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ICRAF

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY
CONSEIL INTERNATIONAL POUR LA RECHERCHE EN AGROFORESTERIE
CONSEJO INTERNACIONAL PARA INVESTIGACION EN AGROSILVICULTURA

P.O. Box 30677, Nairobi, Kenya, Tel: 29867. Telex: 22048 Cable: ICRAF

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GATHERING SOCIO- AND BIO-ECONOMIC INFORMATION FOR AGROFORESTRY PROJECTS

D.A. HOEKSTRA

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International Council for Research in Agroforestry
P.O. Box 30677, Nairobi, Kenya

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1. INTRODUCTION

The main objective of gathering socio- and bio-economic information is to enable scientists to influence the (re)design and choice of technologies before and during the implementation of a project or a programme. The second objective of gathering such information is to facilitate the establishment of a data base for future design decisions either in the same project or programme or elsewhere.

The difference between these two objectives should be stressed because too often "information gatherers" have taken a rather uncommitting attitude by opting for the second objective, whilst the design of the projects or programmes under which such information is collected is hardly affected.

It is felt that the emphasis in data collection should be put on the first objective. If not, there is a danger of data collection becoming an end in itself, which may further estrange socially oriented scientists from technical scientists. At the same time, with proper interaction, scientists may guide each other in their information collecting activities by spelling out the difference between "nice", "useful" and "essential" information.

To achieve the first objective, information is required on what a system* needs and on potential agroforestry technologies. In this paper, attention is drawn to gathering information on these aspects either before or during the implementation of a project. The emphasis is on general principles and guidelines while references are provided for a more detailed coverage of the individual topics.

2. SYSTEMS INFORMATION

Information gathering on a farming system should focus on describing and understanding the existing land-management systems and the overall economic environment in the area in which it is found. More specifically it should identify:

i. general opportunities for the introduction and/or improvement of agroforestry technologies (system design specification).

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* A system will here be referred to as a farming system (micro system) or the combination of farming systems and available biophysical and socio economic infrastructure in a given area (macro system). Each farming system in turn comprises one or more technologies.

ii. the constraints of the system which may limit the applicability of the above or which must be taken into consideration for the technology design (for research and/or development).

ICRAF has developed a set of forms and a questionnaire on which relevant information on a system (at micro and macro-level) can be recorded in the pre-technology development phase and the reader is referred to "ICRAF Working Paper No. 7, "Resources for Agroforestry Diagnosis and Design" (ICRAF, 1983) for a comprehensive coverage.

Often little time and few resources will be available to formulate a project and hence such information on a system has to be gathered rather rapidly, leaving little time for quantification. Subsequent gathering of data may be necessary to verify/quantify diagnosed problems and/or potentials in the supply and demand of products which might be supplied by trees, i.e., energy (woodfuel), fodder (pods, leaves), shelter materials (poles, timber, fence posts) and food (fruits).

Verification studies may also be necessary to assess the need for diagnosed service functions which can be fulfilled by trees, i.e., erosion control, shelter from wind and protection against animals. Depending on the availability of funds such follow-up data-gathering exercises can take place before or during implementation of a project. The nature of information which needs to be gathered for these studies as well as its availability in the literature is discussed next.

2.1 Energy-woodfuel studies

2.1.1 Type of information required

To be able to detect or confirm problems in the supply and demand of energy for domestic use, information on the following aspects is required:

Demand for energy

- for cooking, heating, lighting, cottage industries, others
- quantities required

Supply of energy

- type of energy, e.g. woodfuel, gas, kerosene, agricultural residues, cow dung, others
- sources of woodfuel, e.g. purchased/gathered; private land/communal land/forest, etc.
- standing volume and present/future sustainable yield

While this information would enable the researcher to make a quantitative estimate of present and future discrepancies between woodfuel demand and supplies, woodfuel scarcity indicators may be used to make a qualitative assessment. The following indicators could be tested against standards for the area:

- type of wood used
- time required to collect wood
- number of meals cooked in a day

If woodfuel is, or has the potential of becoming a marketable commodity, additional information is required on potential demands ("demand area" being delineated by transport distance/costs).

2.1.2 Availability of written information

Use and production of woodfuel

Before embarking on any field activity to obtain more details on use and production of fuelwood, it is strongly suggested first of all to review the existing literature on these items. FAO (1981), for example, has produced the "Map of the Fuelwood Situation in Developing Countries", which gives an indication of the supply/demand situation in different countries. The same report also provides an estimated range of average per capita use of fuelwood in a number of broad regions in the developing world (see Table 1).

