4. Toward scientist-farmer cooperation in ecofarming development

4.1 Participatory research and development

Summarizing the results of Technical Cooperation projects in the agricultural sector, BECKER (1986) concluded that:

> "technical innovations which are designed by development organizations at technology centres, for the most part without any knowledge of the prevailing institutional and organizational conditions, and are tested on target groups do not lead to any change in existing farming systems".

In his view, a transformation of existing farming systems "in African smallholder societies will be possible only if research and extension work help to initiate participatory innovation processes" (BECKER 1985). Theories of participatory research and development (R & D) and reports about relevant experiences are only beginning to appear (e.g. LEDESMA, n.d., FERNANDEZ 1986, CHAVANGI & NGUGI 1987, FARRINGTON & MARTIN 1987, LIGHTFOOT et al 1987). Here, we offer a contribution to the discussion in the hope that it will stimulate innovative projects to promote sustainable agriculture.

Basically two approaches to ecofarming development are possible: designing new ecofarming systems or improving existing smallholder farming systems. Here, we argue for emphasis on the latter, in such a way that activities of agricultural researchers complement and support the informal R & D efforts of the local farmers. New, integrated systems of ecofarming are too complex and risky to be readily adopted by smallholders. The farmers are better able and more likely to test small changes or new components which fit into

their existing production system. Through their informal R & D, they already have experience in observing the effects of small changes within highly complex and interactive agroecosystems involving multistory cropping, intercropping, livestock, microvariations in land forms and soils, and highly variable climatic conditions.

A development approach is needed which combines the farmers' knowledge and skills to deal with their particular environments and the researchers' new ideas and scientific knowledge about ecological agriculture. The researchers have the tasks of discovering the ecologically sound methods practised by the farmers, recognizing their attempts to adjust to changing conditions yet retain sustainability of their farming system and, in collaboration with the farmers, devising methods to help them adjust.

The smallholder farm/household is the focus of these activities, for it is primarily on this level that decisions are made to modify production methods. This means that ecofarming R & D programmes must be highly pragmatic, i.e. related to the realities of the situation. The nature of these realities can be grasped only if technical and scientific questions are viewed in relation to the social, economic and political features of the production system as experienced by the smallholders. Where, for example, 98% of the farmers have no access to mineral fertilizers because roads and transport facilities are lacking, trials involving a combination of organic manure and chemical fertilizer are of limited value (and, of course, trials involving only chemical fertilizer would be of purely academic value). The same holds true if such trials are carried out without considering the questions of purchasing power and profitability for the smallholder family. Ecofarming R & D programmes obviously need to be system-oriented and interdisciplinary if they are to address the problems of these farm families.

The specific circumstances of production make each system unique and set narrow limits for generalizations and predictions. By definition, ecofarming is location-specific.

Rather than any particular ecofarming technique, it is the partici-

patory approach to ecofarming research and development which has wide applicability.

The groundwork for developing this participatory approach has already been laid by the practitioners of Farming Systems Research and Development in its various forms. The basic components of this approach are:

- investigations by an interdisciplinary team of scientists of the existing farming system,
- identification of constraints to higher production,
- design of innovations to alleviate the constraints,
- on-farm testing of the innovations, and
- extension of successful innovations to a wider group of farmers operating under similar conditions.

However, as discussed above, even this approach which emphasizes research on the farm level tends to be top-down: on-farm trials usually represent a test phase for establishing the practical relevance of results already obtained on research stations. If ecofarming techniques are to be adapted to the conditions of smallholders in specific environments, the farming systems approach must be modified to permit farmer participation throughout all phases of R & D.

Situation analysis

The first tasks of the research scientists are:

- to investigate existing farming practices and the reasons behind them, and
- to analyse the decision-making situation of the farm families, taking into consideration such factors as natural conditions, local infrastructure, sociocultural setting, farmers' production aims, and labour economics.

This is best done by means of primarily qualitative and descriptive methods such as Rapid Rural Appraisal (cf. CONWAY et al 1987) and case studies. Larger formal surveys, which are time-consuming and

costly in terms of labour for enumeration and supervision, should be kept to a minimum until the rationale and dynamics of the farming systems have been illuminated by exploratory studies, and hypotheses about major problem areas can be made. Appropriate research methods include:

- review of secondary data (also relevant anthropological studies),
- key informant interviews,
- chain interviews,
- ethnohistories,
- in-depth interviews of farm family members,
- direct observations and key measurements
- semistructured discussions with farmers (individuals and groups, also purposively selected, e.g. women farmers, resource-poor farmers), and
- participation of scientists in farmwork.

