, G.A. (1987)
A MATHEMATICAL MODEL FOR GENERATING LAND-USE ALLOCATION ALTERNATIVES FOR AGROFORESTRY SYSTEMS
Agroforestry Systems
Vol. 5 pp. 443-453 EN XZ
ICRAF acc. no: 8131

The author insists that land use allocation for any agroforestry system should address economic, biological/ physical and silvicultural/ ecological concerns. His paper proposes a land use allocation model which treats these concerns as constraints which must be satisfied. This problem is addressed by using the 'Modelling to Generate Alternatives' (MGA) model of multiple objective programming. The method is illustrated with a case study from Verinumbe's work in Nigeria on a linear programming model for hedgerow intercropping. Restrictions are imposed in terms of available farm labour, minimum economic return, availability of operating capital, and a minimum area managed under hedgerow intercropping. A number of satisfactory -rather than optimal- allocation alternatives are generated, each meeting some restrictions imposed by the various concerns.

TYPE OF ANALYSIS: economic concepts/methodology, non-linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala, Cajanus cajan*
TREE/SHRUB PRODUCT: mulch
CROP/GRASS: maize, *Stylosanthes spp*
DATA SOURCE: farm survey, research plot

147
A
MENZIES, N. (1988)
THREE HUNDRED YEARS OF TAUNGYA: A SUSTAINABLE SYSTEM OF FORESTRY IN SOUTH CHINA
Human Ecology
Vol. 16 No. 4 pp. 361-376 EN XP/CN
ICRAF acc. no: 10384

Historical research indicates that successional systems of forest management which follow the pattern of taungya have been used for at least three centuries by the Han population of south China. The resilience of these systems is associated with economic and social factors which have made the cultivations of trees an adaptive strategy of land use for the inhabitants of the highlands of south China. Some of these factors included the development of profitable urban markets for timber in the lowlands, an ideal timber species (*Cunninghamia lanceolata)* which is easy to propagate and manage; the availability of easy transportation to markets by river; and tenure arrangements whereby revenues from harvested timber were divided between tenants and mountain lords; and later through contracts with the state.

Historical evidence of the markedly higher returns from timber production relative to alternative cash crops is presented.

TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: region
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Tectona grandis, Cunninghamia lanceolata*
TREE/SHRUB PRODUCT: timber, poles
DATA SOURCE: unspecified, research plot

148
B
MICHIGAN, UNIVERSITY OF (1982)
AGROFORESTRY IN NIGER: ECONOMIC AND SOCIAL ANALYSIS; RESEARCH PROPOSAL
Ann Arbor, Michigan, USA: University of Michigan, Centre for Research on Economic Development and School of Natural Resources
13 pp. EN XA/NE
ICRAF acc. no: 9961

This research proposal defines critical economic, social, and political issues needed for designing fuelwood and forestry activities in Niger. It looks into the issue of how woodlots could fit into the farming system, and which social, organisational and institutional factors are critical in influencing the adoption by farmers and communities.

ECOZONE: semi-arid
TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: community
TECHNOLOGY: woodlot
TREE/SHRUB PRODUCT: fuelwood
CROP/GRASS: millet

149
A
MINDAJAO, N.M. (1979)
THE ECONOMICS OF AGRO-FORESTRY
Paper presented at the PCARR Agroforestry Symposium, 19-21 Dec 1979, College, Laguna, The Philippines
9 pp. EN XP/PH
ICRAF acc. no: 12166

The formula of net present worth is used to derive an equation of the cost price per unit of wood for a farmer planting trees in a woodlot. An example is given, using tree yield data from an industrial plantation, and cost data from previous research by the author among farmers in Bislig, Surigau del Sur and neighbouring provinces in the Philippines. A table with average discounted (at 16%) costs per cubic meter of wood for trees 1 to 15 years old and for 7 different site indices is

presented. It appears average costs decrease up to year 6 and then increase again, for all sites. This is illustrated with a figure showing the average and marginal costs of wood for one site. The economic conversion age differs by site and is at least 6 years. The economic cost-price varies from 8 pesos for the best land to 65 pesos for the worst. At an interest rate of 10%, the lowest economic conversion age becomes 9 years. It is concluded that if the selling price is at least equal to the per unit cost, tree farming can be a financially sound enterprise.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante, production-function analysis
ANALYSIS LEVEL: farm
TECHNOLOGY: woodlot
TREE/SHRUB SPECIES: *Albizia falcataria*
DATA SOURCE: farm survey, case studies

150
B
MISHRA, J. (1979)
AGRI-SILVICULTURE - A SYSTEM HOLDING GREAT PROMISE FOR SOCIAL FORESTRY IN BIHAR
The Indian Forester
Vol. 105 No. 9 pp. 638-643 EN XP/IN
ICRAF acc. no: 12180

This paper presents the preliminary economic analysis of ten experiments carried out at the Mandar Research Station in Bihar, India, on establishment of social forestry plantations with food crops, oil seeds, tubers, medicinal plants and fibre/pulpwood intercropped with dalbergia and teak. Details on establishment of trees and crops and management are presented. A summary of total expenditures, total crop yield, gross revenue per hectare and net income per hectare is given for maize, ragi, and paddy rice intercrops. The author concludes that farmers will be more encouraged to plant trees under this taungya system.

TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Dalbergia sissoo, Tectona grandis*
TREE/SHRUB PRODUCT: timber, fuelwood, poles
TREE/SHRUB SERVICE: soil conservation
DATA SOURCE: research plot

151
B
MITTAL, S.P.; PRATAP SINGH (1989)
INTERCROPPING FIELD CROPS BETWEEN ROWS OF LEUCAENA LEUCOCEPHALA UNDER RAINFED CONDITIONS IN NORTHERN INDIA
Agroforestry Systems
Vol. 8 pp. 165-172 EN XP/IN ICRAF acc. no: 10252

A field study was conducted on hedgerow intercropping for tree-fodder production in northern India during six years. Pure hedges, intercrops and pure field crops were compared at different spacings; all crops received N and P fertilizer each year. An economic analysis was carried out on the trial results. For two years, only fodder was obtained from leucaena; in the third year fuelwood was harvested. Crops, although supplied with N and P fertilizer each year, showed a reduction in output with 25-30% when interplanted with leucaena hedges. Net returns are calculated for the four years when both fodder and fuelwood were available. Mean net returns are significantly different between the treatments. Pure leucaena at close spacing gives higher returns than at wide spacing. Leucaena with cluster bean gives the highest returns, similar to a pure crop of cluster bean (at prevailing market prices). The intercropping treatments with maize and black gram give higher net returns than pure leucaena at wide spacing or pure crops.

ECOZONE: semi-arid
TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood, fodder
CROP/GRASS: maize, black gram, cluster bean
DATA SOURCE: research plot

152
A
MOL, S. (1989)
AGROFORESTRY AND SMALL FARMERS: SOME ISSUES ON RISK AND UNCERTAINTY
Working Paper No.56. Nairobi: ICRAF
11 pp. EN XZ
ICRAF acc. no: 11220

The author reviewed papers on economic analysis of agroforestry to evaluate the treatment of risk. Of 103 papers reviewed, only 13 refer to risk issues, in cost-benefit analysis (4), in project analysis (4), or general issues (5). Agroforestry systems may reduce or increase farmer risks depending upon biological and climatologic factors, constraints of labour, capital and land, price fluctuations and institutional or socio-cultural factors. Examples are presented from available case material. The author suggests that researchers assess risk in diagnosis and design exercises, collect empirical data on risk from farmers, measure risk in on-station experiments, and incorporate risk and uncertainty in economic appraisals.

TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: farm

153
B
MOORE, R. (1985)
MANAGEMENT OF FORESTS COMBINING PINES AND GRAZING IN AUSTRALIA
Proceedings from the Institute of Foresters of Australia 1985 Conference, Perth, Australia
pp. 465-476 EN XP/AU/NZ
ICRAF acc. no: 9844

The author provides an excellent review of the management options and considerations for grazing pasture under pine plantations, using data from Australia. The extent of this system now ranges from 35% of pine plantations in Queensland to a negligible amount in Tasmania. The author discusses the development of tree establishment in already pastured sites, and pasture establishment in pine plantations. These range from dense plantations which can only be grazed for 10 years to widely spaced agroforestry stands where high pruning is practised to allow continuous grazing. He notes the benefits from grazing in forests include reduction of fire risk, improved tree growth, easier access to trees, better rapport with the community, and extra income for both Forest Services and farmers. The system involves extra management factors compared to the forestry alternative: farmers need continuous high quality pasture, and stock-handling facilities. Foresters need protection of trees. The paper discusses management methods that have been developed in relation to pasture establishment, grazing management, tree management and administration.

ECOZONE: temperate, lowlands
TYPE OF ANALYSIS: economic concepts/methodology, agroforestry sector analysis
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Pinus spp*
TREE/SHRUB PRODUCT: timber
TREE/SHRUB SERVICE: shade
LIVESTOCK: goats, cattle, sheep

154
B
MRUTHYUNJAYA (1981)
BENEFIT-COST CONSIDERATIONS IN AGROFORESTRY
Lecture delivered at the Summer Institute on Agroforestry of Arid and Semi-Arid Zones. Jodhpur, India: Central Arid Zone Research Institute
6 pp. EN XP/IN

A cost-benefit analysis is desirable for agroforestry investments. The author explains the principles of such an analysis. A definition of benefits and costs is given and the difference between intangible and tangible benefits and costs is explained. Only the latter can be expressed in monetary terms. Likewise, a distinction can be made between direct and indirect costs and benefits. All should

be included in a cost-benefit analysis. Other requirements for the analysis are summed up, including discounting techniques. The paper concludes with an illustration of the cash flow and net present value from a 79- hectare woodlot intercropped during the first year, which is derived from the literature (Srivastava and Pant, 1979).

ECOZONE: arid, semi-arid lowlands
TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-ante and ex-post
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Eucalyptus spp*
DATA SOURCE: unspecified

155
B
MUKHEBI, A.W.; ONIM, J.F.M.; OYUGI, L. (1985)
ECONOMICS OF INTERCROPPING MAIZE WITH FORAGE CROPS IN SMALL-SCALE FARMING SYSTEMS IN WESTERN KENYA
Proceedings of the Second PANESA Workshop on LIVESTOCK Feed Resources for Small-Scale Livestock Producers, 11-15 Nov 1985, Nairobi
pp. 220-230 EN XA/KE
ICRAF acc. no: 8150

Maize was planted solely and as an intercrop with Sudan grass (*Sorghum sudanese*), pigeon pea and *Sesbania sesban* in trial plots at Maseno, Kaimosi and Masumbi (west Kenya). For each combination, one plot was treated with fertilizer (40 kg/ha) and one plot was left without. Partial budgeting was applied for economic evaluation of the biological (dry matter) data. Incremental benefits and incremental costs for each crop treatment at each site were calculated. The resultant incremental benefit/cost ratio was used as the choice criteria for ranking the various maize-forage intercrops. Results varied per site but, overall, fertilizer application was more profitable than applying no fertilizer at all the sites for both pure-stand maize and maize intercrops. It is concluded that while intercropping maize with forage crops in some areas yields greater economic returns than pure-stand maize in their areas, it may lead to economic loss in other areas depending upon soil fertility and rainfall conditions. Sources of data other than those from research plots are not specified.

ECOZONE: humid highlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Sesbania sesban*
TREE/SHRUB PRODUCT: fodder
TREE/SHRUB SERVICE: soil-fertility improvement
CROP/GRASS: maize, pigeon pea, sorghum, *sorghum sudanese*
DATA SOURCE: research plot, unspecified

156
A
MUSSAK, M.F.; LAARMAN, J.G. (1989)
FARMERS' PRODUCTION OF TIMBER TREES IN THE CACAO-COFFEE REGION OF COASTAL ECUADOR
Agroforestry Systems
Vol. 9 pp. 155-170 EN XL/EC
ICRAF acc. no: 11049

The coastal region of Ecuador produces cacao and coffee and, increasingly, industrial wood from shade trees and pasture trees. This paper reports findings from a survey of 122 farmers in the region. The survey indicates an abundance of land for growing farm trees and excellent regeneration of many species on farms. Farm owners gave two principal reasons for sales of farm trees: 1) periods of depressed farm income and a consequent need to generate cash flow from additional sources, and 2) cutting cycles to replace mature shade trees in the plantations. Current stocking of trees is well below potential, and fewer than half of interviewed farmers deliberately managed trees for sale as timber. Only 2.2% of gross farm income derived from tree sales, although over half of surveyed farmers had sold trees to industrial buyers at least once. Constraints for production and sales of farm trees for timber include risks of damage to coffee and cacao; perceived incompatibilities with current farming practices; inadequate methods of classification and pricing of farm trees; and insufficient knowledge of the industrial uses of farm trees by agricultural extensionists.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: region, farm
TECHNOLOGY: trees mixed in perennial cropland, trees in pasture
TREE/SHRUB SPECIES: *Cordia alliodora, Triplaris cumingiana, Erythrina poeppigiana, Cedrela odorata, Chlorophora tinctoria, Anacardium excelsum, Theobroma cacao, Citrus spp*
TREE/SHRUB PRODUCT: timber, fuelwood, fruit, nuts
TREE/SHRUB SERVICE: shade
DATA SOURCE: farm survey

157
B
NAIR, P.K.R. (1979)
INTENSIVE MULTIPLE CROPPING WITH COCOnuts IN INDIA - PRINCIPLES, PROGRAMMES AND PROSPECTS
Berlin: Verlag Paul Barey
123 pp. EN XP/IN
ICRAF acc. no: B1060

In this book the possibilities for increasing agricultural production from the areas planted with coconuts under small farmers' conditions are described. Use is made of data from the Central Plantation Crops Research Institute in Kerala, India. There is one chapter on agro-economics in which farm management data for

rainfed intercrops in an established coconut plantation are presented. Monthly costs and income of a coconut and cacao combination as well as a multistoreyed crop combination are given. For different intercropping possibilities net income is compared. Different farm models are drawn up, each showing net income. Employment potentials, gross value and benefit-cost ratio are given for the different combinations, both rainfed and irrigated.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-ante
ANALYSIS LEVEL: research plot, plantation
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Cocos nucifera, Theobroma cacao*
TREE/SHRUB PRODUCT: fruit
CROP/GRASS: cassava, yam, potato, banana, pineapple, pepper
DATA SOURCE: research plot, case studies

158
B
NESARGI, V.S. (1978)
POPLARS, A TREE CROP FOR ECONOMIC REGENERATION OF THE TROPICS
Paper prepared for the Eight World Forestry Congress, 16-20 Oct 1978, Jakarta
7 pp. EN IN/XP
ICRAF acc. no: 1230

Based on 15 years experience with growing poplar in India, it is stated that the species is suitable for cultivation as a source of industrial soft wood and for pulpwood. Cost and benefit data for an agroforestry model yielding matchwood, rice and wheat, are presented. Rotation length is 15 years and planting was phased at a rate of 250 ha per year. The internal rate of return is 25% and sensitive to variations in crop and tree yield as well as early benefits from early tree thinning. It is concluded poplars offer good returns to farmers as a 'rabi' (winter) intercrop due to its deciduous habit in such periods in most tropical and sub-tropical countries. The production potential for production on farm bunds is presented.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Populus deltoides*
TREE/SHRUB PRODUCT: pulpwood
CROP/GRASS: rice, wheat
DATA SOURCE: estimates

159
A
NGAMBEKI, D.S. (1982)
ECONOMIC EVALUATION OF ALLEY CROPPING LEUCAENA-MAIZE
1981 Annual Report, Agricultural Economics. Ibadan, Nigeria: International Institute of Tropical Agriculture
14 pp. EN XA/NG
ICRAF acc. no: 9852

An agro-economic hedgerow intercropping experiment was carried out at the IITA research station in Nigeria during the first and second seasons of 1981. Leucaena was planted at 2 x 0.5 meter. Objectives were 1) to monitor labour and other inputs; 2) assess the effect of leucaena on crop yield; 3) determine economic viability. Other introduced variables were herbicides and nitrogen application. Detailed data on yield of leucaena and maize as well as labour are given, although for the latter it is not shown how they are obtained. The net return, marginal rate of return, and cost-benefit ratio are given, but costs are not specified. It is concluded that although leucaena stands occupy about 20% of the land, and cutting and pruning of leucaena increases yearly labour costs by about 58%, the economic contribution of leucaena are more than 2 times those of nitrogen, 1.25 times those of herbicide-nitrogen and 1.5 times those of leucaena-nitrogen.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch
TREE/SHRUB SERVICE: soil-fertility improvement
CROP/GRASS: maize
DATA SOURCE: research plot

160
B
NGAMBEKI, D.S. (1984)
ECONOMIC AND ON-FARM EVALUATION OF ALLEY CROPPING WITH LEUCAENA LEUCOCEPHALA
1980-1983 Activity Consolidated Report. Ibadan, Nigeria: International Institute of Tropical Agriculture
43 pp. EN XA/NG
ICRAF acc. no: 11059

On-station hedgerow intercropping trial results at IITA are presented for 1981-1983. These include labour data on hedge cutting at different stages of the hedges. Cowpea and maize are compared for their labour inputs and yields with the following treatments: leucaena, fertilizer, herbicide, leucaena- fertilizer, leucaena-herbicide, leucaena-fertilizer-herbicide, and herbicide-fertilizer only. Their economics are compared in terms of net returns per ha, marginal rate of return, and benefit-cost ratio. In 1981 maize-maize with leucaena gave the highest

B/C-ratio but in 1982 the fertilizer-herbicide was highest (1.76). In that year the leucaena treatment alone was lower than the control (B/C ratio of 1.23 and 1.39 respectively). The initial results of the on-farm trials are discussed. There is a brief comparison of returns per unit cost of yam staking between a leucaena cut and carry system and collection of stakes from grassland bushes. It is concluded that the leucaena system has better results but cost specifications are not given. On-farm labour data for planting and weeding leucaena and cutting the hedges after one year of fallow are given. The latter are the same as on-station: 24.3 persondays per ha.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: research plot, farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch, stakes
CROP/GRASS: maize, cowpea
DATA SOURCE: research plot, case studies

161
A
NGAMBEKI, D.S. (1985)
ECONOMIC EVALUATION OF ALLEY CROPPING LEUCAENA WITH MAIZE-MAIZE AND MAIZE-COWPEA IN SOUTHERN NIGERIA
Agricultural Systems
Vol. 17 pp. 243-258 EN NG/XA
ICRAF acc. no: 4248

A study was undertaken in southwest Nigeria to determine the economic viability of the maize and/or cowpea-leucaena hedgerow intercropping system, with and without herbicide or nitrogen application. Data on labour and other input requirements were collected. The labour data are based casual workers hired on a daily task work basis, which resulted in more efficient labour than with regular workers. Trees were cut three times per season or six times per year. The first cutting of the hedges in 1981 including shredding the leaflets took 185 person-hours per ha, which at 15,000 trees per ha is about 80 trees per person-hour. In 1982 the first cutting was done at 150 trees per person-hour in both seasons. In-season pruning productivity varied between 170-360 trees per person-hour. On the average the hedges increased labour inputs by 52% per season but increased yield by 68%. In 1981 the economic contributions of leucaena were higher than those from leucaena-nitrogen, herbicide-nitrogen or herbicide alternatives with a benefit/cost ratio of 1.32. However, in 1982 the ratio was 1.23 which was lower than the control. On average a crop sequence of maize-maize with leucaena gave the best economic returns. Depressing effects of leucaena were observed on cowpea yields.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: research plot

TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch, fuelwood
CROP/GRASS: maize, cowpea
DATA SOURCE: research plot

162
A
NWONWU, F.O.C. (1987)
COST MINIMIZATION THROUGH THE USE OF TAUNGYA SYSTEM IN PULPWOOD PLANTATION ESTABLISHMENT
Agroforestry Systems
Vol. 5 pp. 455-462 EN XA/NG
ICRAF acc. no: 8130

The costs and benefits of the use of three labour alternatives are investigated for gmelina pulpwood plantation establishment in Nigeria: direct permanent, direct casual and taungya labour. The results show that cost per hectare is lowest with taungya labour and highest with permanent labour. Savings in labour costs with taungya are 30% and 47% over casual and permanent labour respectively. The net present value per hectare of investment is highest when taungya labour is used and lowest and negative with permanent labour. The internal rate of return gives a similar picture. Data were collected from the field in the tropical-rainforest area of Nigeria.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Gmelina arborea*
TREE/SHRUB PRODUCT: pulpwood
DATA SOURCE: estimates, farm survey

163
B
O'KTING'ATI, A.; MONGI, H.O. (1986)
AGROFORESTRY AND THE SMALL FARMER: A CASE STUDY OF KILEMA AND KIMA VUNJO IN KILIMANJARO
International Tree Crops Journal
Vol. 3 pp. 257-265 EN XA/TZ
ICRAF acc. no: 6456

The authors describe a system of multiple cropping with trees on the slopes of Mt Kilimanjaro, Tanzania. A survey of 48 farmers was used to collect data on fuelwood use, farm characteristics, livestock, settlement patterns, and trees on farm. The average farm of 0.68 hectare had 21 timber, 10 fodder, and 8 other trees on the farm. The value of timber and poles sold and bought in 1983 is presented, showing net purchases. Merchantable tree volume per farm was 10.3

sq.m. The authors conclude that agroforestry practices have helped to maintain a large and expanding population in an area very prone to erosion and soil degradation.