Table 1: Fuelwood use in selected regions

	m^3/cap/yr
Africa	
Arid and sub-arid areas	0.5
Savanna areas	1.0 to 1.5
High forest areas	1.2 to 1.7
Mountainous areas	1.4 to 1.9
Asia	
Indo-Gangetic plains	0.2 to 0.7
Lowland areas in S.E. Asia	0.3 to 0.9
High forest areas	0.9 to 1.3
Mountainous areas	1.3 to 1.8
Latin America	
Andean plateau	0.95 to 1.6
Arid areas	0.6 to 0.9
Semi-arid areas	0.7 to 1.2
Other areas	0.5 to 1.2

Source: Map of the Fuelwood Situation in Developing Countries - Explanatory Note. Food and Agriculture Organization, Rome, 1981.

It should be noted that differences between regions mainly reflect differences in fuelwood availability and economic conditions.

De Montalembert and Clement (1983) produced a report on fuelwood supplies in developing countries and some of the results are summarized in Table 2.

Table 2: Estimated potential fuelwood yield of major woody vegetation types in 37 African countries

Woody vegetation type	Fuelwood yield (m^3/ha/yr)
Closed forest 1/	2.0 - 4.0
Open forest and wooded savanna	0.8 - 1.2
Tree savanna	0.2 - 0.8
Bush and shrub formations	0.05 - 0.2
Closed forest fallow	0.5 - 2.0
Wooded savanna fallow	0.5 - 2.0

1/ Note: The estimated standing volume/ha. of closed forest varies from 250 to 600 m^3/ha. but the standing volumes of the other categories are much less.

Source: de Montalembert and Clement, 1983.

Energy content of woodfuel

The energy given off from a piece of wood (at a given moisture content) is more or less the same on a weight basis, irrespective of species. The low heat values of 111 tropical woods from Africa, Asia and South America were found to be on average 18.3 MJ/kg oven dry weight (Bialy, 1979). The low heat value of fuelwood at different moisture contents can be calculated using the following formula.

$$\frac{100\ X - 2.4\ (54 + M)}{100 + M} = MJ/kg$$

where X = (high) heat value of wood (around 20 MJ/kg) and M = moisture content. The factor 2.4 MJ/kg of water is the amount of heat required to drive off 1 kg of water from the wood.

The calorific value of charcoal (at 5% m.c.) is usually twice that of fuelwood (at 15% m.c.)

In computing the energy requirements of a household, account should also be taken of differences between thermal efficiency of different types of fuel. Open wood-burning cooking fires have a very low thermal efficiency, usually not more than 5%; properly designed simple charcoal burning grates have a thermal efficiency of about 27%.

Production and energy content animal dung and crop residues

Some global data have been published on the potential use of some renewable, non-woody energy sources. For example, based on the work of several authors and data from different countries, dung production estimates have been made. (Barnard and Kristoferson for Earthscan, 1985). In the same report estimates are made for crop residue ratios for selected crops (See Table 4).

Table 3: Dung production from animals - Summary table

Animal	Annual dung production tonnes (air dry)
Buffaloes	0.7 - 2.0
Cows	0.5 - 1.7
Camels	0.6 - 1.0
Horses & donkeys	0.3 - 0.8
Pigs	0.2 - 0.3
Sheep & goats	0.1 - 0.2

Source: Barnard and Kristoferson, 1985

The gross calorific value of dung, derived from various literature searches, varies from 10-17 MJ/kg on an air dry basis.

Table 4: Crop to residue ratios for selected crops - Summary table

Crop	Residue	Residue production (per ton of crop)
Rice	straw	1.1 - 2.9
Deep water rice	straw	14.3
Wheat	straw	0.7 - 1.8
Maize	stalk + cob	1.2 - 2.5
Grain sorghum	stalks	0.9 - 4.6
Millet	stalks	2.0 - 3.7
Barley	straw	0.6 - 1.8
Rye	straw	1.1 - 2.0
Oats	straw	0.9 - 1.8
Groundnuts	shell straw	0.5 2.3 - 2.9
Pigeon pea	stalks	5.0
Cotton	stalks	3.5 - 5.0
Jute	sticks	2.0
Coconut (copra)	shell husk	0.7 - 1.1 1.6 - 4.5

Source : Barnard and Kristoferson, 1985

It should be noted that as a rule, modern high-yielding varieties give a smaller proportion of residues than traditional varieties.

When oven dried, most crop residues have a similar heat content, i.e., 15-20 MJ/kg.

2.2 Fodder-pods/leaves

2.2.1 Type of information required

Present or future problems in the supply/demand situation of fodder, and in particular tree fodder (pods, leaves and twigs), may be quantified if information on the following aspects is available:

Demand for fodder

- type and number of animals per farm or area
- quantity of fodder used

Supply of fodder

- sources/type of fodder e.g. grazing land (grasses, bushes, trees); crop residues; concentrates;
- (seasonal) production and availability of each source.