Combining several of these methods permits verification of data from different sources. With a view to developing ecofarming techniques, particular attention must be paid to investigating local agricultural knowledge, identifying local problems, and discovering local potential solutions.

Investigating local agricultural knowledge. In some cases, smallholders can explain farming practices in "folk" terms; the researchers need then only translate these into conventional scientific terms. In many cases, however, the farmers can only say that they do things in a certain way because "it is good" or "we have always done it this way." These are practices which have evolved out of several generations of experimentation within the farming group; the present practitioners are no longer aware of the experiences of their forebears which led to the present "traditions". In such cases, the scientists must first investigate the practices to gain an understanding of their ecological validity.

All indigenous farming practices are but the "surface manifestations of an underlying cognitive system of folk knowledge about resource management" (MURTON 1980). An investigation of the farmers' classifications of land and vegetation types, soils and crops can uncover the indigenous knowledge of the ecological principles underlying these practices. It can also help scientists recognize how local farmers measure soil fertility, possibly by indicator plants. Most importantly, knowledge of the indigenous classification systems enables the scientists to communicate with farmers during participatory ecofarming research.

In investigating indigenous knowledge systems, it cannot be assumed that knowledge is equally shared by all members of a farming community. In systems with a pronounced division of labour by gender, women will possess the knowledge required in the areas of production for which they are responsible. For example, the "remarkable knowledge about qualities and uses of indigenous tree species" held by East African women is "tied to their cultural roles and ... unknown to men" (THRUPP 1987a; see also BECKER 1984). It is therefore necessary that scientists recognize and approach the appropriate groups within the community to gain access to specific types of indigenous agroecological knowledge.

Besides forming the basis for development of improved ecofarming techniques, scientific investigation of indigenous knowledge and practices can also make the farmers more aware of the conservation and production-augmenting aspects within their farming system. It gives them greater self-confidence in their own abilities to manage their environment, and more strength in defending themselves against outside "experts" who advocate or try to impose inappropriate "improvements". For example, if farmers learn that, in their traditional intercropping of maize and beans, the small growths on the bean roots help to improve the growing power of the soil for the beans and the maize, they are in a better position to defend their traditional technique against outsiders who may advocate sole cropping of maize (CARLIER & CARLIER 1985).

Identifying local problems. Once the scientists have become more familiar with local conditions and practices, they can contribute to discussions with farmers about possible improvements. Rather than imposing their own view of the problems and potential

solutions, the scientists must respect the farmers' perceptions of the situation. Through dialogue, scientists and farmers can attain a joint recognition of the constraints and possibilities of maintaining or increasing productivity of the land. It is essential that much time be devoted to this step of mutual learning. Such participatory processes of problem analysis have already been practised by innovatory projects in, for example, Peru (FERNANDEZ 1986), Guatemala (BUNCH 1985) and the Philippines (LIGHTFOOT et al 1987). In the Philippines, the combined efforts of researchers and farmers in analysing and prioritizing problems and in seeking possible solutions led to farmers' experiments with legumes to control *Imperata cylindrica* on fallow land and to simultaneously speed up soil fertility regeneration.

In cases where the farmers appear to lack a consciousness of environmental degradation which outside ecologists perceive, the combined efforts of biological and social scientists will be needed to awaken this consciousness (whereby the ecologists must remain open to the possibility that their initial judgement of the situation was not entirely correct). This must be done in the language and concepts of the farmers, in joint observations and evaluations in the field by farmers and scientists. If no consensus can be reached about the necessity for conservation measures, it cannot be expected that the farming community will carry these out voluntarily. If they are recompensated in some way, e.g. through a food-for-work programme, maintenance of the conservation measures by the farmers will cease as soon as the programme does. In such a situation, it would be more advisable for the scientists to encourage the testing of innovations which coincide with farmers' primary interests, e.g. producing food, fodder and/or firewood, and in which the conservation aspect is a by-product, e.g. through contour planting of multipurpose trees or forage grasses.

Discovering local potential solutions. Already within the existing farming system, researchers can find indications of promising innovations. In no community do all men and women cultivate in exactly the same way. Comparisons of neighbouring farmers or villages may reveal that certain practices, e.g. land preparation, sowing dates, plant densities, crop mixtures or the use of certain varieties of crop species, lead to higher sustained yields, possibly combined with more efficient use of water, better ground cover etc.