ECOZONE: humid highlands
TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: farm, region
TECHNOLOGY: trees mixed in annual cropland, trees mixed in perennial cropland
TREE/SHRUB PRODUCT: timber, fodder, fuelwood, fruit, poles
TREE/SHRUB SERVICE: shade
LIVESTOCK: cattle, sheep, goats, poultry
CROP/GRASS: coffee, banana
DATA SOURCE: farm survey

164
B
OLAWOYE, O.O. (1978)
FOOD PRODUCTION IN FOREST AREAS - AN ECONOMIC INVESTIGATION
Ibadan, Nigeria: Rosanno Modern Printers (financed by the Rockefeller Foundation)
55 pp. EN XA/NG
ICRAF acc. no: 1434

This study reviews departmental and traditional taungya and their localities in Nigeria. In the first type, farmers are paid a salary but do not own the crops. Details of management costs and the organization of the schemes are highlighted. The magnitude and types of food produced as well as the number of farmers and size of the farm are discussed. The value of the total amount of food crops in each area is shown. Marketing appears to be much better organized in 'departmental agrisilviculture' where it is arranged by Forest Department officials, than in 'traditional agrisilviculture' where the farmer has to do it alone. Costs for a pure tree plantation making use of paid labour and for a taungya system are shown and compared: non-taungya is about three times more expensive. Departmental taungya seems to improve poverty of rural dwellers to a larger extent than traditional taungya due to the facilities which accompany it. Total income per year is also higher for the first type. Departmental taungya has in the past, however, recruited too many labourers, causing inefficiency and other problems.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-post, agroforestry sector analysis
ANALYSIS LEVEL: farm, region, plantation
TECHNOLOGY: taungya afforestation
CROP/GRASS: maize, cassava, yam
DATA SOURCE: farm survey, estimates

165
B
OPENSHAW, K.; MORRIS, J. (1979)
THE SOCIO-ECONOMICS OF AGRO-FORESTRY
In Chandler and Spurgeon (eds) *International Cooperation in Agroforestry.* Nairobi: ICRAF
pp. 327-352 EN XZ/XA/TZ
ICRAF acc. no: 1547

The author presents costs and benefits of a 0.5 ha woodlot in Kenya to show that agroforestry is an economically attractive investment. Case studies of successful communally-based agroforestry projects in China and South Korea are noted. In Africa some instances of success have been achieved in densely populated areas. It is argued that from the standpoint of anthropological analysis, most agroforestry projects under typical conditions of land-tenure and land-use (including bush fires) in the miombo woodlands of eastern and central Africa are doomed to failure. Measures should be taken to legalise individual landownership to make agroforestry systems, which are profitable on paper, feasible in practice. A table is included with Kenyan figures for annual per caput requirements and prices of alternative sources of energy.

TYPE OF ANALYSIS: economic concepts/methodology, agroforestry sector analysis, cost-benefit analysis ex-ante
ANALYSIS LEVEL: community, farm
DATA SOURCE: estimates, unspecified

166
B
OPENSHAW, K. (1982)
COSTS AND BENEFITS OF PROPOSED TREE PLANTING PROGRAMME FOR SATISFYING KENYA'S WOOD ENERGY REQUIREMENTS
Stockholm, Sweden: The Beijer Institute
134 pp. EN XA/KE
ICRAF acc. no: 3680

Fuelwood is compared to other sources of energy in Kenya. The study concludes that woodfuel is much cheaper than conventional energy sources, while the costs in foreign exchange of fuelwood are also lower. Costs of growing by the Forest Department in Kenya are said to be more expensive than in Tanzania because of low task rates. Detailed input/output models are presented for fuelwood plantations (government-operated), a taungya model with different rotation periods, and other agroforestry systems. Proposed trees and shrubs for the latter are prosopis and leucaena. Recommended short-rotation fuelwood tree/shrubs are calliandra and sesbania.

TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: country
TREE/SHRUB SPECIES: *Prosopis spp, Leucaena leucocephala, Sesbania grandiflora*

TREE/SHRUB PRODUCT: fuelwood, fodder, mulch
CROP/GRASS: maize
DATA SOURCE: estimates, unspecified

167
A
OSEMEOBO, G.J. (1989)
AN IMPACT AND PERFORMANCE EVALUATION OF SMALLHOLDER PARTICIPATION IN TREE PLANTING, NIGERIA
Agricultural Systems
Vol. 29 pp. 117-135 EN XA/NG
ICRAF acc. no: 11217

The economics of tree planting by peasant farmers participating in a rural forestry development programme in Nigeria was investigated. 400-600 trees per hectare were planted between crops in the first year, after which they became part of a eight year fallow. Inputs and outputs of trees and crops were obtained from interviewing a sample of 12 farmers, Forest Department records, and on-farm tree yield measurements. The cash flow and benefit-cost ratios for the agroforestry systems are presented and compared with pure crop and pure tree models. Although the author concludes differently and in spite of the low discount rate used, the data show that for a small farmer this agroforestry system is not any better than the pure crop system.

ECOZONE: sub-humid, semi-arid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: improved tree fallow
TREE/SHRUB SPECIES: *Gmelina arborea, Tectona grandis, Eucalyptus camaldulensis*
TREE/SHRUB PRODUCT: timber, fuelwood
TREE/SHRUB SERVICE: soil conservation
CROP/GRASS: maize, yam, cassava
DATA SOURCE: farm survey, case studies

168
B
PADOCH, C.; CHOTA I.J.; DE JONG, W.; UNRUH, J. (1985)
AMAZONIAN AGROFORESTRY: A MARKET ORIENTED SYSTEM IN PERU
Agroforestry Systems
Vol. 3 pp. 47-58 EN XL/PE
ICRAF acc. no: 5171

The authors present an analysis of a cyclic agroforestry system employed by non-tribal 'Mestizo' farmers in Tamshiyacu in the Peruvian Amazon. The system differs from traditional shifting cultivation by a longer period of clearing the burned plot and by planting some long lasting fruit trees as well as crops. Farmers usually have several agroforestry plots in operation at any time. The plots produce

charcoal, as well as annual, semi-perennial, and perennial crops for local consumption and for a regional market. The sale of these products provides a substantial and steady cash income for farmers with such agroforestry plots and their average income appears to be among the highest in the region (up to US$ 5000). Estimated production figures for major commercial crops grown in a one hectare plot made in six to seven-year fallow are shown. Although production cost calculations need further research, preliminary data indicate that up to 40% of gross income from the sale of fruits may be paid to workers by households short of labour. Extending this system would require an improvement of transport systems throughout the Amazon, since local demand is limited.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: region
TECHNOLOGY: taungya afforestation, improved tree fallow
TREE/SHRUB SPECIES: *Poraquieba sericea, Bactris gasipaes, Anacardium occidentale, Chrysophyllum cainito, Pourouma cecropiaefolia, Inga edulis, Bertholletia excelsa, Astrocaryum chambira, Heteropsis jenmani, Mauritia flexuosa*
TREE/SHRUB PRODUCT: fruit, timber, fiber
TREE/SHRUB SERVICE: shade
CROP/GRASS: cassava, rice, plantain, pineapple
DATA SOURCE: farm survey, estimates

169
B
PARAFINA, S.S. (1989)
ASSESSING ENVIRONMENTAL BENEFITS IN AGROFORESTRY PROJECTS
Unpublished draft. Miami, USA: University of Florida, Department of Geography
26 pp. EN XZ
ICRAF acc. no: 11058

This theoretical paper proposes a methodological framework for analysing and including environmental benefits in economic analysis of agroforestry systems. First an overview of the production aspects of agroforestry and their methods of analysis is given. Distinction is made between productive and service roles of agroforestry. It is said that interdependency between system components should be stressed in economic analysis in order to capture environmental benefits. Interaction must be studied empirically in order to determine the production function. Secondly, a static mathematical model for economic analysis of environmental benefits is given. It is based upon the concept of external economies reflecting interdependence among enterprises. The latter are represented in non-separable production functions. An example is given of such a function with leucaena hedgerows and maize isolating the interaction effects. The author admits that the data requirements for these functions necessitate very intensive agronomic research.

TYPE OF ANALYSIS: economic concepts/methodology, production function analysis

ANALYSIS LEVEL: project
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch
TREE/SHRUB SERVICE: soil-fertility improvement
CROP/GRASS: maize

170
B
PATEL, V.J. (1983)
A NEW STRATEGY FOR HIGH DENSITY AGRO-FORESTRY
Bombay, India: Economic Intelligence Service, Centre for Monitoring Indian Economy
61 pp. EN XP/IN
ICRAF acc. no: 4396

The promising and successful phenomenon of high-input and high-density tree plantations (0.6x0.6 meter) in Bhavnagar District, Gujarat, India is described in this study. Biomass from such plantations in research plots was 3-5 times higher than in plots with usual densities. Three chapters in this study are dedicated to assessing the financial aspects of such woodlots on 0.4 hectare of a farmers' field. Investment and maintenance costs are considerable (total Rupees 17,500) since fertilization, irrigation, and weeding are required. After the fourth year 3,000 trees can be cut yearly, of which most could be sold as poles, with firewood as a by-product. This would result in an income four times higher than agricultural crops or conventional woodlots. A loan is required for the high investment costs but, according to the author, the analysis shows no risk of non-repayment. Furthermore, the fuelwood crisis in the area would be solved. A separate analysis is made for a tree plot of 0.08 hectare for marginal farmers, with the same positive results.

ECOZONE: semi-arid
TYPE OF ANALYSIS: partial budgeting ex-ante
ANALYSIS LEVEL: research plot, farm
TECHNOLOGY: woodlot, boundary planting
TREE/SHRUB SPECIES: *Eucalyptus spp, leucaena leucocephala*
TREE/SHRUB PRODUCT: poles, fuelwood, pulpwood
DATA SOURCE: research plot, estimates

171
B
PORRAS, J.M.; LUYANO, G.B. (1974)
IS IT POSSIBLE TO INCREASE THE PRODUCTIVITY OF TROPICAL FORESTRY IN MEXICO THROUGH THE TAUNGYA SYSTEM?
(Es Posible mediante el Sistema Taungya Aumentar la Productvidad de los Bosques Tropicales en Mexico?)
Boletin Técnico No.39. Mexico: Secretaría de Agricultura y Ganadería, Subsecretaría Forestal y de la Fauna, Instituto Nacional de Investigaciónes Forestales
47 pp. ES XL/MX
ICRAF acc. no: 1840

A description and analysis of the results of seven years of work in an experimental plantation of the taungya type are given. The plantation is located on an area of 500x500 meters, in the experimental forest 'El Tormento', State of Campeche (Mexico). This was intercropped with maize during the first two years. Six treatments were applied varying the space between each species and the form of plantation and sowing. Detailed yield, labour and financial data are presented.

ECOZONE: sub-humid
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Swietenia macrophylla, Cedrela mexicana, Cordia alliodora*
TREE/SHRUB PRODUCT: timber
CROP/GRASS: maize
DATA SOURCE: research plot, estimates

172
B
PRINSLEY, R.T. (1989)
AGROFORESTRY FOR SUSTAINABLE DEVELOPMENT - ECONOMIC IMPLICATIONS
Proceedings of the workshop held in Swaziland, April 1989. London: Commonwealth Science Council and Mbabane, Swaziland: Ministry of Agriculture and Cooperatives
141 pp. EN XA
ICRAF acc. no: B06262

This publication includes the proceedings of the workshop held in Swaziland by the same title. It is composed of four parts. The first presents summary reports of working groups, covering topics of: why farmers plant trees, application of cost-benefit analysis (CBA) to agroforestry, short-term technical issues, modelling and long-term changes, economic and financial analysis in rapid rural appraisal, the potential of the SCUAF soil model in CBA, and guidelines for CBA of agroforestry. The second part looks at ICRAF's approach to the integration of economics in agroforestry research programmes. The third part presents project

proposals for economic research in Zambia, Malawi, Lesotho, and Botswana. The fourth and last part presents case studies of economic analysis of agroforestry trials in Zambia and a group agroforestry project in Botswana.

TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post, agroforestry sector analysis
ANALYSIS LEVEL: farm, community, project
DATA SOURCE: case studies

173
A
PRINSLEY, R.T. (ED) (1990)
AGROFORESTRY FOR SUSTAINABLE PRODUCTION: ECONOMIC IMPLICATIONS
London: Commonwealth Science Council
417 pp. EN XZ
ICRAF acc. no: B06240

This volume contains the papers presented at the Commonwealth Science Council's meeting on 'Agroforestry for Sustainable Development: Economic implications' in Swaziland in 1989. Participants included natural scientists, social scientists and economists. The approach is multi-disciplinary. Part I contains a keynote paper by Stocking, Bojö and Abel on adapting cost-benefit analysis for agroforestry. Part II has four chapters. The first is on incentives for agroforestry, from the households' point of view with case studies from Kenya, Sudan and Zimbabwe, and an overview paper on household food security. The second chapter is on technical inputs to economic analysis, with case studies focusing primarily on problems of valuing service functions from trees related to soil fertility and conservation. Chapter three presents a spreadsheet approach for economic modelling of agroforestry systems. The fourth chapter on economics for sustainable production presents two theoretical papers on evaluation of sustainability. Some of the papers in this volume have been entered separately in this bibliography.

TYPE OF ANALYSIS: cost-benefit analysis ex-ante, cost-benefit analysis ex-post, agroforestry sector analysis, economic concepts/methodology
ANALYSIS LEVEL: farm, region, research plot

174
A
RAINTREE, J.B.; TURAY, F. (1980)
LINEAR PROGRAMMING MODEL OF AN EXPERIMENTAL LEUCAENA-RICE ALLEY CROPPING SYSTEM
Research Briefs Vol. 1 No. 4. Ibadan, Nigeria: International Institute of Tropical Agriculture
pp. 5-7 EN XA/SL
ICRAF acc. no: 2997

A linear programming model is tested to evaluate the economic attractiveness of an experimental leucaena-rice hedgerow-intercropping system. The model is used to explore the relative profitability of various rice growing activities at 0, 20, 40, 60, 80, 100 kg elemental nitrogen (N)/ha from three different sources: urea, ammonium-sulphate and in situ Leucaena hedgerows. The model suggested it was more profitable to grow rice with N from leucaena hedgerows than from either of the two mineral N sources. The economically optimal proportions are 0.37 ha of leucaena hedgerow to 1.28 ha alley-grown rice.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch
CROP/GRASS: rice
DATA SOURCE: unspecified, research plot

175
A
RAINTREE, J.B. (1983)
LANDUSE AND LABOUR INTENSITY: FACTORS AFFECTING THE ADOPTABILITY OF CONSERVATION FARMING PRACTICES UNDER CONDITIONS OF POPULATION PRESSURE
Paper prepared for the Workshop on Conservation Farming, 17-21 Jan 1983, Colombo, Sri Lanka
8 pp. EN XA/KE
ICRAF acc. no: 11206

The design of technologies which intensify agricultural land-use and at the same time preserve the ecosystem has been difficult. However, zero-tillage or agroforestry practices seem to be able to bring benefits of conservation measures within farmers' planning horizon, and therefore increase its adoptability. The author explains why the adoption of increasingly intensive technologies is an orderly phenomenon which is part of the response of traditional farmers to increasing population pressure. The task for technology developers and extensionists is to match up the labour requirements and land-use intensities of candidate technologies with the corresponding levels of labour availability and land-use intensity appropriate to the farming system. Therefore, if agroforestry technologies are introduced it would be best to use a phased approach to intensification and develop a succession of technologies. This is illustrated with an example from Kenya where the following sequence of agroforestry technologies with increasing population would be useful: coppiced woodlot with taungya intercropping, hedgerow intercropping with fallow, continuous hedgerow intercropping, continuous multistorey intercropping. The usefulness of reliable labour data for the above analysis is stressed.

ECOZONE: sub-humid highlands
TYPE OF ANALYSIS: economic concepts/methodology, agroforestry sector analysis
ANALYSIS LEVEL: farm

176
A
RAINTREE, J.B. (1983)
BIOECONOMIC CONSIDERATIONS IN THE DESIGN OF AGROFORESTRY SYSTEMS
In P.A. Huxley (ed) *Plant Research and Agroforestry.* Nairobi: ICRAF
pp. 271-289 EN XZ/XA/SL
ICRAF acc. no: 6068

Productivity of agroforestry (AF) systems cannot be assessed using conventional measures of productivity in monocultural fields. Indices such as the Land Equivalent Ratio can be useful, but the ultimate unit of evaluation in AF is the enterprise, not the field. Returns to the most limiting factor are crucial. The author argues that the relationships between trees and their understorey intercrops can be competitive, complementary, supplementary, or some composite of these. Which of these will dominate depends also on which growth factors are limiting for the respective components under realistic field conditions. An analysis of interactional effects indicates that certain highly promising AF complementaries are significant only under low-input production conditions. Therefore the author states that unless AF research concentrates on the low-input conditions typical of the majority of the farmers, AF intercropping potentials will remain seriously underdeveloped. The main bioeconomic principles for a decision on the optimum number of trees are presented. Budgeting techniques are discussed and an illustration is given of a linear programming model with rice and leucaena in Sierra Leone. The latter is seen as a practical bioeconomic design tool in AF.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: economic concepts/methodology, linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, hedgerow intercropping
DATA SOURCE: unspecified, research plot

177
B
RANGANATHAN, R.; FAFCHAMPS, M.; WALKER, T.S. (1989)
EVALUATING BIOLOGICAL PRODUCTIVITY IN INTERCROPPING SYSTEMS WITH PRODUCTION POSSIBILITY CURVES
Document No. 882. Andhra Pradesh, India: ICRISAT, Resource Management Program, Economics Group
36 pp. EN XP/IN
ICRAF acc. no: 9857

The author presents an analytical procedure for evaluating trade-offs in biological productivity in intercropping experiments, based on the economic concept of production possibilities curves. This is also applicable to some agroforestry technologies. Yield trade-off between species is evaluated by plotting yields on a graph. The shape of the curve passing through a scatter of mean treatment-yield observations indicates whether the two crops are competitive, independent, or complementary. A 'global' index of biological productivity is defined and can be evaluated at different price ratios between the crops. Computation procedures for the index are described, and examples shown from three sets of intercropping experiments at ICRISAT, including one of leucaena with sorghum and pigeon pea. Implications for experimental research and extension are discussed. The index is compared to the alternative land equivalent ratio.