If a preliminary diagnosis of the macro system reveals a potential for increased livestock production (government policy or market studies), account should be taken of the potential increase in the demand for fodder for commercial purposes.

A qualitative assessment of fodder shortage may be made with the help of fodder scarcity indicators such as:

- mortality rate of animals (at different times during the year);
- type of fodder used;
- labour involved in obtaining fodder/grazing.

A relative indication of the scarcity of fodder may be obtained by comparison with the standard for a particular area.

2.2.2 Availability of written information

Nutritional requirements and fodder production

Assessment of the fodder supply/demand situation should also start with a review of the existing literature.

Information on the type and number of animals in an area can usually be obtained from census reports. In general, nutritional requirements of animals have been well documented for the temperate zone but much less is found in the literature

for the tropical regions. In the standards developed for the temperate zones to fit tropical conditions, account should be taken of the usually much lower body weights of animals, which lead to lower maintenance requirements. Some broad estimates for daily nutrients allowance for growing and fattening zebu cattle in East Africa are shown in Table 5.

Another reference which may be used to calculate the feeding requirements of animals in Africa is "Memento de L'Agronome" (Ministère de la Coopération in France, 1973).

The supply of fodder in the temperate zones is also much better documented than in the tropical zones.

Although there is some conceptual knowledge on quantitative and nutritional aspects of herbaceous and tree fodder, very little quantitative information on yields and nutritional content is available. Some useful references on the supply of fodder from trees and shrubs are ILCA (1980), Negi et al. (1979), Singh (1982), Panday (1982) and Göhl (1981).

Table 6 shows the relationship between ecological zone, livestock carrying capacity and maximum population density under subsistence pastoralism as proposed for Kenya by Pratt (1968).

2.3 Shelter materials

2.3.1 Type of information required

To quantify the supply/demand situation for shelter materials the following information is required.

Demand for shelter material

- for use in construction of wooden houses, farm buildings, cattle pens, fence posts (rate of replacement);
- length of internal and external boundaries;

Supply of shelter materials

- standing volume and annual increment;
- purchase of shelter materials.

Table 5: Suggested daily nutrient allowances for growing and fattening zebu cattle

Live weight (kg)	Approximate consumption of dry matter (kg)	Starch equivalent required for maintenance (kg)	Digestive crude protein required for maintenance (kg)	Starch equivalent required for maintenance and 0.5 kg production (kg)	Digestible crude protein required for maintenance and 0.5 kg production (kg)
100	3.0	0.9	0.10	1.7	0.25
150	4.0	1.2	0.13	2.0	0.33
200	5.3	1.5	0.17	2.4	0.37
250	6.5	1.8	0.20	2.7	0.40
300	7.3	2.1	0.23	3.1	0.43
350	8.0	2.3	0.25	3.3	0.45
400	8.7	2.6	0.27	3.6	0.47
450	9.3	2.8	0.29	3.9	0.48
500	9.8	3.0	0.31	4.2	0.48

Source: Pratt, D. J. and M. D. Gwynne (1977).

Table 6: Relationship between ecological zone, livestock carrying capacity and maximum population density under subsistence pastoralism, as proposed for Kenya by Pratt (1968)

	Eco-climatic zones				
	II	III	IV	V	VI
Hectares required per livestock unit	0.8	1.6	4.0	12.0	42.0
Livestock units required to support one head of population	2.5	3.0	3.5	4.0	4.5
Hectares required per head of population	2.0	4.8	14.0	48.0	189.0
Maximum population density per square kilometre*	5.0	21.0	7.0	2.0	0.5

* These figures presume that all land is accessible and productive; if actual population density under subsistence pastoralism even approaches these estimates, over population is indicated. Higher populations can only be sustained if the pastoralists derive a substantial part of their subsistence from vegetable foods - collected, grown or procured in exchange for livestock.

II - Tropical climate, humid to dry sub-humid (moisture index not less than 10) (Braun III)

III - Dry sub-humid to semi-arid (moisture index 10 to 30) (Braun IV)

IV - Semi-arid (moisture index 30 to 42) (Braun V)

V - Arid (moisture index 42 to 51) (Braun VI)

VI - Very arid* (moisture index 51 to 57) (Braun VII).

Poles and local construction timber are becoming increasingly scarce in the rural areas and many farmers are forced to buy those materials in local markets. Therefore supply/demand of poles and timber should not only be examined in relation to the household requirements but also in relation to the commercial needs of a larger area (and/or nearby urban centres).