Deviations from traditional practices can also be indicators of stress: when farmers encounter difficulties with which traditions cannot cope, they begin to experiment (VIERICH 1984). Observation of farmers' experimentation can help researchers identify the constraints which farmers face and the type of innovations in which they would be interested. Often, researchers can learn of these experiments from other local farmers who are waiting to observe the results before testing the innovation themselves.

Further sources of ideas are traditional techniques which are no longer used, for example, manuring practices which have been replaced by the use of highly price-subsidized chemical fertilizers, or traditional mechanisms of managing communal resources which have been replaced by externally imposed land laws.

Researchers can stimulate farmers' discussions of the ideas already within the community, in addition to providing new ideas (possibly from ecologically similar areas) and scientific knowledge of ecological principles. In this way, the farmers and scientists can work toward an agreement about innovations which should be investigated, tested and adapted to suit the local situation. The research priorities for on-farm trials must be set by the farmers. As already discussed above, enthusiastic and conscientious cooperation of farmers in the R & D programme can be achieved only if the farmers regard the innovations as desirable and necessary.

During joint situation analysis by farmers and scientists, problems may become obvious for which neither group can suggest possible solutions. In such cases, research under controlled conditions (on agricultural stations or in laboratories) will be necessary before options can be offered to farmers for on-farm trials.

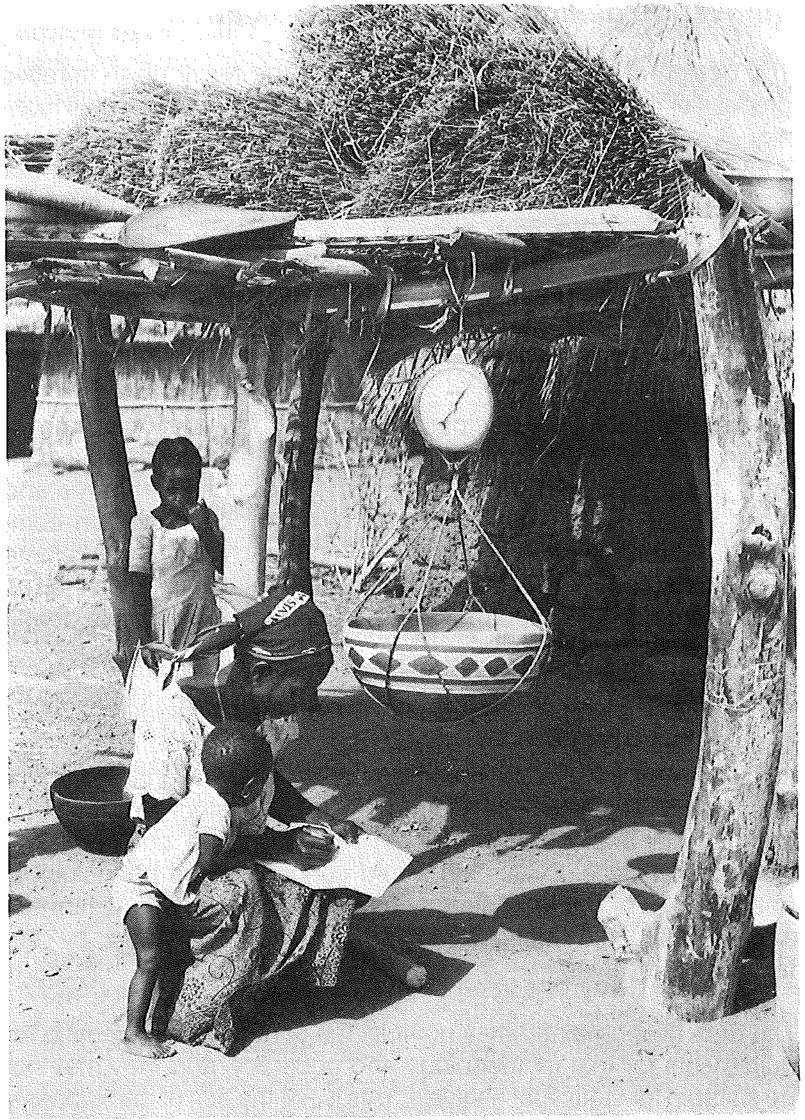
Innovation design, testing and evaluation