ECOZONE: semi-arid lowlands
TYPE OF ANALYSIS: production-function analysis
ANALYSIS LEVEL: research plot
TECHNOLOGY: trees mixed in annual cropland, hedgerow intercropping
TREE/SHRUB SPECIES: *Cajanus cajan, Leucaena leucocephala*
TREE/SHRUB PRODUCT: fodder
CROP/GRASS: sorghum, millet, groundnut
DATA SOURCE: research plot

178
B
RAO, N.V.; REDDY, B. (1988)
COMPONENTS OF INCOME AND CHANGES IN SHIFTING CULTIVATION IN WEST GARO HILLS
Paper presented at the Review and Reappraisal Seminar on Shifting Cultivation, 13-14 May 1988, Shillong, India. N-E India Council for Social Science Research
10 pp. EN XP/IN ICRAF acc. no: 9845

This paper concerns a study of income components of tribal farmers and changes in shifting cultivation in West Garo Hills District of Meghalaya, India. 44 farmers, from two relatively progressive villages and two others, were selected and surveyed. A detailed analysis of the components of gross income, cash income, and farm size in the shifting cultivation (jhum) plots are given. It is concluded that the importance of income from jhum cultivation in the gross and cash incomes of the tribal farmers is still significant. However, the degree of dependence on jhum cultivation in progressive villages is less than in the two others (63 vs. 69%). Ginger provides the dominant source of income. The study does not provide data on costs, labour or tree species.

TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: farm, community
TECHNOLOGY: improved tree fallow
TREE/SHRUB PRODUCT: timber, fruit
LIVESTOCK: bees, pigs, poultry, cattle
CROP/GRASS: pineapple, banana, rice
DATA SOURCE: farm survey

179
B
RATHAKRISHNAN, L. (1987)
RELATIVE ECONOMICS OF TREE AND AGRICULTURAL CROPS IN PONDICHERRY UNION TERRITORY
Unpublished draft
6 pp. EN XP/IN
ICRAF acc. no: 11057

In Karnataka and Gujarat, Indian farmers have increasingly converted their cropland to tree-growing. This has resulted in reduced employment for agricultural labourers. This paper tries to identify economic reasons for this change. It compares net returns from annual crops with casuarina trees. Net returns are higher for sugercane and paddy than the annualized net returns for casuarina (3-4 or 5 year rotation cycle). The latter are, however, higher than the outcome for 'dry' crops like groundnut. Reasons farmers gave for preferring trees are presented: water and labour problems, sandy soil, assured return for tree crops (less risk). The author does not try to support these arguments with economic calculations. Cost and return figures are not specified. Data are from a single visit survey of 30 farmers.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, woodlot
TREE/SHRUB SPECIES: *Casuarina spp*
TREE/SHRUB PRODUCT: fuelwood
TREE/SHRUB SERVICE: soil-fertility improvement, soil conservation
CROP/GRASS: rice, sugarcane, groundnut
DATA SOURCE: farm survey

180
B
REDDY, Y.; KORWAR, G. (1985)
A COMPARATIVE ECONOMIC EVALUATION OF AGRO-FORESTRY, SILVO-AGRICULTURE AND SILVO-PASTORAL SYSTEMS IN DRYLANDS
Agricultural Situation in India, Nov 1985 (reprint). New Delhi: Ministry of Agricultural and Rural Development, Department of Agriculture and Cooperatives, Directorate of Economics and Statistics.
pp. 705-708 EN XP/IN
ICRAF acc. no: 6297

Economic evaluations were made of several agroforestry systems, i.e. hedgerows with *Acacia tortilis*, hedgerow intercropping with *Leucaena leucocephala* and leucaena trees in pasture in the Hyderabad-research project (India). The technologies are, however, not described in detail. All these systems were found to be economically viable. The corresponding benefit/cost ratios were 1.45, 1.29 and 2.25. Detailed cost (including labour) and return data are calculated for the 10-year project period.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: trees in pasture, hedgerow intercropping, trees mixed in annual cropland
TREE/SHRUB SPECIES: *Acacia tortilis, Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood, fodder
TREE/SHRUB SERVICE: soil conservation
CROP/GRASS: sorghum, pigeon pea, castor, *Cenchrus ciliaris, Stylosanthes spp*
DATA SOURCE: research plot

181
B
REICHE, C. (1984)
ECONOMIC DATA TAKING AND PRACTICAL ANALYSIS IN AGROFORESTRY SYSTEMS
(Obtención y Analysis Practico de Datos Económicos en Sistemas Agroforestales)
Paper presented at the International Short Course 'Agroforestry for the Humid Tropics', CATIE, Turrialba, Costa Rica
pp: 9 ES XL
ICRAF acc. no: 7063

A summary is presented of the methodological process developed by CATIE's Firewood Project to obtain cost data and to economically analyse firewood plantings, including agroforestry systems. A simple form is presented for the daily registration of labour and material inputs. Where the farmers participate in management of the plantings the form is to be filled in by them, or, if this is not possible, by a technician visiting the farm regularly. Four phases in such a study are outlined: 1) describe activities and collect data; 2) classify and standardize the activities; 3) analyse data; 4) prepare a technical and economic description of each feasible alternative. Additional forms needed in the exercise are provided, including a form describing activities and corresponding costs and a form to determine productivity and control of activities by sampling.

TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-post
ANALYSIS LEVEL: farm

182
A
REICHE, C. (1987)
ADVANCES IN ECONOMIC STUDIES OF AGROFORESTRY plantationS IN CENTRAL AMERICA
In J.W. Beer, H.W. Fassbinder and J. Heuveldop (eds) *Advances in Agroforestry Research; Proceedings of a Seminar.* Turrialba, Costa Rica: CATIE
pp. 338-345 EN XL/CR/HN
ICRAF acc. no: 9428

This document shows certain aspects of the cost of firewood production from agroforestry systems in Central America. Data have been systematically collected within the framework of CATIE's Firewood Project. Preliminary results show that (unspecified) production costs in temporary nurseries are less than in permanent nurseries, but differences between countries are large. Detailed establishment costs for small woodlots with and without intercropping in the first year are presented. One such system with eucalyptus (at 2x2 meter) is analysed in detail, and its net present value, benefit/cost ratio and internal rate of return are shown. These indicate small differences between the pure tree system and the one intercropped during the first year. Results of a documented economic evaluation of live fences in Honduras is given, showing high establishment costs due to wiring and other materials. But the outcome was favourable compared to fencing with dead posts.

ECOZONE: humid
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, woodlot, live fence
TREE/SHRUB SPECIES: *Eucalyptus saligna, Gliricidia sepium*
TREE/SHRUB PRODUCT: fuelwood
TREE/SHRUB SERVICE: fencing
DATA SOURCE: case studies, estimates

183
B
REICHE, C. (1988)
SOCIO-ECONOMIC APPROACH AND ANALYSIS OF AGROFORESTRY SYSTEMS APPLIED ON DEMONSTRATION FARMS IN CENTRAL AMERICA
Proceedings of a Symposium on 'Fragile Lands in Latin America'.
Turrialba, Costa Rica: CATIE
24 pp. EN XL/CR/SV/GT
ICRAF acc. no: 11184

The author presents the approach of CATIE's Tree Crop Production Project for establishing agroforestry demonstration plots/farms in Central America. The framework includes: 1) area selection and assessment and farm selection; 2) diagnosis of selected farms; 3) ex-ante assessment; 4) farm production plan with farmer; 5) dynamic diagnosis to obtain and monitor socio-economic and production variables to evaluate performance; 6) ex-post analysis. Of the 45 farms planned, 30 have been established. Fourteen MPT species were used based on prior on-farm/on-station screening. Farm-level cost-benefit analyses calculate establishment costs, cash flow, rate of return, and net present value, but are not reported here. A manual has been developed for farm monitoring. Plans exist to expand to community/regional evaluation.

ECOZONE: humid
TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm, region

TECHNOLOGY: woodlots, taungya afforestation, live fence, trees mixed in annual cropland, trees mixed in perennial cropland, windbreak, trees in pasture
TREE/SHRUB SPECIES: *Bombacopsis quinata, Cupressus lusitanica, Gmelina arborea, Tectona grandis, Pinus caribaea, Acacia mangium, Caesalpinia velutina, Casuarina equisetifolia, Eucalyptus camaldulensis, Leucaena leucocephala*
TREE/SHRUB PRODUCT: timber, fuelwood, fodder
TREE/SHRUB SERVICE: soil conservation, soil-fertility improvement, fencing, wind protection
LIVESTOCK: cattle
CROP/GRASS: coffee, maize, beans, rice

184
B
REICHE, C. (1988)
PROPOSED METHODS FOR QUANTIFYING THE ECONOMICS OF MULTIPURPOSE TREE SYSTEMS
Paper presented at a Workshop on Database Management Applications in Forestry Research, June 20-25 1988, CATIE, Turrialba, Costa Rica
8 pp. EN XL
ICRAF acc. no: 9956

The paper explains the socio-economic research carried out by the Madeleña Project in Cental America in order to design suitable production systems and management recommendations for multipurpose tree systems. The need for socio-economic information is explained, then an overview of the major end-users of a socio-economic data set and the information required by each are given. Different variables to be monitored are shown, as well as methods of data collection. Difficulties to be overcome in information gathering and possibilities for model development are presented.

ECOZONE: humid/sub-humid highlands/lowlands
TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: region, project

185
B
ROCKENBACH, O.C. (1980)
BIO-SOCIO-ECONOMIC ANALYSIS OF THE FORESTRY COMPONENT IN AN AGROSILVOPASTORAL SYSTEM IN THE TURRIALBA AREA, COSTA RICA
(Analisis Biosocioeconómico del Componente Forestal en una Explotación Agrosilvopastoril en el Area de Turrialba, Costa Rica)
Paper presented at the International Short Course 'Agroforestry for the Humid Tropics', CATIE, Turrialba, Costa Rica
16 pp. ES XL/CR
ICRAF acc. no: 11210

A detailed analysis of costs and benefits of the thinning of 80 eucalyptus within an agroforestry system on a small farm is presented. The results only refer to the cost of felling the tree and carrying it to the sawmill. Costs of planting and maintenance expenses are not calculated.

ECOZONE: sub-humid
TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Eucalyptus deglupta*
TREE/SHRUB PRODUCT: timber

186
A
ROLA, W.R. (1989)
IMPACT ASSESSMENT OF THE JALA-JALA AGROFORESTRY AREA: A MULTI-DIMENSIONAL APPROACH
In E.R. Ponce; R.S. Salazar; A.B. Zerrudo (eds) *Sustaining Upland Development; selected papers - second national seminar workshop on research in the uplands.*
Manila: De la Salle University
pp. 185-203 EN XP/PH
ICRAF acc. no: 7368

Data were collected from three sites in the Integrated Social Forestry Program in the Philippines, which promotes, among other technologies, planting of leucaena for cash between crops. Socio-economic information are from a farm survey and environmental data from field measurements. Data include tenurial status, income, labour use, soil fertility and organic matter content of both agroforestry and non-agroforestry soils. A regression analysis integrating these multi- disciplinary aspects is carried out. It shows the positive impact of tenure status on the number of leucaena planted for sale, which in turn relate strongly to higher income, more labour use and less erosion. Other relations found are not causal and basically derive from these.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: regression analysis
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: timber, poles
TREE/SHRUB SERVICE: soil-fertility improvement
DATA SOURCE: farm survey

187
B
ROMM, J (1980)
ASSESSING THE BENEFITS AND COSTS OF SOCIAL FORESTRY PROJECTS
The Indian Forester
Vol. 106 No. 7 pp. 445-455 EN XP/IN
ICRAF acc. no: 3204

Some of the theoretical concepts for analysing communal forestry projects are discussed. The author states that the objectives of such projects are two-fold: to save future forest yield and to improve village well-being. A relationship needs to be established therefore between plantation productivity and forest preservation. These savings have to be valued in terms of benefits which would otherwise be foregone (including watershed protection) from now into the future. It elaborates on the costs and benefits of social forestry projects using the opportunity cost principle. It also proposes a three-tier mode of analysis to account for the distributive requirements of project viability with benefit/cost estimation: for the project as a whole, as perceived by the Forest Department and as perceived groups and villages involved.

TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-ante
ANALYSIS LEVEL: community, plantation, project
TECHNOLOGY: woodlot

188
A
RUEDENAUER, M.; IMBORIBOON, N.; KUANTHAM, A. (1987)
ECONOMICS OF THE FOREST SECTOR IN THREE LAND RESETTLEMENTS IN NORTH AND NORTHEAST THAILAND: AGROFORESTRY SYSTEMS WITH *E. CAMALDULENSIS* ON PRIVATE LAND
Bangkok: Thai-German Land Settlement Promotion Project, Department of Public Welfare
11 pp. EN XP/TH
ICRAF acc. no: 9848

The costs and revenues of boundary planting and woodlots in three land resettlements in North and Northeast Thailand are analysed. Planting of *Eucalyptus camaldulensis* in the marginal and erosion prone farmland is a highly profitable enterprise at farm level, even on a very small scale. The authors also conclude that labour demands are concentrated in the dry season when there is hardly any alternative occupation. On the national level, promotion of small scale growing of *E. camaldulensis* for charcoal production is equally profitable, especially if the indirect benefit of reduced illegal logging for charcoal production is taken into account.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: farm, country

TECHNOLOGY: boundary planting, woodlot
TREE/SHRUB SPECIES: *Eucalyptus camaldulensis*
TREE/SHRUB PRODUCT: charcoal
DATA SOURCE: estimates, unspecified

189
B
SCHERR, S.J. (1987)
SETTING PRIORITIES FOR AGROFORESTRY RESEARCH AND DEVELOPMENT: POTENTIAL CONTRIBUTIONS OF ECONOMICS RESEARCH
Working Paper No.15. Nairobi: ICRAF
No. 51 23 pp. EN XZ
ICRAF acc. no: 7997

The author discusses the process and problems of setting agroforestry research priorities, and the current and potential contributions of economic research in improving agroforestry research planning and implementation. The ICRAF 'diagnosis and design' approach to selecting priority technologies is introduced. The research planning process used in ICRAF's collaborative projects and the role of economic analysis in that process are described. Priority economic research needed to improve both our methodologies and the empirical basis for decision-making are identified. Some requirements for good economic research for agroforestry are indicated.

TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: country

190
B
SCHUH, G.E. (1987)
POLICY AND RESEARCH PRIORITIES FOR AGROFORESTRY
In *The Potential of Agroforestry*. Keynote addresses delivered during the Tenth Anniversary conference of ICRAF. Nairobi: ICRAF
pp. 70-80 EN XZ
ICRAF acc. no: B06227

World Bank lending for agroforestry has increased considerably over the past years. One reason for this is the relatively high internal rates of return (IRR) these projects yield. They usually produce higher rates than those of industrial plantation forestry. This is illustrated with IRRs of 50 reviewed (agro)forestry World Bank projects. Two examples from the Philippines and Kenya of farmers growing trees in woodlots for cash are given, including the project cash flow from one of these. A third example from a shelterbelt/soil conservation project in northern Nigeria shows that benefits from poles and fuelwood alone could not justify the investment made. Including benefits like fodder, improved crop yields, and soil conservation appeared to be crucial. The author mentions five priority areas for research: 1) cost-effectiveness of alternative policies for encouraging

farmer participation in agroforestry schemes; 2) evidence for and against the use of exotic tree species; 3) the development and distribution of new technologies; 4) integrating agriculture and forestry research; and 5) economic policy discriminating against agriculture and forestry.

TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-post
ANALYSIS LEVEL: project
TECHNOLOGY: woodlot, windbreak
DATA SOURCE: unspecified

191
A
SCOONES, I.C.; PRETTY, J.N. (1989)
RAPID RURAL APPRAISAL FOR ECONOMICS: EXPLORING INCENTIVES TO TREE MANAGEMENT IN SUDAN
In R.T. Prinsley (ed) *Agroforestry for Sustainable Production: Economic Implications.* London: Commonwealth Science Council
pp. 174-184 EN XA/SD
ICRAF acc. no: B06240

To understand farmers' perception of the costs and benefits of tree management requires a disaggregrated analysis incorporating regional, village, group and individual levels. The authors, therefore, carried out a rapid rural appraisal in two villages, approached from each of the different levels mentioned. They found that tree planting is relatively unimportant because of: more profitable crop growing, high risks due to frequent droughts and floods, import of cheap charcoal and wood from other areas, unavailability of seedlings of drought-resistant indigenous species, and insecure tenure systems for both land and trees. All these reasons differ for different groups in the villages. Furthermore, factors which determine the maintenance of communal woodlands are mainly institutional. An existing complementarity between different acacia species in terms of year-round fodder availability is threatened by disappearing species. The authors conclude that issues affecting local incentives to tree management are locally determined and need a detailed approach. A number of different rapid appraisal methods are illustrated.