2.3.2 Availability of written information

Unlike the two previously mentioned tree products, it is difficult to make an initial assessment of the supply/demand situation for shelter materials from literature.

2.4 Fruits, nuts and condiments

2.4.1 Type of information required

The potential role of fruits in a farming system should be examined in relation to their domestic use and commercial potential. The latter should be determined with the help of marketing studies.

The domestic demand for fruits may be derived from the daily diets (over time) and the output of different fruit trees throughout the year. The information required is the energy content, protein content, mineral content and vitamin content of the fruits.

2.4.2 Availability of written information

The nutritional requirements of human beings will depend on such factors as body size, basal metabolic rate, activity, pregnancy, lactation, age and climate. A good description of requirements in terms of energy protein, minerals and vitamins is provided in "Human nutrition in tropical Africa" (F.A.O. 1968). Another more recent F.A.O. publication (FAO, 1983) and ICRAF Working Paper 32 (Nair, 1985) give some indication of the potential role of some of the lesser-known tree species.

2.5 Service role

2.5.1 Type of information required

Data collection to verify a potential service role requires information from existing farming systems. In most cases, it will force the researcher to identify and quantify the damage which could have been prevented. Examples of this damage are: loss of crops due to stray animals, wind, degradation of the land resources (erosion, continuous cropping) and reduction in animal production due to lack of shade.

2.5.2 Availability of written information

Little information is available on any of these topics. Some studies have been carried out in the U.S. relating soil erosion to crop yields but their usefulness for tropical conditions where cropping patterns and levels of input differ considerably is doubtful (Hufschmidt et al., 1983). Some literature is also available on the effects of shelterbelts on crops. Yield differences of 25% have been quoted in areas up to 16 times the height of the windbreak (Bogneteau-Verlinden, 1980).

3. TECHNOLOGY INFORMATION

Information gathered on technologies should include answers to the following questions:

i. What technologies are available/can be designed to meet the specifications of the system?

ii. What inputs are required and what outputs are expected?

iii. What are the prices of such inputs and outputs?

iv. What is the potential for adoption?

Such information is required not only at the design stage of a project/programme but also during the implementation stage (during which technologies might have to be redesigned or selected as a result of new findings about a system or the initial experimentation stage.

Normally very little time will be available to provide detailed information on each of these topics during the project design phase. As with the overall system's information, it will therefore often be necessary to obtain more detailed information during the project implementation phase.

3.1 Available technologies

3.1.1 Type of information required

Having determined the general requirements for improvement of a land use system through a diagnostic exercise, several potential technologies, in particular agroforestry ones, should be considered.

A preliminary list might be obtained from an inventory of existing agroforestry technologies in the area by obtaining answers to the following questions.

Where are trees found in the farm/landscape?

- type of land: communal/private or productive/unproductive land;
- planting arrangement: zonal or mixed.

What is the purpose of the trees?

- to provide woody products such as timber, poles, fuelwood, fruits, tree fodder, leaf litter.

- to provide a service role in the system, such as erosion control, wind shelter, protection against animals/humans, demarcation of property, etc.

How has the tree component been established and managed?

- seed/seedlings
- family/hired/communal labour

3.1.2 Availability of written information

It is only on rare occasions that a detailed list of agroforestry technologies in a particular area is available and hence such information will usually have to be collected by project staff. However, technologies from elsewhere may also be considered for the list. Several descriptions of agroforestry systems have appeared in "Agroforestry Systems" as a result of ICRAF's Agrforestry Systems Inventory Project. A consolidated output of the descriptions is expected to appear in book form (Nair, in preparation).

Recently some attempts have been made to classify agroforestry technologies in relation to land use and labour intensity (Raintree and Warner, 1986). By superimposing some additional factors, such as soil types and climate, 'matching' potential agroforestry technologies with the corresponding landuse systems may become much easier.

3.2 Inputs/outputs of agroforestry technologies

3.2.1 Type of information required

A description of the inputs and outputs to be collected from either an existing or an experimental agroforestry technology is outlined below.

Land area on which data are collected will normally be expressed in surface area. However, inputs and outputs of some agroforestry activities, such as boundary planting, can be expressed in length units. The actual delineation of the land area affected by the agroforestry technology should take account

of on- and off-site* effects. Off-site effects can be negative as well as positive.

Labour inputs will be by far the most important input in most agroforestry enterprises. In recording labour inputs, attention should be paid to:

i. the type of labour used; male/female; family/hired/community/project; adult/child; skilled/unskilled

ii. the activity for which it is being used

iii. timing in the year and over the years.

Labour input is normally expressed in workdays or hours.