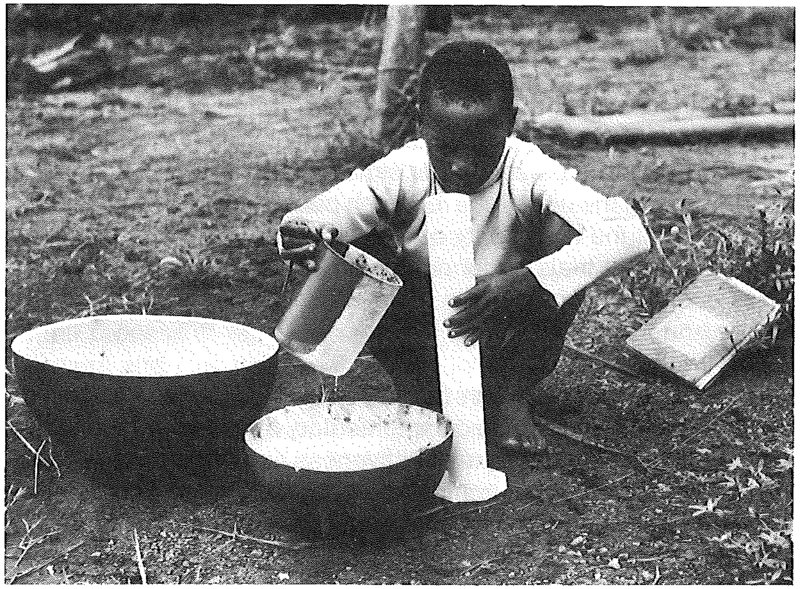
The design of appropriate innovations is the result of an iterative process of testing, evaluation, retesting and re-evaluation until techniques are developed and optimized for the given farming system. It involves on-farm research by farmers as well as research under controlled conditions by scientists. Early beginning of small-scale experimentation by both farmers and scientists should be encouraged, for a technique can be adapted to a particular environment only through practice. Moreover, collaborating with farmers in on-farm trials gives researchers an ideal opportunity to become directly acquainted with local constraints.

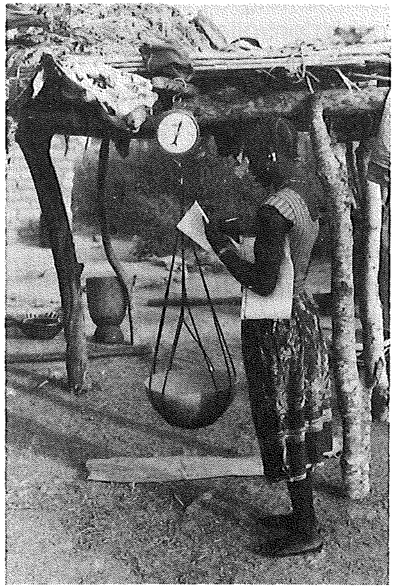
On-farm-trials. Truly participatory testing and evaluation of innovations means that the farmers manage the trials themselves. "On-farm" trials can refer to those conducted on individual farms and those conducted by members of a farming community on communal land. Observing how local farmers carry out and evaluate their own informal experiments can give the scientists guidelines as to how to simplify and adapt formal experimental designs to permit participatory research.

For example, a simple research procedure for investigating how an existing multiple cropping system (maize and beans) can be optimized might involve the incorporation of an additional variety or crop (using gene pools developed, possibly by other smallholders, under similar ecological conditions) on a small area, and variations in stand densities. Evaluation would concentrate on phenological observations of the type already made by the indigenous farmers and simple yield measurements, preferably recorded by the farmers themselves.

The data thus obtained may not fulfil the conventional scientific requirements for trial methodology and accuracy, and they may not be suitable for statistical analysis. This is not the aim of participatory R & D, which is meant to benefit primarily the farming community rather than the scientific community. Nevertheless, in this way, scientists can still amass a wealth of practical knowledge and







Plates 18, 19 and 20:
In participatory R & D, recording is best done by members of the farm families – here, a woman without any formal education (left), a schoolboy (top) and a schoolgirl (bottom) recording milk yields in an agropastoral system in Nigeria. Instead of conventional scientific equipment as shown here (scales, measuring cylinder), standardized local measures which farmers apply in evaluating their own informal experiments can be used.

methodological possibilities. The wider value of such on-farm trials should not be underestimated:

- supported by trial results from comparable locations, they can form the basis of recommendations which can be passed on to other farmers operating under similar conditions;
- from among the numerous research possibilities, they allow identification of the top-priority questions which require further study in more exact trials under controlled conditions; this focusing of research questions permits more effective allocation of research time and funds.