ECOZONE: arid lowlands
TYPE OF ANALYSIS: agroforestry sector analysis, economic concepts/ methodology
ANALYSIS LEVEL: region, community
TREE/SHRUB SPECIES: *Acacia spp, Azadirachta indica, Ziziphus spina-christi*
TREE/SHRUB PRODUCT: charcoal, fuelwood, mulch
TREE/SHRUB SERVICE: shade
DATA SOURCE: farm survey

192
B
SEGURA DE LOS ANGELES, M. (1986)
UPLAND ECONOMICS AND ECONOMIC IMPACT ANALYSIS
In S. Fujisaka, P. Sajisake and R. Del Castillo (eds) *Man, Agriculture and the Tropical Forest: Change and Development in the Philippine Uplands*. Bangkok: Winrock International
pp. 169-188 EN XP/PH
ICRAF acc. no: 11558

This article reviews and synthesizes various studies of Philippine upland development. It examines economic effects of specific strategies for improving uplands and its communities, and respective research methodologies used in assessing such effects. The behaviour of upland communities is analysed from the economist's perspective. Evaluation of impacts of planned interventions in the uplands are presented, including a number of social forestry and agroforestry projects, promoted for different objectives. Corresponding data and research gaps are identified, and priorities for future uplands economic research are suggested. Specific problems are described in assessing gross income, labour allocation, yield per unit, soil fertility change, extent of soil conservation, impact on migration, lost productivity through environmental decline. Macro concerns are also depicted such as cost-effectiveness of alternate projects, contribution to national production, employment and savings on foreign exchange.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: farm, community, project
DATA SOURCE: farm survey, research plot

193
A
SERRES, H. (1980)
REVIEW STUDY OF THE LIVESTOCK UNDER OIL AND COCONUT PALMS PROJECT
(Project Étude pour une revision du projet d'elevage bovin sous palmeraies et cocoteraies)
Ivory Coast: Palmindustrie and Maisons-Alfort, France: Institut d'Elevage et de Medicin Veterinaire des Pays Tropicaux
83 pp. FR CI/XA
ICRAF acc. no: 3874

The study describes the agri-silvipastoral system as practised at the oil-palm plantations in Ehania, Toumanguie, Fresco and Soubre in the Ivory Coast. Several problems are mentioned: too much shade affecting the grass beneath the palm trees, the need for fertilisers, and overgrazing which harms the condition of the soils. Extended cost/benefit-analyses show that the profitability of the agrisilvipastoral system has been negative. Suggestions for improvement are reduction of the number of cattle and the use of sheep in the first 4 years. A

detailed analysis of costs and benefits of a proposed project using an improved system is given.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: plantation
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Elaeis guineensis*
TREE/SHRUB PRODUCT: oil
LIVESTOCK: cattle
DATA SOURCE: unspecified

194
B
SHAH, P. (1984)
ECONOMICS OF WASTELAND DEVELOPMENT PROJECTS UNDERTAKEN BY GUJARAT STATE RURAL DEVELOPMENT CORPORATION
Proceedings of a Seminar on 'Economics of Wasteland Development'. New Delhi
pp. 69-81 EN XP/IN
ICRAF acc. no: 9860

One hundred hectares of saline wasteland were developed by making use of water impounding, irrigation, manuring, and crop and tree planting. Referring to the latter, three systems were used: a dense leuceana plantation (20 ha), leuceana mixed with fodder crops (60 ha), and crops only (20 ha). Capital costs for the total area and tree planting costs for a period of 15 years for the first two systems were calculated. The recurrent costs for crop-growing in the mixed system are presented separately. Total income from the trees and from the crops are calculated separately for the period. Finally, costs and benefits are compared.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: plantation
TECHNOLOGY: trees mixed in annual cropland, woodlot
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood, fodder, tree seed
CROP/GRASS: sorghum, lucerne
DATA SOURCE: case studies, estimates

195
A
SHAH, P. (1988)
POTENTIAL OF AGROFORESTRY AS LAND USE TECHNOLOGY FOR RURAL POOR
Advances in Forestry Research Vol. 1, India
pp. 28-100 EN XP/IN
ICRAF acc. no: 9851

The study presents and analyses production data for 25 farmers practising agroforestry in Bhatsan village in Gujarat, India. The data are collected from an activity where landless labourers produce the outputs stated under the technical supervision of an external agency. The socio-economic benefits, i.e. extent of fulfilment of basis needs, output generated/man-day and benefit-cost ratios, have been analysed according to land use. These indicators have been compared for both groups: those who practise agroforestry and those not practising agroforestry. The most important observations are: (1) by practising agroforestry the extent of fulfilment of basic needs is 264% higher in the case of a 2-ha rainfed farmer (mainly because of fuelwood and timber), as compared to pure cultivation land use; (2) if a farmer puts border plantations on a 1-ha holding, the extent of fulfilment increases by 50%; (3) average output/man-day increases by 107% if a 2-ha rainfed farmer practices agroforestry as compared to pure cultivation, whereas (4) his benefit-cost ratio increases by 60%. The data show that agroforestry helps the rainfed farmer more than the farmer with irrigation.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: community
TECHNOLOGY: trees mixed in annual cropland, boundary planting
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood, timber
LIVESTOCK: cattle
CROP/GRASS: sorghum, lucerne
DATA SOURCE: farm survey

196
A
SHAIKH, A.; LARSON, P. (1981)
THE ECONOMICS OF VILLAGE-LEVEL FORESTRY: A METHODOLOGICAL FRAMEWORK
Washington D.C.: USAID, Africa Bureau
68 pp. EN XA/ML
ICRAF acc. no: 4398

The authors provide a framework for field analysis of the economics of village level forestry programmes and define key policy issues for such analysis. The paper consists of four parts. The first, on economics of village forestry, argues that a cost-benefit analysis should incorporate socio-economic and institutional mechanisms affecting participation and incentives. Part 2 provides a methodological framework with detailed steps for carrying out an economic analysis of village forestry projects. According to the authors, the difficulty of measuring external benefits can be overcome if adequate resources are devoted to the effort. Any government subsidy to a project should equal the external benefits. Part 3 identifies the information needs for valuing inputs and outputs of the project. A distinction is made between financial and economic analysis, between tradeables and non-tradeables and between direct and indirect benefits. Finally, in part 4, two case studies in Mali are compared. One is a community woodlot and the other is an agroforestry project, involving individual farmers. The latter

appears to be more attractive and has a lower cash outlay.

ECOZONE: semi-arid lowlands
TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-ante and ex-post (economic)
ANALYSIS LEVEL: project, community
TECHNOLOGY: woodlot, trees mixed in annual cropland
TREE/SHRUB PRODUCT: fuelwood, mulch
TREE/SHRUB SERVICE: soil conservation, soil fertility improvement
CROP/GRASS: sorghum
DATA SOURCE: case studies, estimates

197
B
SHEKHAWAT, J.S.; SEN, N.L.; SOMANI, L.L. (1988)
EVALUATION OF AGROFORESTRY SYSTEMS UNDER SEMI-ARID CONDITIONS OF RAJASTHAN
The Indian Forester
Vol. 114 No. 2 pp. 98-101 EN XP/IN
ICRAF acc. no: 8592

A 15-year old plantation of *Acacia tortilis* is used to conduct an experiment of seven treatments including different intercropping combinations. Yields of fuelwood and green fodder are analysed in terms of monetary value. Intercropping with *A. tortilis* gives higher returns than sole forestry or sole fodder crops, and results in additional attractive returns of about Rupees 2000,- per hectare in between stumps left for coppicing.

ECOZONE: semi-arid
TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Acacia tortilis*
TREE/SHRUB PRODUCT: fuelwood, fodder
CROP/GRASS: cowpea
DATA SOURCE: research plot

198
A
SPALL, J.G.; MEISTER, A.D. (1988)
DIVERSIFICATION OF WAIRARAPA HILL COUNTRY: THE POTENTIAL FOR AGROFORESTRY
Discussion paper in Natural Resource Economics No.12. Palmerston North, New Zealand: Massey University, Department of Agricultural Economics and Business
85 pp. EN XP/NZ
ICRAF acc. no: 11061

A linear programming model is drawn up in order to assess the profitability of growing pine trees with pasture in Wairarapa District in New Zealand. A multiple objective function is used. Trees are expected to be harvested after 28 years, but the model is only run for 21 years. Several land classes for the whole farm model are taken into consideration. Data are from a case-study of one farm supplemented with secondary data. The results indicate that agroforestry is an economically viable option. By year 20 one third of the farm is planted with trees while 80% of the farm's initial stock units are still being carried. (Cattle are gradually being replaced by sheep.) Labour requirements increase with agroforestry (AF) but net income is consistently lower in the AF model and even negative after year 12. Including the tree harvest after 28 years results, however, in a higher objective function value, which includes discounted (at 10% interest) future income. The outcome appears to be highly sensitive to capital availability and timber value.

ECOZONE: temperate
TYPE OF ANALYSIS: linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Pinus radiata*
TREE/SHRUB PRODUCT: timber
LIVESTOCK: sheep
CROP/GRASS: wheat
DATA SOURCE: case studies, biological models, research plot, estimates

199
A
SPEARS, J. (1987)
AGROFORESTRY: A DEVELOPMENT-BANK PERSPECTIVE
H. Steppler (ed) *Agroforestry: A Decade of Development.* Nairobi: ICRAF
pp. 53-66 EN PH/IN/SD
ICRAF acc. no: 8301

The period 1977-1986 has seen a sharp escalation in development banking support for forestry and agroforestry. Comparative rates of return for agroforestry projects financed by development banks are significantly higher than earlier in lending programmes. This is shown in several tables. Issues like land-tenure, ecological sustainability, the expenditure of World Bank funds, cost recovery and incentive policies are discussed. Examples from the Philippines (woodlots), India (boundary- and bund planting) and the Sudan illustrate how the Bank tries to reach the small farmers, formulates lending-conditions and creates necessary institution-building practices.

TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: country, region, farm

200
B
SRINIVASAN, V.M.; SUBRAMANIAN, S.; CAULFIELD, J.P. (1990)
AGROFORESTRY: A PROFITABLE FARMING SYSTEM
Unpublished draft
14 pp. EN XP/IN
ICRAF acc. no: 11557

Between 1983 and 1986, an experiment was conducted in Tamil Nadu, India to compare volume and value differences among crop monoculture, tree monocultures and agroforestry alternatives. Three tree species and 11 crop species, and their intercrops were compared. Plots were irrigated, and fertilizer and other cultural treatments were carried out as per Department of Agriculture recommendations. Operational costs, revenues, and cash flow are calculated for each treatment. Net present values and benefit-cost ratios are analysed to compare results. Only the revenue from sale of wood for firewood is included. Net present value for the agroforestry plots exceeds all the tree monocultures, and all but one of the crop monoculture alternatives (turmeric). The highest average net present values and benefit-cost ratios of the agroforestry alternatives are with eucalyptus intercropping. A breakdown of costs and returns is not presented in the paper.

ECOZONE: semi-arid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Casuarina equisetifolia, Eucalyptus tereticornis, Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood
CROP/GRASS: turmeric, cotton, groundnut, maize, green gram, sunflower, sorghum, soybean, black gram
DATA SOURCE: research plot, estimates

201
B
SRIVASTAVA, B.P.; PANT, M.M. (1979)
SOCIAL FORESTRY ON A COST-BENEFIT ANALYSIS FRAMEWORK
The Indian Forester
Vol. 105 No. 1 pp. 2-35 EN IN/XP
ICRAF acc. no: 1424

Different social forestry components in India are described, including farm forestry, forestry on community land and along roadsides, and urban forestry. Aggregated costs and benefits are given for a eucalyptus woodlot (spacing 3x1 meter) intercropped during the first four years, with data derived from a 79-hectare farm. Net present value (NPV) and employment data are presented and the internal rate of return (IRR) is 89%. The NPVs, IRRs and generated employment for a number of practical examples of road side and village plantations are also given. These case studies suggest that total output from the land is a function of the initial investment in tree planting, irrigation and fertilization, and that the productivity of woodlots can be increased by closer

spacing of plants and through irrigation and fertilization. The primary need of defining ownership of trees and sharing benefits is emphasized.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: plantation, farm, community
TECHNOLOGY: woodlot, taungya afforestation, boundary planting
TREE/SHRUB SPECIES: *Eucalyptus spp*
TREE/SHRUB PRODUCT: fuelwood, pulpwood
CROP/GRASS: cotton, wheat, tobacco, *Pennisetum purpureum*
DATA SOURCE: case studies

202
A
STERK, A.; GINNEKEN, P. VAN (1986)
COST-BENEFIT ANALYSIS OF FOREST PLANTATIONS IN A WATERSHED IN NORTHEASTERN THAILAND -EXECUTIVE SUMMARY-
11 pp. EN XP/TH
ICRAF acc. no:

The authors present a cost-benefit analysis taken from a national point of view, of (agro-)forestry components of the Phu Wiang watershed project in Northern Thailand. Several simulations were carried out for *Eucalyptus camaldulensis*, as a plantation system, as an intercropping system with cassava, and with pure cassava planting. The simulations are done with the help of MULBUD, using three different eucalyptus products: charcoal, pulpwood and timber. Based on the simulated data, forest plantations and agroforestry technologies seem able to compete with pure cassava-growing in terms of net present value, return to labour and employment generation.

ECOZONE: sub-humid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: region
TECHNOLOGY: woodlot, trees mixed in annual cropland
TREE/SHRUB SPECIES: *Eucalyptus camaldulensis*
TREE/SHRUB PRODUCT: charcoal, pulpwood, timber
CROP/GRASS: cassava
DATA SOURCE: estimates

203
B
STEWART, K.M. (1985)
ECONOMICS OF AGROFORESTRY: THE FARMERS' VIEWPOINT
New Zealand Agricultural Science
Vol. 19 No. 3 pp. 107-109 EN XP/NZ
ICRAF acc. no: 6332

Mixed intercropping of timber trees in pasture for grazing of sheep and cattle is investigated in a range of farming situations and product price assumptions in the hill country of New Zealand. Profitability is measured using post-tax net present value and internal rates of return. Post-tax cash flows specify financial requirements from tree establishment to clear-felling at 30 years. Investment is found to be profitable. Profits are sensitive to tree harvest costs, transport costs and the cost of lost agricultural production from area under trees. The major constraint to adoption is financing. The author concludes that tree rotations need to be developed slowly, with less than 10% of the farm established at once.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Pinus radiata*
TREE/SHRUB PRODUCT: timber
LIVESTOCK: sheep, cattle
DATA SOURCE: case studies, estimates, biological models

204
A
STOCKING, M.; BOJÖ, J.; ABEL, N. (1990)
FINANCIAL AND ECONOMIC ANALYSIS OF AGROFORESTRY: KEY ISSUES
In R.T. Prinsley (ed) *Agroforestry for Sustainable Production: Economic Implications*. London, Commonwealth Science Council
pp. 13-119 EN XA/NG/CM/XP/IN ICRAF acc. no: B06240

This paper provides an overview of cost-benefit analysis (CBA) and its application to peasant economics, and then discusses selected issues of importance in agroforestry. It identifies key technical information needed for CBA, and looks at models that can be used to generate estimates for ex-ante analysis. The authors examine case studies to identify common problems: a lack of information on distribution of benefits, environmental benefits, and secondary benefits to communities from increased agroforestry income; lack of data on management or on the costs of back-up services used in projects; a lack of empirical basis for assumptions made about long-term technology performance; partial, ad-hoc or obscure valuation of costs and benefits; arbitrary discounting rates; inadequate methods to analyse uncertainty; and a tendency to draw general conclusions from a single case study. Key issues identified for future work are: the need for agroforestry case material; the need for long-term monitoring of agroforestry systems, using suitable controls, and including sensitivity tests and externalities; and more attention to time and scale effects.

TYPE OF ANALYSIS: economic concepts/methodology, cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TREE/SHRUB SPECIES: *Azadirachta indica, Leucaena leucocephala, Acacia spp, prosopis spp*
DATA SOURCE: unspecified

205
A
STURMHEIT, P. (1989)
AN *EX-ANTE* ECONOMIC ANALYSIS OF SIMULATED MAIZE MONOCROPPING AND *CASSIA SIAMEA* / MAIZE ALLEY CROPPING SYSTEMS IN THE MAIZE / CATTLE FARMING AREAS OF SOUTHERN ZAMBIA
Unpublished MSc Thesis. Bangor, North Wales, UK: University College of North Wales, Department of Environmental Forestry
43 pp. EN XA/ZM
ICRAF acc. no: 11595

The author presents an ex-ante analysis of alternative alley-cropping systems for southern Zambia, differing in tree population and alley width. Data on maize and gram yields are simulated based on reports on trial results from semi-arid Machakos District in Kenya, reports on traisl in Zambia and on N application trough leaves. Maize yield in the row bordering the hedge decreased with 50%. Labour requirements are based on the literature and vary between 50 trees pruned per person-hour for a single hedge to 90 for a double hedge. Labour needed for transport of the mulch is calculated and a detailed overview is given of labour requirements for the different systems. Net present worth, returns to land and labour resources, benefit-cost ratio and internal rate of return are calculated. Intercropping with single lines of trees was found to be inferior to maize monocropping. The greatest comparative advantage was with a system having 4450 trees per hectare with hedges consisting of six rows of trees and wide alleys with 30 rows of maize. Requirements for economic and social cost-benefit analysis as tools to consider sustainability and equity aspects of alley-cropping are discussed. Data sets and analysis are contained in appendices.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Cassia siamea*
TREE/SHRUB PRODUCT: mulch, fodder
CROP/GRASS: maize
DATA SOURCE: research plot, estimates

206
A
SUBPAMONG, C.; RUEDENAUER, M.; IMBORIBOON, N. (1986)
ECONOMICS OF LAC-LICE RAISING ON PIGEON PEAS ON CONTOUR BUNDS IN NORTHERN THAILAND
Quarterly Journal of International Agriculture
Vol. 25 No. 4 pp. 374-380 EN XP/TH
ICRAF acc. no: 11062

Erosion is a major long-term problem in rainfed agriculture in Thailand. Lac-lice (*Laccifera lacca*) raising for the production of stick-lac on pigeon peas planted on contour bunds proved to be a viable system for erosion control. It not only compensates for the costs and losses of cropping area but also increases farmers' income by reducing their risk through diversification. Under the price/cost relationships in Thailand, the system is only moderately sensitive to price and yield variations of stick-lac with minimal additional labour requirements. Detailed yield and cashflow data of the 13 farms considered in this study are presented.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: contour planting
TREE/SHRUB SPECIES: *Cajanus cajan*
TREE/SHRUB PRODUCT: stick-lac
TREE/SHRUB SERVICE: soil conservation
DATA SOURCE: farm survey, case studies

207
A
SUMBERG, J.E.; MCINTIRE, J.; OKALI, C.; ATTA-KRAH, A. (1985)
AN ECONOMIC ANALYSIS OF ALLEY FARMING WITH SMALL RUMINANTS
Addis Ababa: International Livestock Centre for Africa
23 pp. EN XA/NG
ICRAF acc. no: 7360

In this paper the authors compare hedgerow-intercropping models with and without sheep and goats, with traditional fallow. It is based on data from on-station and on-farm research by IITA and ILCA in south-west Nigeria, but it is not clear which data are from which type of research. Maize production with *Leucaena leucocephala* and *Gliricidia sepium* would be more profitable than a 3-year fallow system under all assumptions, regardless labour requirements. Incorporating the mulch leaves into the soil increases profitability. For goats, provided they receive careful disease control, an increase of 20-30% in milk yield from 25% supplementary feeding makes small ruminant feeding with tree fodder competitive with maize production. Input and output data of the models are shown.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-post, cost-benefit analysis ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala, Gliricidia sepium*
TREE/SHRUB PRODUCT: fodder, mulch
LIVESTOCK: sheep, goats
CROP/GRASS: maize
DATA SOURCE: research plot, case studies

208
A
SWINKELS, R.A. (1990)
REVIEW OF METHODS USED FOR ON-FARM ECONOMIC EVALUATION OF AGROFORESTRY TECHNOLOGIES
Paper presented at a workshop on 'Methods for Participatory On-Farm Agroforestry Research', 19-23 Feb 1990, ICRAF, Nairobi
14 pp. EN XZ
ICRAF acc. no: 11185

A review is presented of 15 studies dealing with ex-post on-farm economic evaluation of various agroforestry technologies on private land of small farmers in the tropics. The paper compares methods used for data collection and data analysis. Only five of the 15 studies were based on pure on-farm data. For data collection single-visit surveys appeared to be most popular. In those cases the studies often relied heavily on data from on-station conditions, other secondary data or estimates. Only two studies used multi-visit surveys and one used data obtained from weekly monitoring. Unfortunately, in the latter the analysis was not yet complete. For data analysis usually either cost-benefit analysis or partial/farm budgeting was carried out. A cost-benefit analysis based on farm budgets appeared to be better and feasible. The most useful analysis came from a study assessing the effect of the technology on farmers' total income (De Graaff and Dwiwarsito, 1987).

TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: farm

209
B
TAJUDDIN, I. (1986)
INTEGRATION OF LIVESTOCKS IN RUBBER plantationS
Agroforestry Systems
Vol. 4 pp. 55-66 EN XP/MY
ICRAF acc. no: 6053

This paper describes an agroforestry system integrating sheep, poultry, and bees in smallholder rubber plantations in Malaysia. The approach is based on the existence of surplus family labour, utilization of interspaces between the rows of rubber, availability of cheap and nutritious animal feed, and presence of favourable microclimate for animal growth under rubber. Farm data suggest positive net family returns to poultry enterprises, and alternate management approaches are evaluated. Management guidelines for profitable sheep-raising under rubber are presented, which recognize significant economic returns from sale of sheep and from reduced costs for weeding and fertilizer. No economic data are presented for bee-keeping under rubber, but the author postulates good returns based on income from sale of honey and low establishment costs.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-post, cost-benefit analysis ex-post

ANALYSIS LEVEL: research plot, farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Hevea brasiliensis*
TREE/SHRUB PRODUCT: fodder, latex
TREE/SHRUB SERVICE: shade
LIVESTOCK: sheep, poultry, bees
DATA SOURCE: research plot, farm survey

210
A
TAUBE, G. (1988)
AN ECONOMIC ANALYSIS OF SECAP'S BASIC RECOMMENDATIONS
Unpublished draft. Lushoto, Tanzania: Tana Integrated Rural Development Programme - Soil Erosion Control and Agroforestry Project
58 pp. EN XA/TZ

This study evaluates the economic viability of the integrated soil erosion control measures promoted by the SECAP project in the West Usambara mountains of Tanzania. The most important intervention is 'macro contour lines' including grass, fodder species, leguminous creepers and trees (spacing 1.8x8-15 meter). Gross margin analysis is used to compare maize/beans cultivation on sloping fields, macro-contour lines without woody perennials, and macro-contour lines with fodder bushes, creepers and trees for fuelwood, in four different zones of the project. The results show that in all zones higher gross margins per hectare and per manday are achieved with the full erosion control measures and zero-grazing. Production of fodder is more profitable than maize and beans. If trees for fruit production are also planted, their production can increase gross output even further. A complete farm budget is presented for a typical farm in one zone. Macro-contour lines provide additional benefits in sustaining crop yields through soil erosion control. While returns to labour are higher than for subsistence crops, they are lower than for cash crops. Recommendations are made to the project to increase use of non-fodder crops and fruit trees, to use economic data as extension tool and to increase economic monitoring and evaluation.

ECOZONE: humid highlands
TYPE OF ANALYSIS: partial budgeting ex-post, whole-farm budgeting ex-ante and ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: contour planting
TREE/SHRUB SPECIES: *Calliandra calothyrsus, Leucaena leucocephala, Sesbania aculeata, Grevillia robusta, Albizia falcataria, Acrocarpus fraxinifolius, Casuarina montana, Cajanus cajan*
TREE/SHRUB PRODUCT: fuelwood, fruit, fodder
TREE/SHRUB SERVICE: soil conservation
LIVESTOCK: cattle
DATA SOURCE: research plot, case studies, estimates

211
B
THOMAS, T.H.; BRIGHT G.A. (1990)
A SPREADSHEET APPROACH TO THE ECONOMIC MODELLING OF AGROFORESTRY SYSTEMS
In R.T. Prinsley (ed) *Agroforestry for Sustainable Production: Economic Implications*. London: Commonwealth Science Council
pp. 353-385 EN XE/GB
ICRAF acc. no: B06240

Section A of this 2-part paper is concerned with methodological aspects of the economic evaluation of a system of multiple land-use in which agricultural and forestry enterprises are undertaken on the same area of land. It proceeds from a general approach and assumptions to outline key components of a computerised spreadsheet model embodied within the VP Planner package. This allows a large number of parameters, both technical and economic, to take on a range of possible values, thus enabling an assessment of the sensitivity of profitability to changing conditions. The analysis is confined to 1-hectare 'cells' of land apportional to varying fractions between forestry and agriculture, but can theoretically be aggregated for whole farm analysis. The model has 10 sub-models for estimating yields, prices, gross margins, prices, net present values, and interactions between tree and crop components. Section B of the paper presents the results of applying the methodology to a poplar, cereals and sheep agroforestry system. Sensitivity analysis is carried out. It shows the agroforestry system unattractive for high quality land but very attractive on lower productivity land. The author concludes by emphasizing data requirements of the model and data source options.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante, computer program
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture, taungya afforestation
TREE/SHRUB SPECIES: *Populus spp*
TREE/SHRUB PRODUCT: timber
LIVESTOCK: sheep
CROP/GRASS: cereals (unspecified)
DATA SOURCE: estimates, biological models

212
B
TSCHINKEL, H. (1987)
TREE PLANTING BY SMALL FARMERS IN UPLAND WATERSHEDS: EXPERIENCE IN CENTRAL AMERICA
International Tree Crops Journal
Vol. 4 pp. 249-268 EN XL/CR/PA/SV/HN
ICRAF acc. no: 9756

The author analyses seven cases of afforestation in Central America to identify factors encouraging small farmers to plant trees. The study suggests that future projects: select species and technologies which can be easily incorporated into farming practices and not compete for agricultural land; use faster-growing, multiple-use species which resist neglect and are easy to propagate; personal, intensive extension service coordinated between agriculture and forestry; start small with detailed monitoring to develop demonstrations; allow two years before expecting general interest; plants are readily available; other incentives should be temporary and kept to a minimum. Details on tax, subsidy, cash and credit incentives for selected projects are presented. Various constraints to project expansion are identified, including cost of technical assistance, land costs, and unclear individual incentives. The author notes that the initial motivations of smallholders for tree planting were usually not commercial, but rather self-sufficiency in wood products, positive effect on crops or livestock and emotional or aesthetic reasons. Interest in markets developed later, except with large landowners.

ECOZONE: humid
TYPE OF ANALYSIS: agroforestry sector analysis
ANALYSIS LEVEL: project
TECHNOLOGY: woodlot, boundary planting, trees in pasture, live fence, trees mixed in annual cropland, trees mixed in perennial cropland
TREE/SHRUB SPECIES: *Pinus caribaea, Cupressus lusitanica, Alnus acuminata*
TREE/SHRUB PRODUCT: timber, fuelwood, poles
TREE/SHRUB SERVICE: soil conservation, fencing
DATA SOURCE: case studies

213
B
UPRA/ CORDECRUZ (1990)
MANUAL FOR THE DCA PROGRAMME ON COSTS OF PRODUCTION 2. PERENNIAL CROPS
(Manual Para el Programa DCA de Costas de Producción 2. Cultivos Perennes)
Santa Cruz, Bolivia: Corporación Regional de Desarrollo
52 pp. ES XL/BO

This computer programme was developed by the Department of Agricultural Marketing of CORDECRUZ in Bolivia, to permit management analysis of farms including both annual and perennial crops. The programme is written in Lotus 1-2-3. It allows analysis of any type of farm, peasant or commercial, with manual or mechanical operations. Nine measures of profitability can be calculated, of which eight are based on discounted cash flow. Monthly labour use can also be calculated. The programme allows rapid adjustments in model parameters, so that it can be used to estimate costs on individual farms. The manual includes two computer diskettes. Detailed instructions on structuring and using the model are provided, and two annexes illustrate output format with a sample farm.

TYPE OF ANALYSIS: partial budgeting ex-ante, partial budgeting ex-post, cost-benefit analysis ex-ante, cost-benefit analysis ex-post, economic concepts/ methodology, computer program
ANALYSIS LEVEL: farm

214
B
VEGA, L. (1979)
PROFIT-MAKING CAPACITIES OF REGULAR plantationS AS COMPARED WITH THE AGRISILVICULTURAL MODEL
In G. De Las Salas (ed) *Agroforestry Systems in Latin America; Workshop Proceedings*. Turrialba, Costa Rica: CATIE
pp. 107-121 EN XL/SR
ICRAF acc. no: 1611

A look is taken at different models for the development of commercial tree plantations in Surinam, South America. These include 1) plantings in understorey rows of natural forest; 2) regular plantation in cleaned forest combined with farm crops in the first two years; 3) plantings in heavily logged forest (over 70% of trees above 15 cm diameter taken out); and 4) agrisilviculture (taungya) either a) farmer managed or b) under state control. All are 20-year rotations. A detailed overview of inputs and outputs of these models is presented. Net present values at 4, 6, and 8% discount rate and benefit/cost ratios at 4% are compared. The taungya model under state control gives the best outcome. Results are sensitive to 1) changes in wood prices; 2) utilization of secondary products (wood and farm crops; 3) cuts in costs of establishment and management. However, to develop an agroforestry model for Surinam, a careful analysis must be made of social aspects and organization.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: plantation
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Cordia alliodora, Eucalyptus deglupta*
TREE/SHRUB PRODUCT: timber, poles, charcoal
DATA SOURCE: case studies, estimates,

215
B
VELAYUTHAN, A.; LIM, C.Y. (1986)
SHEEP FARMING - ANOTHER TOOL FOR WEED CONTROL UNDER OIL PALM/RUBBER PLANTATIONS BY USING A CHEAPER MANAGEMENT TECHNIQUE
PLANTER, KUALA LUMPUR
No. 62 pp. 319-332 EN XP/MY
ICRAF acc. no: 7281

This paper argues for the economic advantages of using sheep instead of chemical control in oil palm plantations. A history of the use of sheep in estates is summarized as are key management guidelines, including selection of breeds, animal management under both a raised slatted floor and simple attap shelter, and lambing. Breeding of sheep can be managed at low cost to avoid excessive overhead costs. Partial budget analysis of the costs and returns from adding the sheep enterprise are presented. It is possible to get a 100% return on capital in the second year of introduction. For the third year a profit in the range of about 58% of initial capital invested is anticipated. Cash value of savings from reduced weed control in oil palm are not quantified, nor is the value of reduced health risks from handling dangerous chemicals.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: research plot
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Elaeis guineensis, Hevea brasiliensis*
TREE/SHRUB PRODUCT: latex, oil
LIVESTOCK: sheep
DATA SOURCE: research plot

216
B
VERGARA, N.T. (ED) (1982)
NEW DIRECTIONS IN AGROFORESTRY: THE POTENTIAL OF TROPICAL LEGUME TREES - ECONOMIC EVALUATION OF AGROFORESTRY PROJECTS
Paper prepared by a Working Group on Agroforestry. Honolulu, Hawai, USA: Environment and Policy Institute, East-West Centre
23 pp. EN XZ
ICRAF acc. no: 3059

Some guidelines are provided on how to evaluate agroforestry land-use systems. Factors in economic evaluation are discussed like the scope of the evaluation, the time horizon, data collection, valuation, and discount rates. Economic evaluation techniques are introduced and explained. Finally, a simplified example of an alley-cropping system of *Leucaena leucocephala* and maize on a 2-hectare upland farm is presented. The example gives physical as well as financial data and it concludes that hedgerow intercropping is more beneficial than the traditional cropping pattern of two maize crops/year. The author ends by saying that an understanding of the farmer's view of a proposed system and his or her reservations or uncertainties are crucial for conducting a realistic and sensitive analysis.

TYPE OF ANALYSIS: cost-benefit analysis ex-ante, economic concepts/ methodology
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*

TREE/SHRUB PRODUCT: fuelwood, fodder
CROP/GRASS: maize
DATA SOURCE: estimates

217
B
VERINUMBE, I. (1981)
ECONOMIC EVALUATION OF SOME ZERO-TILLAGE SYSTEMS OF LAND MANAGEMENT FOR SMALL-SCALE FARMERS IN SOUTH-WESTERN NIGERIA
Unpublished PhD Thesis. Ibadan, Nigeria: University of Ibadan
263 pp. EN XA/NG
ICRAF acc. no: B2260

The study was conducted to determine the most profitable zero-tillage land management system for southwestern Nigeria. Input-output data for six different systems were collected from the literature (mostly from the International Institute of Tropical Agriculture), with stylo, pigeon pea, and leucaena as cover crop or tree for mulch. The resource base of a typical farmer (identified from a survey) was six ha of land, one labour unit and 300 Naira cash. Combining both sets of data in a linear programming model shows that the maize/stylo and maize/leucaena systems were both technically superior, but due to the cash constraint of small farmers, the maize/leucaena combination came out best. Spacing for the leucaena hedges used in the analysis was 4x0.5 meter. Pruning of hedges was carried out 6 times per year and was estimated to cost 85 personhours per ha per cutting.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: linear programming
ANALYSIS LEVEL: research plot
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala, Cajanus cajan*
TREE/SHRUB PRODUCT: mulch
CROP/GRASS: maize
DATA SOURCE: case studies, farm survey

218
A
VERINUMBE, I.; KNIPSCHEER, H.C.; ENABOR, E.E. (1984)
THE ECONOMIC POTENTIAL OF LEGUMINOUS TREE CROPS IN ZERO-TILLAGE CROPPING IN NIGERIA: A LINEAR PROGRAMMING MODEL
Agroforestry Systems
Vol. 2 pp. 129-138 EN XA/NG
ICRAF acc. no: 4343

An economic evaluation of zero-tillage farming systems for small-scale farmers in southwest Nigeria is presented. Linear programming is used to maximize yearly net returns on alfisols. Alternative crop rotation systems considered are maize-

maize (maize in the first and second season), maize-stylo, maize-maize/stylo, maize-pigeon pea, maize-maize/pigeon pea, and maize/leucaena-maize/leucaena. Stylo, pigeon pea and leucaena are considered as cover crops only and their additional benefits like forage, wood and food are ignored in favour of effects of nitrogen contributions to maize yield. Yields are derived from a fertilizer-response curve. The maximum net profit farm plan for an individual farmer with Naira 300 cash investment, comprised 1.35 ha (95%) maize/leucaena-maize/leucaena and 0.07 ha (5%) maize-stylo rotation system. Under severe cash constraints and where hired labour is available at relatively low cost, the maize/leucaena alley-cropping system is the most promising package. If hired labour is not available, 100% maize-stylo is the optimal system with half the profit of maize/leucaena in both seasons. Results for different wage rates show that maize/leucaena and maize/stylo are the two most attractive options.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: fuelwood
CROP/GRASS: maize, pigeon pea, *Stylosanthes spp*
DATA SOURCE: research plot, farm survey

219
B
WAGGENER, T. (1985)
THE ECONOMICS OF SHIFTING LAND USE MARGINS
In Sedjo (ed) *Investments in Forestry*, Westview Press.
pp. 35-71 EN XN/US
ICRAF acc. no: B4802

This paper provides a thorough overview of the theoretical economic model of competition between forestry and agricultural uses in the rural land market. A distinction between land use decisions at the 'intensive' margin (when economic value for both uses is positive and equal) and the 'extensive' margin (the marginal area where net value is zero) is useful. The analysis could be extended to agroforestry, in making decisions on relative extensity and intensity of the woody and non-woody components with shifts in relative prices. No empirical data are reported.

ECOZONE: temperate
TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: region
TREE/SHRUB PRODUCT: timber

220
B
WAKE, N.L. (1978)
LEUCAENA, A PROMISING SMALLHOLDER CROP WITH EXPORT POTENTIAL FOR COASTAL KENYA - PRE-FEASIBILITY STUDY
Unpublished draft. Nairobi: Ministry of Commerce and Industry, Industrial Survey and Promotion Centre
13 pp. EN XA/KE
ICRAF acc. no: 1809

A pre-feasibility study for production of leucaena leaf meal by smallholders in the coastal area of Kenya is described. Cost and benefit data are adjusted from Malawi findings. Harvest costs are excluded from the analysis. Yield is set at 5 tons per hectare, which leads to a gross margin of almost double that from the highest yield of maize.

ECOZONE: sub-humid lowlands
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: farm
TECHNOLOGY: fodder bank
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: fodder
DATA SOURCE: estimates

221
A
WALKER, A.B. (1984)
AN EVALUATION OF THE PROFITABILITY AND FEASIBILITY OF AGROFORESTRY
In G.W. Bilbrough (comp) *Proceedings of a Technical Workshop on Agroforestry.* Dunedin: New Zealand Forest Service
pp. 71-88 EN XP/NZ
ICRAF acc. no: 10962

A financial comparison of a silvipastoral system and pastoral system is given. Two models of farming systems are used in two different regions in New Zealand. Attention is given to the effect of the silvipastoral system on the farm as a whole. The author concludes that the silvipastoral system is a good investment. For the moderate hill country model, cattle production is considerably more profitable than sheep production and the optimal agroforestry area is approximately 15% of total farm area. For the hill country model the optimum is 62% of total farm area. Labour, yield, cost and benefit data are presented.

ECOZONE: temperate
TYPE OF ANALYSIS: cost-benefit analysis ex-ante and ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: trees in pasture
TREE/SHRUB SPECIES: *Pinus spp*
TREE/SHRUB PRODUCT: timber

LIVESTOCK: cattle, sheep
DATA SOURCE: biological models, estimates

222
B
WALKER, T.S. (1987)
ECONOMIC PROSPECTS FOR AGROFORESTRY INTERVENTIONS IN INDIA'S SAT (SEMI-ARID TROPICS): IMPLICATIONS FOR RESEARCH RESOURCE ALLOCATION AT ICRISAT
Progress Report No. 79. Hyderabad, Andhra Pradesh, India: ICRISAT, Resource Management Group, Economics Group
53 pp. EN XP/IN
ICRAF acc. no: 9850

This study evaluates the economic prospects of agroforestry interventions in India's semi-arid tropics, with regard to 1) the importance of existing agroforestry systems, 2) the scope for synergistic tree-crop interactions, 3) the potential of perennial/annual intercropping land use systems, and 4) alternative land uses. The author concludes that in India's semi-arid tropics (SAT) the present economic importance and the scope for tree-crop interactions are inversely correlated. Gross returns based on the experimental evidence of decreased crop yield in alleys indicate that narrowly spaced hedgerow intercropping with *Leuceana leucocephala* will not compete economically with conventional field cropping systems in India's SAT like fertilizer application. The demand for fodder is increasing, and fodder is the end use that matches best with ICRISAT's mandate. He suggests priority areas for economic research. Methods used for data collection include rapid appraisal, field survey for evaluation of existing systems, and analysis of experimental data from ICRISAT, comparing gross returns from hedgerow intercropping with competing treatments over a range of tree crop price. Analysis was on average yield data for economically optimal treatments.