Material inputs required for agroforestry technologies may include seed/seedlings, fertilizers (organic/inorganic), chemicals, fencing material, polythene bags, water, etc. In surveying/monitoring the use of these inputs, quantities used as well as the length of the period during they are used should be recorded.

Tools/equipment used in establishing and maintaining agroforestry technologies are recorded in terms of time used as well as time of use. Common items in this category of inputs are draft animal power, plough, hoe, planting stick, etc.

Other inputs might comprise taxes, levies, transport costs, etc.

Outputs from agroforestry technologies can be obtained from the tree, annual crop and livestock component. The tree component in the technology may yield material products which are harvested/collected irrespective of whether or not it is an end or an intermediate product or whether it is sold or consumed. The tree component may also provide a service to either the crops or the livestock or both. In such a case, the effect of the trees can only be measured in terms of crop and livestock production. Combinations of productive and service roles are also possible.

In measuring tree products a difference should be made between annually harvested/collected (realised) produce and accrued capital produce. In the latter category are tree products which are not harvested at the time they accrue. For example, although the timber value of a tree increases on an annual basis, the accumulated timber output is only realised at the time of harvesting the whole tree.

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* Off-sites may be roughly defined as sites where the effects of an agroforestry technology are being felt, but which are outside the reach of the one who initiated the technology.

Measuring the annually harvested/collected produce, e.g. fruit, fuelwood, fodder, may be a relatively simple weighing exercise. However, measuring the annual increment of the "unharvested" timber or fuelwood output is much more difficult (if destructive sampling is not opportune) and requires training in tree mensuration methods, an area which is outside the scope of this paper. It should be noted that this distinction between realised and accumulated unharvested output is usually only required in experiments which aim at determining the optimal harvesting/rotation time of a tree.

In surveying/monitoring outputs, the quantities harvested/collected and the time of harvesting/collecting should be recorded.

Both fuelwood and charcoal output may be measured in terms of volume and weight. Because wood density differs from species to species there is no fixed ratio between volume and weight. While softwoods may have an oven-dried weight of 500 kg/m , hardwoods weigh on average 750-800 kg/m (15% moisture content). A similar ratio can be seen for charcoal made from softwoods and hardwoods.

When recording the volume of fuelwood, headloads have to be converted into solid volume by using a conversion factor. Although this factor differs with the size of the fuelwood used, it is, on average, between 0.35 and 0.4. (Openshaw, 1983). For reasons related to the energy value of wood, it is easier and more appropriate to express woodfuel quantities in terms of weight rather than volume (see also page 4).

3.2.2 Availability of written information

While there is some scattered literature on inputs and outputs of selected agroforestry systems, no standard summary exists. Readers are referred to Hoekstra and van Gelder's (1985) annotated bibliography and to Brechin's (1984) review of agroforestry project data, for a list of publications containing this type of information.

3.3 Prices of inputs and outputs

3.3.1 Type of information required

The prices assigned to inputs and outputs of agroforestry technologies will depend on the type of analysis envisaged, i.e., a private or a public economic analysis.

Three different prices are commonly used, viz.

- market price
- opportunity cost/value
- shadow prices

For a more detailed discussion on these prices the reader is referred to Working Paper No. 29 (Hoekstra, 1985).

3.3.2 Availability of written information

In most developing countries, information on prices is limited to market prices while opportunity cost and shadow prices have to be derived from secondary data. A rough indication of market prices of tree products may be obtained from the yearbook of forest products published annually by F.A.O.

3.4 Adoption of agroforestry technologies

Farmers' evaluation of agroforestry technologies is part and parcel of the technology development process. Farmer-managed trials (F.M.T's) are the usual mechanism for obtaining this information.

According to Hildebrand et al. (1985), information is required to measure the potential acceptability or rejection of a technology during the first year of testing (passive evaluation). This information will be used to determine whether a technology may have to undergo further modification/evaluation in F.M.T's or whether it can go for wider distribution. Emphasis should therefore be on level of acceptance and reasons for rejection.

In the second year of the F.M.T's, researchers can obtain the information necessary to make an active evaluation of acceptability. Farmers should be asked in this year if they are now (without the project's assistance) using the technology and, if so, on what proportion of the area for which is was recommended.

In assessing the adoption of a tree-based technology, it is also useful to check the characteristics of the farming system in which it is accepted as compared to those in which it is not accepted.

4. FIELD DATA COLLECTION

Whenever written sources cannot provide sufficient information on the systems and/or technology, the researcher may decide to undertake data collection in the field.

The two most frequently used methods for obtaining detailed information on farming systems and their component technologies are by interview and observation. Questionnaires and recording sheets are commonly used for this purpose. Some general guidelines on how to obtain the necessary field data on the system and technology performance are outlined below.