Collaborative research with farmers cannot replace conventional agricultural research; it is a complementary approach which can reduce the costs, increase the effectiveness and ensure the practical relevance of researcher-controlled experimentation. The development of techniques and systems of sustainable agriculture adapted to particular environments will depend on the synergism of conventional agricultural research and participatory R & D.

Researcher-controlled trials. Through controlled trials, the scientists can gain a greater understanding of how existing and "improved" ecofarming techniques function in ecological terms. If to continue with the above example – the on-farm experiments reveal that an upper storey of *Sesbania* trees fits well into the existing multiple cropping system, it may still not be possible to quantify the relationships between the proportions and stand densities of the individual crops in the mixture accurately enough to be the basis for more widespread recommendation of the practice. The scientists would need to draw up a programme of trials to investigate these questions and the possible influence of crop geometry on microclimate, duration of assimilation, and yield. These trials would be conducted under controlled conditions and designed to meet the requirements of quantitative statistical analysis. Here again, however, the aim should be to quickly produce results which can be used by R & D workers in the field, rather than waiting until ultimate statistical accuracy is achieved.

Monitoring farmer-controlled trials. In their own trials, the farmers see how the innovations function within their farming system and household economy. Of key interest are the alterations that individual farmers make in the innovations while testing them, e.g. differences in planting times and techniques, differences in crop management, differences in utilization of the products. Discussion with the farmers about the reasons for and results of these variations gives valuable insight into ways of improving the new technique and adapting it to the local conditions.

If the process of situation analysis was limited to scientists asking farmers and then making their own interpretation of the problems, monitoring of on-farm trials can also reveal misinterpretations by the scientists, who then have the opportunity to change their research focus accordingly. In Kenya, for example, scientists had advocated alley cropping with *Leucaena* to increase soil fertility and subsequent yields. However, the farmers planted the trees with fodder grasses instead of food crops and fed both the grasses and the *Leucaena* to cattle. They perceived the problem of dry-season fodder shortages as greater than that of decreasing soil fertility. Researchers then adjusted their recommendations for management of the system, e.g. pruning frequency and height, to cater for fodder production (JAMA 1987).

Joint evaluation of trial results. Just as important as the collaboration of farmers and scientists in innovation testing is their collaboration in evaluating the results of on-farm trials. This gives the scientists further insight into the value system and hierarchy of needs within the farming system, and can help in modifying the technique or designing other techniques which suit the farmers' needs and resource availability. Scientists will often find that the productivity indices usually applied on research stations (yield or income/ha) are not of highest priority to the farmers, who will be more concerned with yield per unit of the most limiting production factor, e.g. returns to labour during the labour-bottleneck period (cf. NORMAN et al 1982). The ultimate test of an innovation's value to farmers will be, of course, the adoption and spreading of the innovation.

An important part of the researchers' work in participatory R & D is to help the farmers develop techniques of evaluating on-farm trials, thus strengthening their experimental capacity so that they are better able to adjust quickly and independently to changing conditions. Scientists must also be able "to classify the components of a trial, analyse the interactions between them, and interpret the outcome to facilitate both diffusion (if successful) and incorporation of trial results into the body of scientific knowledge" (FARRINGTON & MARTIN 1987). Scientists involved in evaluating on-farm trials are in a position to identify questions which still require basic or applied research on station to support the process of adaptive research described here.

Spreading the ideas

If, through participatory R & D, the farmers themselves have identified their major farming problems, selected possible solutions, tested these and evaluated the results, any ecofarming techniques thus developed will become a part of their production system. The farmers who were directly involved in this process will have gained new knowledge. They are likely to be the best "extensionists" within the local community. Innovations that have proved in on-farm trials to be truly successful in the farmers' terms are quickly dispersed through indigenous communication channels, mainly by word-of-mouth and by passing small amounts of required inputs (e.g. planting material) to relatives and friends.

This farmer-to-farmer communication can be assisted and extended beyond the local community by means of innovator workshops, such as that in Northeast Thailand where farmer-experimenters in rice-fish farming were brought together to learn from each other, to "teach" the observing scientists, and to generate hypotheses for further research (CHAMBERS & JIGGINS 1986). Rather than on-station training by professional extensionists, farmers are likely to prefer observing and discussing innovations in farmers' fields, together with their colleagues who have already gained experience with the innovations through on-farm trials. In Kenya, for

example, farmers associated with an agroforestry centre organized (and financed) their own training programme, which consisted of periodic visits – at times which suited them – to different local farms rather than to the centre originally intended for formal residential training (JAMA 1987).