ECOZONE: semi-arid
TYPE OF ANALYSIS: cost-benefit analysis ex-ante
ANALYSIS LEVEL: research plot
TECHNOLOGY: boundary planting, windbreak, trees in homegarden, trees mixed in annual cropland, hedgerow intercropping, woodlot
TREE/SHRUB SPECIES: *Cajanus cajan, Faidherbia (acacia) albida, Acacia nilotica, Annona squamosa, Azadirachta indica, Mangifera indica, Melia azedarach, Tamarindus indica, Leucaena leucocephala, Sesbania sesban, Prosopis spp, Casuarina spp*
TREE/SHRUB PRODUCT: fuelwood, poles, fodder, mulch
TREE/SHRUB SERVICE: soil-fertility improvement, wind protection
CROP/GRASS: millet, pigeon pea, castor
DATA SOURCE: farm survey, research plot

223
B
WEAVER, R.D. (1989)
AN INTEGRATED MODEL OF PERENNIAL AND ANNUAL CROP PRODUCTION FOR SUB-SAHARAN COUNTRIES
Policy Planning and Research Working Paper No. 175. Washington D.C.: The World Bank
60 pp. EN XA
ICRAF acc. no: 11221

This working paper presents an integrated mathematical model of crop production for smallholders in sub-Saharan Africa. The micro-economic model of household choice is consistent with empirical characteristics of agricultural systems: integration of annual and perennial crops, price uncertainty, options for on-farm employment, household consumption of farm crops and non-food goods. The model includes nine basic equations for: production of perennial crops, capital accumulation of perennial stocks, annual crop production and technological interactions with perennials, labour constraints, income-expenditure constraint, household objectives and the 'household choice problem' for allocation of productive resources. Details for development of the equation on perennial-annual interactions are not provided, but providing for this in analysis lays the basis for incorporating agroforestry system analysis. Past theoretical and empirical models have assumed production of annuals and perennials to be separable or independent in choice. Key issues for empirical implementation of integrated models are identified by the author to be measurement of price expectations and of the potential production of perennials.

TYPE OF ANALYSIS: non-linear programming, economic concepts/methodology
ANALYSIS LEVEL: farm, region

224
A
WILLIAMS, T.O. (1988)
COMPARATIVE ADVANTAGE OF CROP-LIVESTOCK PRODUCTION SYSTEMS IN SOUTH-WEST NIGERIA AND ITS TECHNICAL RESEARCH IMPLICATIONS
Paper presented at the International Potato Institute (CIP)/ Rockefeller Foundation conference on 'Farmers and Food Systems', 26-30 Sept 1988, Lima, Peru
17 pp. EN XA/NG
ICRAF acc. no: 9863

The paper presents a static analysis of one traditional maize production system and three hedgerow-intercropping (HI) systems with maize between rows of already established trees. System (1) has 100% of foliage applied to the soil, the others apply 75% to the soil and 25% to (2) goats or (3) sheep. Yield and input data (including labour) were collected from on-station trials and a farm survey. Partial budgets for each system are constructed for 1984 and profitability is calculated in both financial and economic prices. Cost of planting the alleys is not

included. In the private analysis HI with sheep was the most profitable in 1984 followed by HI with maize. A resource-cost ratio (RCR)(factor prices at world price equivalent/ value added at world price equivalents) for all four systems was shown. This resulted in a lower outcome for all enterprises, and only HI with sheep and maize had RCRs lower than 1. Sensitivity to maize yield and animal output is tested. For hedgerow intercropping with goats, 50% supplementary feeding should lead to an increase of animal output of at least 25% to compete with hedgerow intercropping and maize. The result seemed to be moderately sensitive (in a positive direction) to mulch incorporation in the soil and animal feed supplementation. The author recommends that research concentrate on alley farming with sheep as it gives higher returns to land than HI with goats

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-ante and ex-post (economic)
ANALYSIS LEVEL: research plot, farm
TECHNOLOGY: hedgerow intercropping
TREE/SHRUB SPECIES: *Leucaena leucocephala*
TREE/SHRUB PRODUCT: mulch, fodder
LIVESTOCK: goats, sheep
CROP/GRASS: maize
DATA SOURCE: farm survey, research plot, estimates

225
B
WIRADINATA, S.; SUTIDJO, D.; FAKUARA, Y.; HAMZAH, Z.; TJAKRAWIRALAKSANA, A.; MATTJIK, A.A.; SOERIANEGARA, I. (1986)
COMPUTER SIMULATION FOR THE OPTIMIZATION OF RURAL FARMERS' INCOME DERIVED FROM AGROFORESTRY ON SLOPING RAINFED AGRICULTURAL LAND IN INDONESIA
Unpublished draft. Bogor, Indonesia: Faculty of Forestry, Institut Pertanian Bogor
29 pp. EN XP/ID
ICRAF acc. no: 12024

This is a project proposal for a study to develop an agroforestry computer program called LEAF based on the Land Evaluation Computer System (LECS). The program model is based on field trials to estimate shading effects, yield of various cropping patterns effects of agroforestry on erosion, and farmers' income studies. Initial work will be done on leucaena and albizia-based systems with annual crops in Java and part of Sumatra. Field studies will be implemented on rural farmers' income in general and income derived from agroforestry, and on existing agroforestry patterns. The flowchart for LEAF is presented. The program is developed to determine optimal agroforestry combinations. After comparing these with LECS crop suitability output, agroforestry crop combinations are processed, with computation of economic returns. The ten highest results are printed and compared with LECS highest agro-economic result for a specified land unit.

TYPE OF ANALYSIS: computer program, economic concepts/methodology
ANALYSIS LEVEL: farm
TECHNOLOGY: hedgerow intercropping, trees mixed in annual cropland

TREE/SHRUB SPECIES: *Leucaena leucocephala, Albizia falcataria*
TREE/SHRUB PRODUCT: poles, fuelwood, fruit
TREE/SHRUB SERVICE: soil conservation
CROP/GRASS: rice, maize, groundnut, cassava, sweet potato
DATA SOURCE: research plot, farm survey

226
B
WOJTKOWSKI, P.A.; BRISTER, G.H.; CUBBAGE, F.W. (1988)
USING MULTIPLE OBJECTIVE LINEAR PROGRAMMING TO EVALUATE MULTI-PARTICIPANT AGROFORESTRY SYSTEMS
Agroforestry Systems
Vol. 7 pp. 185-195 EN XZ
ICRAF acc. no: 10474

The purpose of this paper is to show how multiple objective linear programming (MOLP) can be used to evaluate agroforestry systems and optimize the species mix and density of these systems with regard to more than one objective. The focus is on systems which involve more than one individual or group of individuals. For demonstration, one system was simulated over a multi-year period. In this system a farmer plants maize and cassava, while a forester establishes a long-rotation teak plantation. Leucaena may be planted by the farmer as a mulch crop for maize, or by the forester for sale of poles. A constraint matrix was developed to predict the output for the various crops based on planting densities. Through the use of production functions, the efficient region of the constraint matrix becomes an approximation of the production possibilities frontier. Two examples are shown with different levels of maize prices, and a third illustrating the effect of making changes from a farmer's existing system, defined as a point on the production possibilities frontier. Analyses offer a set of optimal compromise solutions for the different users.

TYPE OF ANALYSIS: linear programming, production-function analysis
ANALYSIS LEVEL: farm, plantation
TECHNOLOGY: taungya afforestation
TREE/SHRUB SPECIES: *Leucaena leucocephala, Tectona grandis*
TREE/SHRUB PRODUCT: timber, poles
TREE/SHRUB SERVICE: soil-fertility improvement
CROP/GRASS: maize, cassava
DATA SOURCE: estimates

227
A
WOJTKOWSKI, P.A. (1989)
BIOECONOMIC SIMULATION OF AGROFORESTRY SYSTEMS: AN APPLICATION TO SOUTHEAST BAHIA, BRAZIL
Unpublished PhD thesis. Athens, Georgia, USA: University of Georgia
68 pp. EN XL/BR
ICRAF acc. no: B5497

This thesis develops a bordered density matrix approach to bioeconomic modelling of multi-canopied mixed intercropping systems. This approach is designed to find the optimal species density and to evaluate the effects of management practices on agroforestry systems. To test the model the technique was applied to two Brazilian agricultural systems: a banana/cassava intercrop and a rubber/cacao system. The paper explains the selection of functional forms for the model, assumptions, spatial interaction between components, and specifies constraints for shade, fertilizer, rainfall. Intercrop labour saving is also included. The objective function was profit maximization. Variations in the model included comparison of economics on different soil types, and with variable time dimensions. Expert judgement and available data on monocrops were used to develop the model specifications. Economic data used are planting costs and selling prices of crops and treecrops. The introductory chapters provide an overview of different approaches used in economic evaluation and modelling of agroforestry systems. The author sees modelling as the most viable approach to screening agroforestry alternatives for more focused field research.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: economic concepts/methodology, non-linear programming
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, trees mixed in perennial cropland
TREE/SHRUB SPECIES: *Theobroma cacao, Hevea brasiliensis*
TREE/SHRUB PRODUCT: fruit, nuts, latex
TREE/SHRUB SERVICE: shade
CROP/GRASS: cassava, banana
DATA SOURCE: estimates, biological models

228
B
WOJTKOWSKI, P.A.; CUBBAGE, F.W. (1989)
A BORDERED MATRIX APPROACH TO THE BIOECONOMIC MODELLING OF MULTI-CANOPIED AGRICULTURAL SYSTEMS
Unpublished draft. Athens, Georgia, USA: University of Georgia
22 pp. EN XL/BR
ICRAF acc. no: 11056

One way to overcome the inherent difficulties of economic analysis of multi-species, multi-variable agroforestry systems is through the use of bioeconomic modelling. The author presents a technique developed to simulate polycultural systems to find levels of productivity and system formulations yielding greatest economic benefits. A simple biological model is developed to simulate interaction among species within a system, and the resulting production functions are used in a quadratic programming format to find the species combination giving optimal economic return. The theoretical basis of a bordered matrix approach is described. The approach is illustrated with a case study of banana/cassava intercropping in Brazil. Available data are used to characterize optimal monocultural conditions. Two factor constraints were modelled: light and rainfall. The shapes of monocultural density functions were approximated. Polycultural production is

estimated by computing deviations in the monocultural factor input levels caused by inter-species competition. The objective function is assumed to be profit maximization, and an intercrop labour savings function was included. The system of equations was solved using mathematical optimization computer software capable of handling non-linear constraints with a non-linear objective function.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: non-linear programming, production-function analysis
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland, trees mixed in perennial cropland
CROP/GRASS: cassava, banana
DATA SOURCE: estimates, research plot

229
B
ZAKRA, A.N.; POMIER, M.; TAFFIN DE, G. (1986)
INITIAL RESULTS OF AN INTERCROPPING EXPERIMENT OF COCONUT WITH FOOD CROPS IN THE MIDDLE IVORY COAST
(Premiers Resultats d'une Experience d'Association Cocotiers-Cultures Vivrières en moyenne Côte d'Ivoire)
Oleagineux
Vol. 41 No. 8 pp. 381-390 FR XA/CI
ICRAF acc. no: 7565

An adaptive research programme has been set up in Ivory Coast which associates coconut with food crops under different rotation conditions. It has been set up in collaboration with volunteer planters in the Gagnoa region. Observations on three rotation treatments were taken for mortality, girth, leaf emission rate and number of living leaves for coconut; and yields and selling price for food crops. The optimum system was found to be in short term rotation; i.e. two years of food crop production followed by establishment of ground cover pueraria. Crop yields were found to be comparable to those in pure food crop areas. Labour figures were not obtained, but intercropping led to reduced labour requirements for weeding of young coconuts. Food crop production covered the cost of land clearing.

ECOZONE: humid lowlands
TYPE OF ANALYSIS: partial budgeting ex-post
ANALYSIS LEVEL: farm
TECHNOLOGY: trees mixed in annual cropland
TREE/SHRUB SPECIES: *Cocos nucifera*
TREE/SHRUB PRODUCT: fruit
CROP/GRASS: yam, cassava, sweet potato, maize, rice, groundnut, *Pueraria javanica*
DATA SOURCE: case studies

230
A
JICKLING, J. (1989)
SHORT-TERM ECONOMIC BENEFITS OF AGROFORESTRY: A SURVEY
Unpublished draft. Washington D.C.: USAID/USDA, Forestry Support Program
36 pp. EN XZ

Increasingly the international development community is becoming aware of the important role that short-term economic benefits (those accrued during the first five years) play in peasant farmers' decisions to adopt agroforestry practices. This study is an effort to assess the current state of the art of agroforestry economics, in particular, the quantification of short-term, on-farm economic benefits of agroforestry. A review of the available literature identifies documents and studies which economically analyse several agroforestry practices and projects around the world. Additionally, a survey of informed sources provides an overview of on-going activities in the agroforestry economics field as well as identifies the principal players in the field. It was found that research and documentation in this field has been limited in scope and generally, piecemeal in nature. Of the studies examined, a majority are based upon either research station field trial data or tenuous assumptions made during pre-investment analysis, rather than on actual results from farm level interventions. Only a very few cases were identified where short-term economic benefits of agroforestry have been quantified. The document concludes with recommendations to the Forestry Support Program on specific contributions that can be made to the agroforestry economics field.