4.1 Systems' data collection

4.1.1 Energy surveys

In trying to establish the pattern of household supply and demand for woodfuel, interviews and observations can be used. Before embarking upon such activities, stratification of the farm population on the basis of anticipated differences in the supply/demand situation may facilitate the analysis of the results and the delineation of recommendation domain areas. A major criteria to be considered for such stratification is the access to woodfuel sources by different user groups.

Another aspect to be considered in the survey design is the pattern of fuelwood collection, i.e., frequency over time. Differences are likely to occur in peak or slack labour demand periods during the year.

When trying to establish the trend in labour input for fuelwood collection over the years, possibilities should be examined for stratification of the farm population based on anticipated differences in time spent on this activity as a result of differences in deforestation.

Studies to determine the standing volume and the annual increment of woodfuel would not normally be conducted by social scientists and are therefore not elaborated here.

A good reference for conducting energy survey is F.A.O.'s "Woodfuel surveys" (1983).

4.1.2 Fodder supply and demand surveys

Farm surveys are commonly used to establish the types and numbers of livestock as well as fodder resources. However, with the exception of concentrates and purchased fodder, actual quantities consumed are not usually part of such surveys. This quantitative information is best determined by specialists in animal nutrition using direct observations rather than interviews. Specialists would also be required to determine fodder production from different sources.

As with energy surveys, stratification of the farm population, based on anticipated differences in supply and demand for fodder, should be considered. The main criteria for stratification in this respect are animal composition (goats/cattle), number of animals and access to fodder.

4.1.3 Shelter surveys

Quantification of the need for shelter materials is probably best handled by breaking it down into different shelter categories.

Fencing

If available, aerial photographs can be very useful in determining the length of boundaries on a farm and/or an area. By relating this information to the fencing needs (farm surveys), the extent of fencing can be determined. In a situation where no aerial photographs are available, actual observations by means of measuring the boundaries would be the most appropriate method.

Building materials

Assessing the need for most building materials is probably best handled by a specialist in construction. Also the availability of building materials from the woody vegetation is best left to a specialist.

4.1.4 Surveys of food/fruit products potential

To determine the nutritional intake of the rural population, interviews as well as observations might be used. The assistance of a nutritionist would normally be required in drawing up questionnaires/checklists.

Data on the availability of energy, protein, minerals and vitamins from tree leaves or fruit might in part be obtained from interviews in which the emphasis is put on establishing the quantities harvested and time of harvesting. Determination of the nutritional value of these tree products is again best left to a specialist if no data is available from literature.

4.1.5 Surveys of service potential

Survey activities to determine the need for technologies with a service function will vary depending on the type of service required.

Shelterbelts for wind protection

The main aim of carrying out surveys on shelterbelts is to establish the amount of damage done to the cropping system as a result of wind. Such an assessment is made by comparing yields of wind-protected fields to those from unprotected fields. Crop surveys, recording inputs and outputs in both situations, are the most appropriate method.

Hedges along contours to prevent soil and water run-off

The effect of soil and water erosion on croping systems may again be measured in terms of differences in yield between fields affected by erosion and protected fields. Since the erosion process takes place over a relatively long time period, a stratification of the affected fields according to the degree of erosion should be made. The decline in inputs and outputs over time may then be compiled on the basis of the different strata.

The effect of using fences to protect crops against damage by stray animals is also measured in terms of differences in yield between damaged and undamaged fields. In surveys of this nature, attention should be paid to the type of fields which are generally affected by livestock damage, i.e., fields near villages, or along main roads, etc.

4.2 Technology data collection

The main sources for information collection on agroforestry technologies are already existing technologies and research projects aimed at generating new and/or modifying technologies.

Information on existing agroforestry technologies can usually be obtained in a single-visit interview in which all relevant input and output data are extracted. It is obvious that records kept on the technology would greatly improve the accuracy of the data. However, stratified sampling over the same technology at different stages of development may also be used to improve the reliability of the data obtained.

Collecting information from newly established research plots requires constant monitoring with the help of recording sheets in which information is either entered at a regular time interval (say, every week) or upon completion of certain activities.

A crucial issue in this respect is to determine the type of data which can be collected from different research plots. A characteristic of most on-station research plots is that they are usually rather small in size, which makes the extrapolation of data a risky business. Another characteristic is the usually rather "luxurious" levels of input and management as compared to actual farm situations. Both factors make the on-station experiments often unsuitable for gathering data on inputs, especially labour inputs, while output data should be handled with great caution.

In principal, on-farm experimentation lends itself much better to data collection, both for input and output data as well as matters related to the adoption of technologies. However, care in data collection should still be taken with those on-farm

trials which require a high degree of researcher involvement in the actual management. Needless to say, such trials may suffer from some of the disadvantages suffered by the on-station trials.