Visits to other farming areas can help not only to extend innovations but also to stimulate farmers' discussions about ecological problems and the need for ecofarming measures. For example, representatives of a community in Haiti were taken to a similar but very degraded environment to discuss the potential in their own area for natural resource degradation and how this could be avoided (THRUPP 1987b).

Just as techniques from industrialized countries can seldom be transferred directly to smallholder farms in developing countries, so also the ecofarming techniques developed within one smallholder farming system cannot be transferred directly to another. Differences in, for example, soil type, climatic variability or farmers' production aims may lead to the failure or rejection of techniques which were successful elsewhere. Development agents (including visiting farmers) can, however, present farming communities with various options from ecologically similar areas, which would merit experimentation and modification by the local farmers.

Conventional extension usually refers to introducing and diffusing innovations from elsewhere. Ecofarming extension has often also consisted of teaching farmers techniques which outsiders devised and regard as ecologically sound.

Within participatory ecofarming R & D, however, *extension* becomes an *advisory service* (as it was formerly known in the English language) which supports local efforts.

The role of the outside agricultural advisor is as a catalyst and facilitator (FERNANDEZ 1986): generating thought and discussion among farmers of their problems (conscientization), encouraging problem-solving initiatives, making farmers aware of techniques found or developed in other smallholder systems which could be adapted to the local farming system, and making available or drawing attention to low-cost inputs which could help improve the system.

Building on local knowledge, initiatives and resources to develop ecofarming techniques encourages the self-reliance of smallholder communities, releasing them from the risk of depending on unreliable and – from their viewpoint – uncontrollable supplies of external inputs. Above all, a participatory approach to ecofarming development increases the capacities of resource-poor families to solve inevitable future problems with little outside resources or aid.

Concern with the costs of agricultural research and advisory services strengthens the argument for such a participatory approach. In countries in which the agricultural sector dominates, as in many developing countries, agricultural development can be financed to only a very limited extent out of the income from other sectors of the national economy. As FARRINGTON and MARTIN (1987) point out, the resources will not be available for researchers alone to develop technologies for the complexity and variability of agroecological conditions under which smallholders operate. Technical Cooperation has the aim of promoting self-sustaining development. Participatory ecofarming R & D represents a means of achieving this aim in the agricultural sector, as it is designed to strengthen self-help capacities. This approach to agricultural development can make efficient use of:

- local skills in developing site-appropriate techniques of sustainable agriculture, and
- local information networks in spreading ecofarming knowledge and in providing stimuli for ecofarming development within and between farming communities.

4.2 The challenge for Technical Cooperation

How can ecofarming be promoted within Technical Cooperation? The process depicted in Figure 1 builds on the principles of ZOPP