TYPE OF ANALYSIS: economic concepts/methodology
ANALYSIS LEVEL: farm

Indexes

ABEL, N.
204

ABU, J.E.
001

AGUIRRE, A.
002

AHMED, P.
003

AKACHUKU, A.E.
004

ALIG, R.
072

ALLES, W.S.
110

ALVAREZ-BRYLLA, M.E.
005

ANDERSON, A.B.
139

ANDERSON, D.
006, 007

ANDERSON, G.W.
008

ANSARI, M.Y.
138

APPLEGATE, G.B.
009

ARIZA-NIÑO, E.J.
010

ARNOLD, J.E.M.
011, 012

ARTHUR-WORSOP, M.J.
013

ATTA-KRAH, A.
207

AVILA, M.
014

BAAH-DWOMOH, J.
015

BALASUBRAMANIAN, V.
016

BALL, J.
017

BALLICK, M.J.
139

BANDOYOPADHYAY
025

BARBIER, E.B.
018

BARRANTES, A.
116

BEALE, C.I.A.
019

BERENSCHOT, L.M.
020, 021

BERMUDEZ, W.
116

BETTERS, D.R.
022

BIRD, P.R.
023

BLANDON, P.
024

BOJÖ, J.
204

BOSE, R.K.
025

BRADLEY, P.
026

BRECHIN, S.
027

BRIGHT G.A.
211

BRISTER, G.H.
226

BRODER, J.M.
028

BROMLEY, D.
029

BROOK, B.A.
030

BROOKS, K.N.
031, 079

BURBRIDGE, P.
032

BURGESS, R.J.
033

BURNISKE, G.
082

CAMPBELL, G.E.
034, 144, 145

CAMPBELL, J.G.
043

CAMPOS, W.
116

CANNELL, M.G.R.
035

CAULFIELD, J.P.
200

CHAND, G.
115

CHATTERJEE, N.
036

CHOTA I.J.
168

CHRISTOPHERSEN, K.A.
037

CRACA, L.R.
038

CUBBAGE, F.W.
226, 228

DAVIS, L.S.
039

DAWSON, J.O.
034

DE GRAAFF, J.
040

DE JONG, W.
168

DE MONTGOLFIER-KOUEVI, C.
041

DEDWIWARSITO, K.
040

DENTON, F.H.
042

DEWEES, P.A.
043, 044, 045, 046

DIXON, J.A.
079

DIXON, P.
032

DOYLE, C.J.
047

DULDULAO, A.C.
048, 049

DVORAK, K.
050

DYKSTRA, D.
051

EARL, D.E.
052

EHUI, S.K.
053

ELLENBROEK, W.E.T.
054, 055

ENABOR, E.E.
056, 218

ESTRADA, R.D.
057

ETHERINGTON, D.M.
058, 059, 060, 061, 062

EVANS, J.
047

FAFCHAMPS, M.
177

FAIRCLOTH, V.L.
063

FAKUARA, Y.
225

FALCONER, J.
064

FAO
065, 066, 067

FERGUSON, I.S.
068

FILIUS, A.M.
021, 069

FISHWICK, R.
006

FLORES, A.S.
070

FOLEY, G.
043

FORESTRY RESEARCH INSTITUTE, NEW ZEALAND
071

FRAZAO, J.M.
139

GARCIA-BARRIOS J.R
005

GARRETT, H.E.
072, 073, 123, 124, 125

GELDER, B. VAN
103

GINNEKEN, P. VAN
202

GISZ, P.L.
074, 075

GLAESER, B.
076

GLOVER, N.
077

GOH, C.L.
130

GOSWAMI, P.C.
078

GREGERSEN, H.M.
031, 079

GRINNELL, H.R.
080

GROSENICK, G.
081

GUERRERO S.
082

GUMBO, D.J.
083

GUPTA, T.
084, 085, 086, 087

HAMILTON, L.S.
079

HAMZAH, Z.
225

HARDJOSOEDIRO, S.
021

HAROU, P.A.
088

HEGDE, N.G.
089

HEUVELDOP, J.
127

HOARE, P.W.C.
090

HOEKSTRA, D.A.
091, 092, 093, 094, 095, 096, 097, 098, 099, 100

HOFSTAD, O.
101

HOSIER, R.H.
102, 103, 104, 105

HOUEROU, LE H.N.
041

HOUT, P. VAN DER
106

HUPE, S.
072

HYMAN, E.L.
107, 108

IMBORIBOON, N.
188, 206

JACKMAN J.B.
109

JACOB, V.J.
110

JENKINS, P.J.
008

JIANG, A.
111

JICKLING, J.
230

JIMINEZ, M.
116

JODHA, N.
112

JONES, J.
072
JOSEPH, N.S.
113

KAJOMULO-TIBAIJUKA, A.
114

KALLA, J.C.
115

KANG, B.T.
053

KARCH, G.E.
037

KARUNANAYAKE, K.
058

KASS, D.L.
116

KELLAS, J.D.
117

KINCAID JR, W.H.
123

KNIPSCHEER, H.C.
219

KNOWLES, R.L.
109, 118

KOLJONEN, K.
119

KORT, J.
120

KORWAR, G.
180

KUANTHAM, A.
188

KUCHELMEISTER, G.
121

KUMAR, P.H.
122

KURTZ, W.B.
072, 073, 123, 124, 125

LAARMAN, J.G.
156

LAGEMANN, J.
126, 127

LAHIRI, A.K.
128

LARSON, P.
196

LAZOS-CHAVERO, E.
005

LEARMONTH, J.
129

LEE, K.A.
130

LEEUWEN, A. VAN
131

LIM, C.Y.
215

LINK, J.
082

LOANE, B.
132

LOTTES, G.J.
034

LUBEGA, A.M.
133

LUYANO, G.B.
171

LUZURIAGA, H.
057

MACBRAYNE, C.G.
134

MAGRATH, W.
135

MARY, F.
136

MATHES, D.T.
137

MATHUR, R.S.
138

MATTHEWS, P.J.
059, 060, 061

MATTJIK, A.A.
225

MAY, P.H.
139, 140

MCDERMOTT ASSOCIATES
141

MCGOWAN, L.
142

MCINTIRE, J.
207

MEINSTOCK, J.
143

MEISTER, A.D.
198

MENDES J.B.
038

MENDOZA, G.A.
144, 145, 146

MENZIES, N.
147

MICHIGAN, UNIVERSITY OF
148

MICHON, G.
136

MINDAJAO, N.M.
149

MISHRA, J.
150

MITTAL, S.P.
151

MOHAN, D.
085

MOL, S.
152

MONGI, H.O.
163

MONSON M.J.
125

MOORE, R.
008, 153

MORRIS, J.
165

MRUTHYUNJAYA
154

MUKAMURI, B.B.
083

MUKHEBI, A.W.
155

MUSSAK, M.F.
156

MUZONDO, M.I.
083

NAINGGOLAN, S.
062

NAIR, P.K.R.
157

NESARGI, V.S.
158

NG, L.H.
130

NGAMBEKI, D.S.
159, 160, 161

NICHOLSON, D.I.
009

NWONWU, F.O.C.
162

O'KTING'ATI, A.
163

ODRONIC, B.H.
028

OKALI, C.
207

OLAWOYE, O.O.
164

ONIM, J.F.M.
155

OPENSHAW, K.
165, 166

OSEMEOBO, G.J.
167

OYUGI, L.
155

PADOCH, C.
168

PANT, M.M.
201

PARAFINA, S.S.
169

PATEL, V.J.
170

PERCIVAL, N.S.
118

POMIER, M.
229

PORRAS, J.M.
171

PRATAP SINGH
151

PRETTY, J.N.
191

PRINSLEY, R.T.
172, 173

RABETTE, J.
129

RAINTREE, J.B.
174, 175, 176

RANGANATHAN, R.
177

RAO, N.V.
178

RATHAKRISHNAN, L.
179

REDDY, B.
178

REDDY, Y.
180

REICHE, C.
181, 182, 183, 184

ROCKENBACH, O.C.
185

ROLA, W.R.
186

ROLFE, G.L.
144, 145

ROMM, J
187

ROSSITER, J.
047

RUEDENAUER M.
206

RUEDENAUER, M.
188

RUTLEDGE, G.
072

SAMBRANI, S.
084

SANCHEZ, J.
116

SAR, N.L.
074

SCHERR, S.J.
189

SCHUH, G.E.
190

SCOONES, I.C.
083, 191

SEGURA DE LOS ANGELES, M.
192

SEN, N.L.
197

SERE, C.
057

SERRES, H.
193

SHAH, P.
194, 195

SHAIKH, A.
196

SHARMA, K.K.
138

SHEKHAWAT, J.S.
197

SOERIANEGARA, I.
225

SOEWARDI, B.
032

SOMANI, L.L.
197

SPALL, J.G.
198

SPEARS, J.
199

SPENCER, D.S.C.
053

SRINIVASAN, V.M.
200

SRIVASTAVA, B.P.
201

STERK, A.
202

STEWART, K.M.
203

STOCKING, M.
204

STURMHEIT, P.
205

SUBPAMONG C.
206

SUBRAMANIAN, S.
200

SUMBERG, J.E.
207

SUTIDJO, D.
225

SWINKELS, R.A.
208

TAFFIN DE, G.
229

TAJUDDIN, I.
209

TAUBE, G.
210

THOMAS, T.H.
211

THURMAN, S.E.
125

TJAKRAWIRALAKSANA, A.
225

TSCHINKEL, H.
213

TURAY, F.
174

UNRUH, J.
168

UPRA/CORDECRUZ
213

USAID
067

VEGA, L.
214

VELAYUTHAN, A.
215

VERGARA, N.T.
070, 143, 216

VERINUMBE, I.
217, 218

VYAS, D.L.
115

WAGGENER, T.
219

WAKE, N.L.
220

WALKER, A.B.
221

WALKER, T.S.
177, 222

WEAVER, R.D.
223

WILLIAMS, T.O.
224

WIRADINATA, S.
225

WOJTKOWSKI, P.A.
226, 227, 228

ZAKRA, A.N.
229

ES (Spanish)
002, 038, 057, 116, 171, 181, 185, 213

FR (French)
054, 067, 193, 229

EN (English)
all others

3 GEOGRAPHICAL LOCATION

CONTINENTS

XA (Africa)
001, 004, 006, 007, 010, 015, 016, 017, 019, 026, 037, 041, 045, 046, 050, 053, 054, 056, 067, 076, 080, 083, 091, 094, 098, 100, 101, 102, 103, 104, 105, 113, 114, 119, 126, 133, 148, 155, 159, 160, 161, 162, 163, 164, 166, 167, 172, 174, 175, 176, 191, 193, 196, 204, 205, 207, 210, 217, 218, 220, 223, 224, 229

XE (Europe)
047, 134, 211

XL (Latin America)
002, 005, 038, 057, 077, 078, 081, 082, 104, 105, 116, 127, 139, 140, 141, 156, 167, 171, 181, 182, 183, 184, 185, 212, 213, 214, 227, 228

XN (North America)
028, 034, 063, 072, 073, 120, 123, 124, 125, 145, 219

XP (Asia, including Australia and New Zealand))

003, 008, 009, 013, 020, 021, 023, 025, 029, 030, 031, 032, 033, 036, 039, 040, 042, 048, 049, 055, 058, 062, 065, 066, 068, 070, 071, 074, 075, 084, 085, 086, 087, 089, 090, 092, 099, 106, 107, 108, 109, 110, 111, 112, 115, 117, 118, 122, 128, 129, 130, 131, 132, 136, 137, 138, 141, 143, 147, 149, 150, 151, 153, 154, 157, 158, 170, 177, 178, 179, 180, 186, 187, 188, 192, 194, 195, 197, 198, 200, 201, 202, 203, 204, 206, 209, 215, 221, 222, 225

XZ (Global)
011, 012, 014, 018, 022, 024, 027, 035, 039, 043, 044, 051, 059, 060, 061, 064, 069, 079, 088, 093, 095, 096, 097, 121, 135, 146, 144, 152, 165, 173, 176, 189, 190, 208, 216, 226

COUNTRIES

AU (Australia)
008, 009, 023, 068, 074, 075, 117, 129, 132, 153

BD (Bangladesh)
048, 049

BF (Burkina Fasso)
054, 067

BO (Bolivia)
213

BR (Brazil)
038, 139, 140, 227, 228

BZ (Belize)
082

CA (Canada)
120

CI (Ivory Coast)
052, 193, 229

CM (Cameroon)
113, 204

CN (China)
039, 111, 147

CR (Costa Rica)
002, 077, 116, 127, 182, 183, 185, 212

EC (Ecuador)
057, 156

GB (United Kingdom)
047, 134, 211

GH (Ghana)
016

GT (Guatemala)
183

HN (Honduras)
182, 212

HT (Haiti)
081, 104, 105, 142

ID (Indonesia)
020, 021, 032, 040, 055, 062, 106, 131, 136, 143, 225

IN (India)
003, 012, 025, 029, 036, 052, 066, 084, 085, 086, 087, 089, 112, 115, 122, 128, 138, 150, 151, 154, 157, 158, 170, 177, 178, 179, 180, 187, 194, 195, 197, 199, 200, 201, 204, 222

JM (Jamaica)
078

KE (Kenya)
012, 026, 046, 091, 094, 100, 102, 103, 104, 105, 133, 155, 166, 175, 220

LK (Sri Lanka)
058, 066, 110, 137

MG (Madagascar)
052

ML (Mali)
015, 037, 067, 196

MW (Malawi)
019, 041

MX (Mexico)
005, 171

MY (Malaysia)
092, 130, 209, 215

NE (Niger)
010, 015, 067, 148

NG (Nigeria)
001, 004, 007, 017, 050, 053, 056, 126, 159, 160, 161, 162, 164, 167, 204, 207, 217, 218, 224

NP (Nepal)
052

NZ (New Zealand)
013, 030, 071, 109, 117, 118, 141, 153, 198, 203, 221

PA (Panama)
212

PE (Peru)
168

PG (Papua New Guinea)
070, 143

PH (The Philippines)
012, 042, 065, 107, 108, 149, 186, 192, 199

SD (Sudan)
041, 045, 191, 199

SL (Sierra Leone)
039, 174, 176

SN (Senegal)
015, 041, 067

SR (Surinam)
214

SV (El Salvador)
183, 212

TH (Thailand)
090, 188, 202, 206

TN (Tunisia)
041

TZ (Tanzania)
076, 101, 114, 119, 163, 165, 210

UG (Uganda)
052

US (United States)
028, 034, 063, 072, 073, 123, 124, 125,
219

WS (Samoa)
033

ZM (Zambia)
205

ZW (Zimbabwe)
083

ARID
045, 086, 087, 115, 154, 191

SEMI-ARID
003, 007, 010, 015, 029, 037, 041, 045, 054, 067, 074, 075, 083, 085, 091, 094, 100, 112, 133, 138, 148, 151, 154, 158, 167, 170, 177, 179, 180, 194, 195, 196, 197, 200, 201, 205, 222

SUB-HUMID
017, 019, 039, 041, 042, 046, 048, 049, 050, 055, 056, 084, 090, 103, 139, 160, 161, 164, 167, 171, 175, 184, 185, 188, 202, 206, 220

HUMID
001, 002, 004, 005, 009, 016, 020, 021, 026, 032, 033, 039, 040, 046, 053, 055, 057, 058, 062, 065, 070, 076, 077, 078, 080, 082, 092, 101, 104, 105, 106, 107, 108, 110, 113, 114, 116, 119, 127, 128, 130, 131, 136, 137, 140, 143, 149, 155, 156, 157, 159, 162, 163, 168, 174, 176, 182, 183, 184, 186, 192, 193, 207, 209, 210, 212, 214, 215, 217, 218, 224, 227, 228, 229

LOWLANDS
001, 004, 005, 010, 016, 023, 029, 033, 039, 050, 053, 054, 055, 057, 058, 062, 068, 070, 080, 092, 107, 108, 113, 130, 131, 136, 139, 140, 149, 153, 154, 156, 157, 159, 160, 161, 162, 164, 167, 168, 174, 176, 177, 184, 186, 188, 191, 192, 193, 196, 200, 206, 207, 209, 214, 215, 217, 218, 220, 224, 227, 228, 229

HIGHLANDS
002, 020, 021, 026, 039, 040, 046, 058, 070, 076, 084, 101, 103, 104, 105, 114, 119, 127, 155, 163, 175, 184, 210

TEMPERATE
008, 023, 028, 030, 034, 047, 063, 071, 072, 073, 109, 111, 117, 118, 120, 123, 124, 125, 129, 132, 134, 141, 153, 198, 203, 211, 219, 221

COST-BENEFIT ANALYSIS
EX-ANTE
007, 013, 014, 017, 022, 023, 025, 027, 029, 030, 031, 032, 034, 037, 047, 049, 052, 053, 058, 060, 061, 062, 063, 065, 068, 071, 072, 073, 075, 079, 082, 085, 086, 088, 091, 092, 094, 095, 101, 102, 103, 106, 109, 113, 115, 117, 118, 120, 121, 123, 125, 129, 132, 134, 137, 138, 149, 158, 162, 165, 166, 173, 183, 187, 202, 203, 204, 205, 211, 216, 220, 222

EX-POST
003, 004, 036, 038, 057, 061, 065, 077, 108, 119, 126, 127, 130, 155, 161, 167, 171, 173, 179, 180, 181, 182, 188, 190, 200, 201, 206, 207, 209

EX-ANTE AND EX-POST
008, 018, 040, 041, 054, 074, 081, 087, 104, 105, 107, 124, 131, 135, 141, 154, 159, 160, 172, 192, 193, 194, 195, 196, 214, 221

ECONOMIC ANALYSIS
018, 029, 031, 102, 107, 196

PARTIAL BUDGETING
EX-ANTE
002, 014, 019, 042, 048, 058, 078, 090, 122, 157, 170, 213

EX-POST
005, 009, 036, 111, 116, 127, 139, 150, 151, 164, 185, 197, 207, 209, 211, 213, 215, 229

EX-ANTE AND EX-POST
016, 077, 110, 128, 140, 224

ECONOMIC ANALYSIS
224

WHOLE-FARM BUDGETING
EX-ANTE
080, 084, 109

EX-POST
036, 066, 070, 126, 136

EX-ANTE AND EX-POST
210

LINEAR PROGRAMMING
010, 022, 028, 033, 039, 040, 051, 062, 065, 133, 144, 145, 146, 174, 198, 217, 218, 226

NON-LINEAR PROGRAMMING
144, 145, 223, 227, 228

PRODUCTION-FUNCTION ANALYSIS
001, 102, 135, 149, 169, 177, 226, 228

AGROFORESTRY SECTOR ANALYSIS
006, 008, 011, 012, 015, 020, 021, 026, 035, 036, 043, 044, 045, 046, 056, 064, 067, 069, 083, 089, 098, 112, 114, 135, 136, 139, 140, 143, 147, 153, 156, 163, 164, 165, 168, 172, 173, 178, 175, 199, 212

REGRESSION ANALYSIS
001, 055, 186

ECONOMIC CONCEPTS/METHODOLOGY
007, 011, 012, 014, 016, 018, 022, 024, 031, 035, 043, 050, 051, 052, 056, 059, 060, 064, 065, 067, 068, 069, 079, 084, 088, 093, 094, 095, 096, 097, 098, 099, 100, 102, 104, 117, 119, 120, 121, 127, 132, 133, 135, 144, 145, 148, 152, 153, 154, 165, 169, 173, 175, 176, 181, 183, 184, 187, 189, 190, 191, 196, 204, 208, 213, 216, 219, 223, 227, 230

COMPUTER PROGRAM
013, 061, 067, 071, 120, 132, 211, 213, 225

RESEARCH PLOT
008, 013, 025, 049, 053, 072, 085, 113, 115, 117, 118, 123, 128, 150, 151, 155, 157, 159, 160, 161, 170, 171, 173, 177, 180, 197, 209, 215, 217, 222, 224

FARM
003, 004, 005, 007, 008, 009, 010, 012, 014, 016, 017, 018, 019, 020, 022, 023, 024, 026, 027, 030, 033, 034, 035, 036, 037, 038, 039, 041, 043, 045, 046, 047, 048, 050, 053, 056, 057, 059, 060, 061, 062, 063, 064, 065, 066, 068, 069, 070, 071, 073, 074, 075, 076, 078, 080, 081, 083, 087, 089, 091, 092, 094, 095, 096, 097, 099, 100, 103, 104, 105, 107, 108, 109, 110, 111, 113, 114, 116, 117, 119, 120, 121, 124, 125, 127, 129, 130, 132, 133, 134, 136, 137, 138, 139, 140, 141, 144, 145, 146, 149, 152, 153, 156, 160, 162, 163, 164, 165, 167, 170, 172, 173, 174, 175, 176, 178, 179, 181, 182, 183, 185, 186, 188, 192, 198, 199, 201, 203, 204, 205, 206, 207, 208, 209, 210, 211, 213, 216, 218, 220, 221, 223, 224, 225, 226, 227, 228, 229

PLANTATION
017, 019, 027, 028, 041, 043, 052, 054, 071, 077, 078, 092, 099, 101, 103, 106, 109, 140, 157, 164, 187, 193, 194, 201, 214, 226

COMMUNITY
021, 022, 026, 029, 036, 037, 039, 040, 044, 056, 083, 085, 090, 126, 132, 136, 148, 165, 172, 178, 187, 191, 192, 195, 196, 201

PROJECT
018, 027, 037, 039, 040, 043, 065, 069, 074, 075, 078, 081, 082, 088, 090, 096, 102, 104, 135, 169, 172, 184, 187, 190, 192, 196, 212

REGION
001, 004, 007, 008, 012, 017, 018, 021, 029, 035, 036, 042, 043, 044, 045, 046, 052, 055, 057, 058, 066, 069, 078, 079, 080, 084, 086, 094, 098, 112, 114, 127, 133, 136, 139, 140, 141, 143, 147, 156, 163, 164, 168, 173, 183, 184, 191, 199, 202, 219, 223

COUNTRY
015, 031, 032, 036, 042, 044, 067, 068, 070, 099, 122, 142, 166, 188, 189, 199

CASE STUDIES
003, 005, 009, 010, 019, 026, 036, 039, 040, 042, 049, 054, 066, 074, 075, 077, 084, 100, 112, 127, 130, 136, 137, 138, 143, 149, 157, 160, 167, 172, 182, 194, 196, 198, 201, 203, 206, 207, 210, 212, 214, 217, 229

FARM SURVEY
001, 003, 005, 006, 017, 020, 021, 026, 033, 036, 038, 039, 040, 042, 044, 045, 046, 049, 053, 054, 055, 057, 058, 066, 070, 071, 076, 081, 083, 085, 086, 087, 089, 102, 104, 105, 108, 110, 111, 112, 113, 114, 123, 126, 131, 133, 136, 139, 140, 142, 143, 146, 149, 156, 162, 163, 164, 167, 168, 178, 179, 186, 191, 192, 195, 206, 209, 217, 218, 222, 224, 225

RESEARCH PLOT
008, 009, 016, 019, 023, 025, 034, 041, 044, 047, 053, 072, 073, 076, 077, 085, 086, 087, 110, 113, 115, 116, 117, 118, 119, 123, 124, 128, 132, 133, 138, 141, 146, 147, 150, 151, 155, 157, 159, 160, 161, 170, 171, 174, 176, 177, 180, 192, 197, 198, 200, 205, 207, 209, 210, 215, 222, 224, 225, 228

ESTIMATES
006, 007, 014, 020, 021, 022, 023, 028, 029, 030, 032, 033, 034, 036, 037, 039, 041, 045, 047, 048, 049, 052, 053, 054, 056, 058, 062, 066, 071, 074, 075, 078, 080, 081, 083, 084, 086, 090, 091, 092, 094, 098, 101, 102, 103, 104, 105, 106, 107, 108, 109, 113, 116, 118, 119, 120, 122, 123, 125, 129, 131, 132, 134, 138, 141, 142, 145, 158, 162, 164, 165, 166, 168, 170, 171, 182, 188, 194, 196, 198, 200, 202, 203, 205, 210, 211, 214, 216, 220, 221, 224, 226, 227, 228

BIOLOGICAL MODELS
034, 047, 053, 071, 117, 118, 123, 125, 132, 141, 198, 203, 211, 221, 227

UNSPECIFIED
004, 006, 012, 027, 028, 029, 032, 033, 036, 041, 043, 044, 053, 060, 061, 062, 063, 064, 065, 067, 068, 069, 074, 075, 078, 080, 081, 084, 098, 099, 101, 104, 105, 106, 107, 121, 132, 134, 135, 147, 154, 155, 165, 166, 175, 176, 188, 190, 193, 204

BOUNDARY PLANTING
003, 046, 114, 125, 143, 170, 188, 195, 201, 212, 222

CONTOUR PLANTING
034, 036, 037, 040, 076, 089, 125, 138, 206, 210

FODDER BANK
010, 013, 026, 040, 041, 220

HEDGEROW INTERCROPPING
012, 014, 016, 026, 049, 050, 053, 091, 094, 100, 116, 121, 133, 146, 151, 158, 159, 160, 161, 169, 174, 176, 177, 180, 205, 207, 216, 217, 218, 222, 224, 225

IMPROVED TREE FALLOW
004, 020, 021, 045, 080, 084, 104, 139, 140, 167, 168, 178

LIVE FENCE
037, 098, 121, 182, 183, 212

TAUNGYA AFFORESTATION
001, 002, 017, 020, 021, 039, 040, 052, 054, 056, 066, 080, 092, 098, 101, 106, 119, 128, 131, 136, 147, 150, 154, 162, 164, 168, 171, 183, 201, 211, 214, 226