In gathering information from on-farm research some degree of farmer's involvement may be considered. The most common is to provide the family with a small notebook in which they record their activities in relation to a specific technology, and in the case of some really advanced farmers, quantative data could be recorded as well.

Another approach to obtain some labour input estimates early on in the project is to design some special studies in which certain activities, for example the digging of planting holes, become the object.

Several projects have designed forms to monitor technology information. However, very few have a wide distribution. An example of a recording system for fuelwood projects has been published by Reiche (1984).

5. SAMPLING IN FARM SURVEYS

Owing to limitations in time and resources, questionnaires and farm records cannot usually be kept for all members of a population. Sampling of the population will therefore have to be undertaken and estimates made of the actual population value of a parameter being studied (for example fuelwood consumption per household).

There are two main types of samples that can be used in conducting a farm survey (Dillon et al., 1981):

- probability samples
- non-probability samples.

The former type of sampling has the important advantage of minimizing the risk of sampling bias, and it is therefore possible to draw inferences from the sample about the population from which the sample was drawn with levels of confidence that can be estimated statistically.

The non-probability sampling usually has a sampling bias, and estimates of population parameters based on such samples cannot be given with statistical levels of confidence.

A field survey on different aspects of the farming systems and/or technologies can, in principle, be conducted at:

i. the level of the study area in which the diagnostic analysis is being conducted;

ii. the anticipated recommendation domain area.

To draw a random probability sample from the anticipated recommendation domain area will often prove to be impossible because of lack of a sampling frame (list of those members of a population from which a sample will be drawn). Multi-stage sampling and cluster sampling reduces the need to inventory all the members of a population for which a parameter has to be estimated; however, considerable time and resources are still required to conduct such surveys. It is therefore not recommended to conduct probability sampling on the population in the anticipated recommendation domain area unless a special project has been developed for that purpose. In all other cases it is best to confine the research to the actual study site in which a probability sample can be drawn. This implies that no statistical conclusions can be drawn with regard to the population in the recommendation domain area (a non-probability sample).

As mentioned in the verification surveys, it is important to look for systematic differences between members of a population, if such differences are expected to have an impact on the design. For example if there are two types of farms in an area, one with tree cover on part of the land and the other with no tree cover at all, it may be hypothesized that there will be differences in time spent to collect woodfuel for energy purposes from each type of farm, which, in turn, may make a fuelwood enterprise an attractive proposition on the one farm type but not on the other.

Such differences between members of a population might be hypothesized before the actual survey is conducted or they might be derived from a preliminary analysis of the survey results.

Determining the strata of the population beforehand enables the researcher to ensure a sufficient sample number in each stratum. It should be noted that stratification of a population may also be undertaken for pure statistical reasons i.e. to get a better estimate of the population parameters.

Before sampling starts the researcher has to make a decision on the size of the sample (n).

In simple random sampling, the first step is to decide how large an error (E) can be tolerated in the estimate. This requires the researcher to think about the use he/she will make of the estimate. The figure finally reached will be arbitrary, however.

The next step is to express the allowable error in terms of confidence limits, e.g. 5 or 10% chance that the error will exceed the previously determined allowable error.

The next bit of information required is an estimate of the population standard deviation (σ). If there is no information available, a two-stage sampling procedure may be used in which the standard deviation is estimated on the basis of a small preliminary sample; this information may be used to determine how many additional observations are needed to achieve the desired degree of precision (Merill, Fox; 1970).

$$n = \frac{(Zc\ \sigma)^2}{E}$$

in which:

n = sample size

Zc = value of standard normal variable at a given confidence level. (=2 at 95% with n 120)

Sampling in the case of a stratified population might be treated in different ways depending on whether the objective is to obtain estimates of the mean and variable of the population in each strata or to obtain these estimates for the population as a whole. In the former case, each stratum can be handled as an independent population, in which case the aforementioned sampling size formulae can be applied to each of the strata: sample size in one stratum does not depend on the other strata.

If, on the other hand, the main aim of stratification is to improve the estimate of the population statistics, sample sizes in each of the strata will be influenced by each other. To arrive at an optimal sample size in each of the strata, estimates of the standard deviation in each stratum as well as the cost of sampling per unit in each stratum are necessary. As compared with proportional allocation, a large sample is taken in a stratum that is unusually variable and a smaller in a stratum where sampling is unusually expensive.

In many surveys, more than one variable is being surveyed/monitored. Each one has its own variance and therefore requires different sample sizes. This method is known as multivariate sampling.