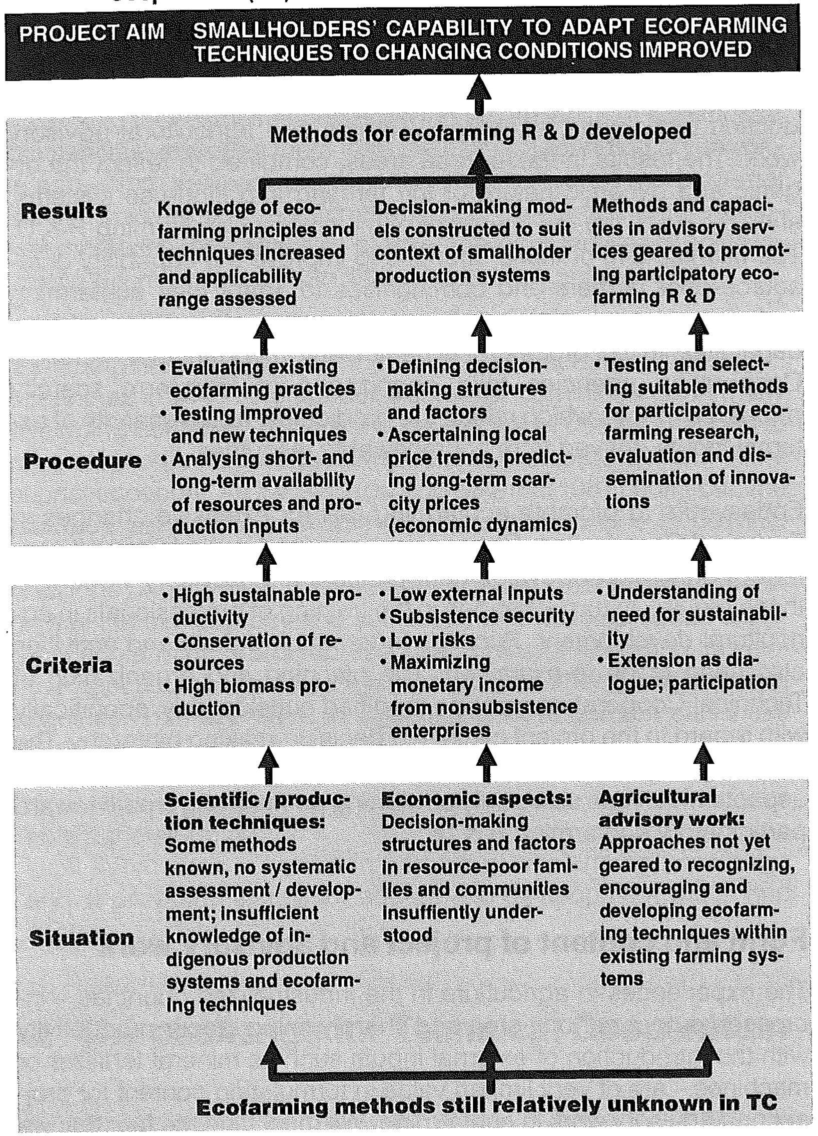
(*Zielorientierte Projektplanung*, derived from USAID's Logical Framework). The figure is to be read from the bottom up, starting with the present situation within Technical Cooperation and passing through the criteria formulated for promotion of ecofarming to the procedures to be adopted, outlined in the areas of scientific/production techniques, economic aspects and agricultural advisory work. The results in these three areas, combined to reflect the organic and dynamic nature of the farming and land-use systems, should lead to the development of methods for ecofarming R & D. The ultimate aim of these efforts is to improve the capability of resource-poor farmers and communities to adapt their ecofarming techniques to changing conditions, i.e. to strengthen their self-help capacities. In this process, it is particularly important that Technical Cooperation agencies take cognizance of long-term scarcity prices, i.e. prices which reflect the predictable future scarcity of external inputs derived from nonrenewable resources.

Endeavours to promote ecofarming call for extensive changes in Technical Cooperation. Changes are required in the form and content of agricultural development projects and advisory work, and these require, in turn, changes in the training of professionals in agricultural development. Priorities in terms of regions and activities also need to be re-examined. The planning and organization of Technical Cooperation must be modified considerably, specifically with regard to the project cycle and decision-making hierarchy. The following brief discussion of required changes is limited to a few aspects which can serve only as starting points along a path toward participatory ecofarming R & D.

Form and content of project and advisory work

The experiences in agriculture in the industrialized countries – increased output per unit area and sharply rising labour productivity with the introduction of external inputs such as mineral fertilizer or machines – are of very limited value in formulating content for project and advisory work in ecofarming. We must face the fact that we are not able to offer alternatives with a similar degree of general

Figure 1: Approach to promoting ecofarming within Technical Cooperation (TC)



validity for the conditions of smallholders in developing countries. Thus far, we have accumulated some knowledge of basic principles and isolated techniques of ecofarming but have not yet established adequate links to indigenous ecofarming knowledge and farming systems in the tropics and subtropics.

In general, and rightfully so, agricultural advisory work is being assigned a position of importance in future rural development strategy extending far beyond its current status (GTZ 1981, VON BLANCKENBURG 1982, THIMM & VON URFF 1982, DE HAEN 1982, GTZ 1983). Growing emphasis has been placed on developing extension approaches and methods. What is now needed is greater consideration of the demands which the special features of ecofarming R & D make on agricultural advisory services. Organizational forms, methods and capacities must be developed to promote site-specific R & D which builds on the knowledge and initiatives of the local farmers. This requires close cooperation of project specialists and agricultural advisors in eliciting farmers' views of ecological problems and possible solutions, in encouraging and facilitating farmers' experiments in ecofarming techniques appropriate to their specific situation, and in helping them evaluate the results. Local agricultural advisors will have more constant contact with individual farmers and farmers' groups than the specialists and should therefore be in a better position to judge a) what type of additional knowledge might be of help to farmers and b) how and when this could best be conveyed.