TREES IN HOMEGARDEN
005, 012, 039, 083, 098, 110, 126, 136, 222

TREES IN PASTURE
008, 009, 028, 030, 032, 041, 047, 057, 063, 068, 071, 072, 073, 074, 075, 078, 083, 086, 087, 092, 098, 109, 112, 117, 118, 123, 129, 130, 134, 139, 141, 145, 153, 156, 180, 183, 193, 198, 203, 209, 211, 212, 215, 221

TREES MIXED IN ANNUAL CROPLAND
004, 020, 021, 022, 026, 033, 037, 038, 039, 040, 041, 045, 048, 049, 057, 062, 066, 070, 073, 076, 080, 081, 082, 083, 094, 104, 105, 107, 113, 123, 124, 137, 143, 145, 155, 157, 163, 176, 177, 179, 180, 182, 183, 185, 186, 194, 195, 196, 197, 200, 202, 212, 222, 225, 227, 228, 229

TREES MIXED IN PERENNIAL CROPLAND
048, 049, 057, 058, 070, 072, 076, 077, 078, 114, 122, 127, 136, 137, 143, 156, 163, 183, 212, 227, 228

WINDBREAK
007, 023, 037, 068, 111, 120, 121, 122, 132, 134, 183, 190, 222

WOODLOT

007, 012, 015, 019, 020, 021, 023, 025, 026, 029, 032, 036, 038, 039, 042, 046, 065, 066, 067, 068, 078, 081, 083, 084, 085, 086, 090, 094, 103, 104, 105, 107, 108, 109, 114, 115, 132, 138, 140, 148, 149, 170, 179, 182, 183, 187, 188, 190, 194, 196, 201, 202, 212, 222

ACACIA SPP (unspecified)
029, 041, 191, 204

ACACIA ALBIDA
(see Faidherbia Albida)

ACACIA AURICULIFORMIS
040, 090

ACACIA CYANOPHYLLA
041

ACACIA DECURRENS
040, 131

ACACIA MANGIUM
092, 183

ACACIA MEARNSII
020, 021, 026, 046

ACACIA MELANOXYLON
023, 068

ACACIA NILOTICA
025, 036, 089, 222

ACACIA SENEGAL
012, 041, 045

ACACIA TORTILIS
036, 085, 086, 087, 115, 180, 197

ACROCARPUS FRAXINIFOLIUS
210

AGATHIS LORANTHIFOLIA
131

AGATHIS ROBUSTA
040

ALBIZIA SPP (unspecified)
076

ALBIZIA FALCATARIA
012, 065, 092, 108, 149, 210, 225

ALBIZIA LEBBECK
025, 036, 085, 086, 087, 115

ALBIZIA PROCERA
048

ALNUS ACUMINATA
212

ANACARDIUM EXCELSUM
156

ANACARDIUM OCCIDENTALE
122, 168

ANNONA SQUAMOSA
089, 222

ARAUCARIA CUNNINGHAMII
068

ARECA CATECHU
110

ARTOCARPUS HETEROPHYLLUS
110

ARTOCARPUS INTEGER
048, 049

ASTROCARYUM CHAMBIRA
168

ATRIPLEX SPP (unspecified)
041

AZADIRACHTA INDICA
007, 025, 054, 089, 115, 191, 204, 222

BACTRIS GASIPAES
168

BAMBUSA SPP (unspecified)
039, 084, 114

BERTHOLLETIA EXCELSA
168

BOMBACOPSIS QUINATA
183

CAESALPINIA DECAPETALA
046

CAESALPINIA VELUTINA
183

CAJANUS CAJAN
076, 078, 146, 177, 206, 210, 217
202

CALLIANDRA SPP (unspecified)
040, 082

CALLIANDRA CALOTHYRSUS
026, 103, 104, 105, 131, 210

CALOPHYLLUM BRASILIENSE
082

CARICA PAPAYA
039, 048, 049

CARISSA EDULIS
046

CASSIA SPP (unspecified)
040

CASSIA SIAMEA
100, 205

CASUARINA EQUISETIFOLIA
036, 122, 183, 200

CASUARINA MONTANA
210

CASUARINA SPP (unspecified)
179, 222

CEDRELA MEXICANA
171

CEDRELA ODORATA
057, 156

CHLOROPHORA TINCTORIA
156

CHRYSOPHYLLUM CAINITO
168

CITRUS SPP (unspecified)
048, 127, 156

CITRUS LIMON
049

COCOS NUCIFERA
033, 048, 049, 058, 060, 062, 070, 110,
122, 126, 137, 143, 157, 229

COLA ACUMINATA
078

CORDIA ALLIODORA
002, 057, 077, 156, 171, 214

CROTON MACROSTACHYS
026, 046

CROTON MEGALOCARPUS
046

CUNNINGHAMIA LANCEOLATA
039, 147

CUPRESSUS LUSITANICA
002, 026, 046, 183, 212

DALBERGIA SISSOO
025, 036, 150

DENDROCALAMUS STRICTUS
089

DOVYALIS CAFFRA
046

DURIO ZIBETHINUS
136, 143

ELAEIS GUINEENSIS
080, 126, 193, 216

ERYTHRINA SPP (unspecified)
127

ERYTHRINA POEPPIGIANA
077, 092, 116, 156

EUCALYPTUS SPP (unspecified)
007, 022, 025, 029, 039, 040, 046, 048, 049, 052, 066, 089, 103, 114, 154, 170, 201

EUCALYPTUS CAMALDULENSIS
023, 054, 167, 183, 188, 202

EUCALYPTUS CLADOCALYX
023

EUCALYPTUS DEGLUPTA
185, 214

EUCALYPTUS MELLIODORA
119

EUCALYPTUS POPULUS
068

EUCALYPTUS SALIGNA
026, 104, 105, 182

EUCALYPTUS TERETICORNIS
003, 138, 200

EUPHORBIA TIRUCALLI
046

FAIDHERBIA (ACACIA) ALBIDA
012, 037, 041, 045, 222

FLEMINGIA SPP (unspecified)
040

FRAXINUS EXCELSIOR
047

GLIRICIDIA SPP (unspecified)
039

GLIRICIDIA SEPIUM
0100, 116, 127, 182, 207

GMELINA ARBOREA
004, 017, 029, 040, 054, 080, 082, 092, 116, 162, 167, 183

GREVILLIA SPP (unspecified)
039

GREVILLEA ROBUSTA
026, 046, 076, 210

HETEROPSIS JENMANI
168

HEVEA BRASILIENSIS
062, 070, 130, 143, 209, 215, 227

HIBISCUS ELATUS
078

INGA SPP (unspecified)
127

INGA EDULIS
168

JACARANDA COPAIA
057

JUGLANS NIGRA
034, 072, 073, 123, 124, 125, 145

LANSIUM DOMESTICUM
136

LARIX HETEROPHYLLA
134

LEUCAENA LEUCOCEPHALA
010, 012, 014, 016, 019, 025, 026, 040, 041, 042, 048, 049, 050, 053, 066, 078, 081, 085, 087, 091, 100, 106, 107, 119, 133, 146, 151, 159, 160, 161, 166, 169, 170, 174, 177, 180, 183, 186, 194, 195, 200, 204, 207, 210, 216, 217, 218, 220, 222, 224, 225, 226

MAESOPSIS SPP (unspecified)
040

MANGIFERA INDICA
039, 222

MAURITIA FLEXUOSA
168

MELIA AZEDARACH
089, 222

MIMOSA SCABRELLA
026, 038

ORBIGNYA SPP (unspecified)
139, 140

PARKINSONIA ACULEATA
037

PERSEA AMERICANA
039, 040, 076, 078, 131

PINUS SPP (unspecified)
013, 028, 039, 049, 114, 129, 153, 221

PINUS CARIBAEA
009, 068, 183, 212

PINUS ECHINATA
063

PINUS ELLIOTTII
063, 068

PINUS PALUSTRIS
063

PINUS PATULA
101, 119

PINUS PINASTER
008

PINUS RADIATA
008, 023, 071, 074, 075, 109, 117, 118, 198, 203

PINUS SYLVESTRIS
125

PINUS TAEDA
063

PIPER NIGRUM
110

PLATANUS OCCIDENTALIS
125

POPULUS DELTOIDES
066, 158

POPULUS SPP (unspecified)
211

PORAQUIEBA SERICEA
168

POUROUMA CECROPIAEFOLIA
168

PROSOPIS SPP (unspecified)
041, 085, 086, 166, 204, 222

PROSOPIS CINERARIA
087

PROSOPIS JULIFLORA
025, 029, 036, 037, 115

PSEUDOTSUGA MENZIESII
068

PSIDIUM GUAJAVA
039, 049

QUERCUS ALBA
034

QUERCUS RUBRA
034

SAMANEA SAMAN
078

SCLEROCARYA BIRREA
083

SESBANIA SPP (unspecified)
040

SESBANIA ACULEATA
210

SESBANIA GRANDIFLORA
166

SESBANIA SESBAN
012, 026, 089, 155, 222

SHOREA JAVANICA
136

SHOREA ROBUSTA
128

SWIETENIA HUMILIS
002

SWIETENIA MACROPHYLLA
171

SWIETENIA SPP (unspecified).
131

SYZYGIUM AROMATICUM
110

TAMARINDUS INDICA
089, 222

TECTONA GRANDIS
002, 017, 056, 066, 089, 106, 128, 147,
150, 167, 183, 226

THEOBROMA CACAO
033, 048, 049, 058, 070, 078, 110, 113,
137, 156, 157, 227

THESPESIA PUPULNEA
089

TRIPLARIS CUMINGIANA
156

ZIZIPHUS SPP (unspecified)
085, 086, 087

ZIZIPHUS JUJUBA
029, 111

ZIZIPHUS MAURITIANA
089

ZIZIPHUS NUMMULARIA
112

ZIZIPHUS SPINA-CHRISTI
191

CHARCOAL
044, 045, 052, 055, 078, 081, 139, 142, 188, 191, 202, 214

FIBER
140, 168

FODDER
008, 010, 014, 019, 026, 029, 036, 040, 041, 045, 049, 066, 076, 082, 085, 086, 089, 092, 094, 107, 112, 121, 131, 139, 151, 155, 163, 166, 177, 180, 183, 194, 197, 205, 207, 209, 210, 216, 220, 222, 224

FRUIT
029, 033, 037, 039, 048, 049, 070, 076, 078, 083, 086, 087, 089, 094, 111, 126, 131, 136, 137, 139, 140, 156, 157, 163, 168, 178, 210, 225, 227, 229

FUELWOOD
003, 004, 006, 015, 020, 021, 022, 025, 026, 029, 034, 036, 037, 038, 039, 040, 041, 042, 044, 045, 047, 048, 049, 052, 054, 055, 057, 066, 068, 076, 078, 080, 082, 085, 086, 087, 090, 091, 094, 102, 103, 104, 105, 106, 107, 112, 114, 115, 121, 122, 125, 127, 131, 134, 136, 138, 140, 148, 150, 151, 156, 161, 163, 166, 167, 170, 179, 180, 182, 183, 191, 194, 195, 196, 197, 200, 201, 210, 212, 216, 218, 222, 225

GUM ARABIC
045

LATEX
062, 129, 209, 215, 227

MEDICINE
083

MULCH
014, 016, 050, 082, 091, 094, 116, 121, 133, 146, 151, 159, 160, 161, 166, 169, 174, 191, 196, 205, 207, 217, 222, 224

NUTS
058, 062, 070, 072, 073, 078, 083, 122, 123, 124, 125, 126, 138, 145, 156, 227

OIL
080, 126, 139, 140, 193, 215

POLES
004, 015, 026, 029, 036, 037, 046, 054, 078, 081, 082, 086, 087, 089, 104, 105, 134, 136, 139, 142, 147, 150, 163, 170, 186, 212, 214, 222, 225, 226

PULPWOOD
003, 034, 108, 158, 162, 170, 201, 202

STAKES
004, 160

STICK-LAC
206

TANNIN
020, 021, 026, 046

TIMBER
002, 003, 008, 009, 013, 015, 017, 020, 023, 028, 034, 038, 039, 046, 047, 048, 049, 054, 055, 056, 057, 063, 065, 066, 068, 071, 072, 073, 074, 075, 076, 077, 078, 080, 081, 082, 085, 089, 090, 092, 101, 106, 109, 117, 118, 120, 122, 123, 124, 125, 127, 128, 129, 131, 138, 141, 142, 145, 147, 150, 153, 156, 163, 167, 168, 171, 178, 183, 185, 186, 195, 198, 202, 203, 211, 212, 214, 219, 221, 226

TREE SEED
087, 194

FENCING
037, 046, 121, 182, 183, 212

SHADE
008, 023, 035, 046, 068, 076, 077, 078, 094, 117, 123, 127, 129, 134, 153, 156, 163, 168, 191, 209, 227

SOIL CONSERVATION
004, 018, 021, 031, 034, 035, 037, 039, 040, 045, 048, 049, 053, 076, 078, 079, 090, 094, 121, 122, 125, 131, 139, 150, 167, 179, 180, 183, 196, 206, 210, 212, 225

SOIL-FERTILITY IMPROVEMENT
007, 014, 016, 018, 020, 021, 026, 035, 037, 039, 045, 050, 068, 083, 094, 116, 121, 127, 139, 140, 155, 159, 169, 179, 183, 186, 196, 222, 226

WIND PROTECTION
007, 023, 037, 068, 093, 111, 120, 121, 122, 134, 183, 222

BANANA
033, 039, 058, 060, 114, 157, 163, 178, 227, 228

BEANS (unspecified)
014, 022, 038, 039, 048, 076, 081, 082, 091, 092, 101, 113, 116, 119, 133, 139, 183

BLACK GRAM
151, 200

BRACHIARIA SPP (unspecified)
139

BRACHIARIA DECUMBENS
057

BRACHIARIA MILIIFORMI
092

CALOPOGONIUM CAERULEUM
092

CARROT
131

CASSAVA
004, 017, 039, 050, 057, 062, 076, 080, 081, 107, 113, 116, 126, 139, 157, 164, 167, 168, 202, 225, 226, 227, 228, 229

CASTOR
180, 222

CENCHRUM SETIQARUS
087

CENCHRUS CILIARIS
087, 180

CEREALS (unspecified)
039, 111, 211

CHILLIES
092

CLOVE
136

CLUSTER BEAN
151

COCOYAM
033, 126

COFFEE (unspecified)
039, 048, 057, 058, 076, 110, 114, 127, 131, 136, 137, 163, 183

COFFEE (ARABICA)
077, 078

COFFEE (ROBUSTA)
113

COTTON
200, 201

COWPEA
007, 016, 133, 160, 161, 197

FESCUE
072, 073, 123, 145

GREEN GRAM
200

GROUNDNUT
007, 010, 054, 081, 113, 177, 179, 200, 225, 229

HYPARRHENIA RUFA
139

LASIURUS SINDICUS
087

LOTUS ULIGINOSUS
117

LUCERNE
194, 195

MAIZE
004, 014, 016, 017, 020, 021, 022, 038, 040, 050, 053, 057, 066, 076, 080, 082, 091, 101, 106, 113, 116, 119, 125, 126, 131, 133, 139, 146, 151, 155, 159, 160, 161, 164, 166, 167, 169, 171, 183, 200, 205, 207, 216, 217, 218, 224, 225, 226, 229

MILLET
007, 010, 037, 148, 177, 222

PANICUM MAXIMUM
139

PENNISETUM PURPUREUM
040, 057, 131, 139, 201

PEPPER
039, 058, 062, 137, 157

PIGEON PEA
133, 155, 180, 218,

PINEAPPLE
058, 107, 157, 168, 178

PLANTAIN
057, 110, 113, 168

POTATO
021, 076, 081, 157

PUERARIA JAVANICA
229

RICE
003, 040, 048, 062, 066, 106, 107, 136, 138, 139, 158, 168, 174, 178, 179, 183, 225, 229

SHALLOT
131

SORGHUM
007, 010, 037, 054, 081, 119, 155, 177, 180, 194, 195, 196, 200

SOYBEAN
062, 072, 073, 123, 124, 125, 145, 200

STYLOSANTHES SPP
146, 180, 218

SUGARCANE
138, 179

SUNFLOWER
200

SWEET POTATO
062, 076, 107, 225, 229

TEA
110

TOBACCO
020, 021, 062, 201

TURMERIC
128, 200

VEGETABLES
017, 040, 048, 092, 107, 126

WHEAT
003, 066, 072, 073, 123, 124, 125, 138, 145, 158, 198, 201

YAM
004, 016, 017, 080, 081, 126, 157, 164, 167, 229

BEES
178, 209

CAMEL
112

CATTLE
008, 009, 010, 026, 028, 029, 030, 040, 057, 063, 072, 086, 087, 109, 112, 117, 123, 145, 153, 163, 180, 183, 193, 195, 203, 210, 221

GOATS
008, 040, 112, 153, 163, 207, 224

PIGS
005, 178

POULTRY
005, 130, 163, 178, 209

SHEEP
008, 013, 023, 040, 047, 074, 075, 092, 109, 112, 117, 118, 129, 134, 141, 153, 163, 198, 203, 207, 209, 211, 215, 221, 224

ACRONYMS AND ABBREVIATIONS

AFRENA:	Agroforestry Research Network for Africa
B/C ratio:	Benefit/cost ratio
CATIE:	Centro Agronomico Tropical de Investigación y Enseñanza (Turrialba, Costa Rica)
CSC:	Commonwealth Science Council (London, UK)
CSIRO:	Commonwealth Scientific and Industrial Research Organization (Canberra, Australia)
FAO:	Food and Agricultural Organization of the United Nations (Rome, Italy)
GTZ:	Gesellschaft für Technische Zusammenarbeit (Eschborn, F.R. Germany)
ha:	hectare
ICRAF:	International Council for Research in Agroforestry (Nairobi, Kenya)
IDRC:	International Development Research Centre (Ottawa, Canada)
IITA:	International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILCA:	International Livestock Centre for Africa (Addis Ababa, Ethiopia)
IRR:	Internal rate of return
m:	metre
NPV:	Net present value
UNDP:	United Nations Development Programme (New York, N.Y, USA)
USAID:	United States Agency for International Development (Washington, D.C., USA)
USDA:	United States Department of Agriculture (Washington, D.C., USA)

Agroforestry has gained considerable popularity as a land-use system in recent years and agroforestry research and development projects are attracting increasing support. This is due to agroforestry's potential for addressing a wide range of household needs with a low level of external inputs and on a sustainable basis. However, this enthusiasm should be accompanied by a critical analysis of the real costs and benefits of adoption of specific agroforestry technologies.

ICRAF has published two previous annotated bibliographies on economic studies of agroforestry technologies—in 1983 and 1985—but little empirical work had been completed at that time. Recent years have seen a notable increase in the number and sophistication of studies on the economic aspects of agroforestry.

Thus, ICRAF has decided to publish a new, comprehensive overview of the existing literature. The present work covers 230 studies, fully annotated and with indexed descriptors of agroforestry technologies, analytical methods, study sites, data sources, and other aspects.

This new bibliography should give researchers access to a range of approaches, methods and experiences related to the collection and analysis of economic data on agroforestry. It should also provide a basis for the comparative analysis of the economics of specific agroforestry technologies. It is intended to be a useful resource for agroforestry researchers, extensionists and development planners.



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