The method of estimating points to allow for different sample sizes according to the variability of the variables concerned would particularly apply to surveys covering perennial crops from establishment to production. In replanting rubber, for instance, four separate activities can be distinguished: (a) land clearing, preparation and planting; (b) inter-cropping; (c) maintenance; and (d) tapping, collecting and processing. These activities stretch over a 7 or 8-year period, and farmers engaged in the last activity could not be expected to recall information pertaining to the first. A reasonable approach would be to take separate samples of groups of farmers, each group being engaged in one of these activities at present. The size of these samples would differ according to the variability of the data obtained.

6. DATA PROCESSING

In the past decade, computerized data processing has made considerable progress and availability of micro computers for research is no longer impossible. A well-known software package for the processing of agricultural input/output data is FARMAP which has been developed by F.A.O. A drawback of this programme is that, although data can be entered for several years, analyses are always on an annual basis, leaving the researcher with the job of composing a multi-year data set from the annual results.

For the processing of non input/output data several statistical packages are available, and the choice will usually be determined by the hardware available.

REFERENCES

Barnard, G. and L. Kristoferson, 1985. Agricultural Residues as Fuel in the Third World. Technical Report No. 4. Earthscan, Energy Information Programme. London, Stockholm.

Bialy, J. 1979. Measurements of the energy released in the combustion of fuels. Edinburgh, University of Edinburgh, School of Engineering Science.

Brechin, S. 1984. Review of agroforestry project data: production, income, environmental impact. In "Agroforestry in Developing Countries" edited by K. Shapiro Michigan: Center for Research on Economic Development. The University of Michigan.

Dillon J. L., Hardaker, J. B. 1980. Farm management research for small farmer development. Bulletin No. 41. F.A.O. Agricultural Service, Rome.

F.A.O. 1981. Map of the Fuelwood Situation in Developing Countries. Rome.

F.A.O. 1983a. Woodfuel Surveys. Forestry for Local Community Development Programme G.C.P/INT/365/SWE. Rome.

F.A.O. 1983b. Food and Fruit-bearing Forest Species: Examples from eastern Africa. Forestry Paper 44/1. F.A.O. Rome.

Göhl, B. 1981. Tropical Feeds. Rome: F.A.O.

Hoekstra, D.A. 1985. The use of economics in diagnosis and design of agroforestry systems. ICRAF Working Paper No. 29. Nairobi.

Hoekstra, D.A., van Gelder, A. 1985. Annotated bibliography of economic analysis of agroforestry systems/technologies. ICRAF Working Paper No. 10 second edition. Nairobi.

Hufschimdt, M.M. et al 1983. Environmental Natural Systems and Development. An economic valuation guide. Baltimore: The John Hopkins University Press.

ICRAF, 1983. Resources for agroforestry diagnosis and design. ICRAF Working Paper No. 7. Nairobi.

ILCA. 1980. Browse in Africa: The current state of knowledge ed. H.N. le Houerou. Addis Ababa.

Latham, M.C. 1968. Human Nutrition in Tropical Africa. Rome: F.A.O.

Merill, W.C., Fox, K.A. 1970. Introduction to Economic Statistics. New York: John Wiley & Sons, Inc.

Ministere de la Cooperation in France 1973. Memento de l'Agronome. Paris.

de Montalembert, M.R., Clement, J. 1983. Fuelwood Supplies in Developing Countries. F.A.O. Forestry Paper No. 42. Rome.

Nair, P.K.R. 1985. Fruit Trees in Tropical Agroforestry Systems. ICRAF Working Paper No. 32. Nairobi.

Nair, P.K.R. (in press). Agroforestry Systems in Developing Countries. A state of the art. The Hague: Martinus Njhoff.

Negi, S.S., Pal, R.N. Ehrich, C. 1979. Tree Fodder in Himachal Pradesh, G.T.Z.

Openshaw, K. 1983. Measuring Fuelwood and Charcoal. In "Woodfuel Surveys", Forestry for Local Community Development Programme, F.A.O. Rome.

Panday, K. 1982. Fodder Trees in India. New Delhi, Oxford & IBH Publishing Co.

Pratt, D.J., Gwynne, M.D. 1977. Rangeland Management and Ecology in East Africa. London: Hodder and Stoughton.

Pratt, D.J. 1968. Rangeland Development in Kenya. Ann. Arid Zone 7: 177-208.

Raintree, J.B., Warner, K. 1986. Agroforestry Pathways for the Introduction of Shifting Cultivation. In "Agroforestry Systems" No. 4: 39-54.

Singh, R.V. 1982. Fodder Trees in India. New Delhi, Oxford & IBH Publishing Co.

Reiche, C.E., 1984. Economic Data Taking and Practical Analysis in Agroforestry Systems. Turrialba: Costa Rica.