Measures which Technical Cooperation agents regard as having potential to solve ecological problems faced by smallholders must be analysed according to the specific situation of the farmers, and the approach to project work must be selected accordingly. For example, the creation of erosion-control strips in a densely populated highland area can initially mean a reduction in cropping area and, thus, in output per unit area. If this measure is to be integrated into the farming system, a lengthy period of joint problem analysis by farmers, scientists and agricultural advisors will be required, followed by collaborative small-scale trials with individual farmers. In sparsely populated arid areas, on the other hand, "loss" of land to erosion-control strips may be of less significance, but the flexible and extensive strategy of resource use required in such dry areas is likely to limit labour availability and inhibit willingness of individuals to establish permanent structures. In such cases, it may be necessary to seek group-based initiatives. Of course, creating erosion-control strips would be possible only if the group enjoys generally recognized and secure rights to use the land area concerned. The possibilities of implementing specific measures under the given socioeconomic and political conditions must be realistically assessed. In insecure tenant farming systems, for example, tenants will have little motivation to invest in resource-conserving measures.

Investments in resource conservation often involve a considerable amount of labour and, at least during the start-up phase, may decrease return per hour of labour expended. It is particularly important to choose an appropriate time for encouraging the measure, so that the additional labour requirements can be coordinated with family labour supply at different seasons or at different points in the family development cycle. In areas where cultivation cannot be expanded, a labour-intensive increase in output per unit area not only produces additional food but also creates employment. Readiness to try an innovation is likely to be particularly great when food requirements and labour capacity are high, e.g. in the middle of the family cycle while children are old enough to work but before they have formed their own households, or when marriage of a son or daughter increases the size of the farm family.

To find out how farm families and communities in a given area can best be assisted in re-establishing, maintaining or further developing sustainable forms of land use, project specialists must work in close cooperation with agricultural advisors in R & D on the farm level. Project workers can no longer be regarded as implementers of preconceived measures, and agricultural advisors no longer as "extenders" of purely external knowledge. They must communicate and collaborate directly and continuously with local farmers so as to find solutions to local problems and, more importantly, to enable the farmers to continue an autonomous process of finding and implementing their own solutions.

Such an approach to ecofarming development demands much closer administrative links between agricultural research and agricultural advisory services in the developing countries (BECKER 1986). This should also facilitate the feedback of information from R & D workers in the field to specialists in commodity and disciplinary research programmes so as to orient current and future research to farmer realities (FARRINGTON & MARTIN 1987). It is particularly important that Technical Cooperation encourages and assists national agricultural research facilities to cooperate with agricultural advisory services in the R & D process.

More attention must also be given to how the results of project work are presented. Results of research in different disciplines are commonly reported in isolation and in such a manner that professionals in other disciplines can recognize few, if any, possible points of contact. On the other hand, efforts to integrate the results in a systems context which reflects the decision-making situation of the farmers often leads to general confusion. Ways must be found of integrating research results from various disciplines into a comprehensible whole and evaluating them within that context, yet at the same time clearly indicating how the results and evaluation were attained. Similarly, ways must be found of exchanging research results between scientists and farmers so that collaboration in testing, refining and evaluating innovations can be a truly iterative process.

Here, social scientists have an important role to play as prime mediators between technical scientists and farmers in facilitating participatory action research, particularly in developing appropriate methods of communication.

Training of professionals in agricultural development

Successful promotion of the ecofarming concept within Technical Cooperation makes considerable demands on the quality and training of professionals for such projects. In the existing structure of the agricultural sciences, combining the various disciplines from the viewpoint of the farmer is the task of applied farm management theory. However, it is beyond the scope of this discipline to assess and improve technical measures or to develop methods of stimulating participatory action research. Therefore, the willingness and ability of representatives from different disciplines to cooperate in project activities is absolutely essential.

In view of the high degree of specialization in agricultural education and research, it is particularly important in ecofarming development that the cooperation between disciplines be well-coordinated and appropriately organized. In addition to the specialists, Technical Cooperation increasingly needs "generalists" with good management skills as project personnel and counterparts. They may not be able to make highly detailed analysis of the scientific principles behind individual ecofarming measures, but they should, by virtue of their knowledge and understanding of the farmers and their situation gained through years of practical experience, be able to recognize ways of introducing, encouraging or improving appropriate ecofarming measures.

Both specialists and generalists in ecofarming programmes require some training in analysing the decision-making behaviour of smallholders and the factors governing it, so that they have a common basis for interdisciplinary discussion, even if a social scientist is available to do the in-depth investigations. The professionals must learn to appreciate indigenous knowledge and indigenous ability to generate further knowledge. They require skills in recognizing, recording and evaluating indigenous ecofarming techniques and innovations. They need sensitizing to other cultures and other ways of classifying nature, so that they can discover the content and methods of "folk science" and find a basis for discussion with farmers. Few professionals trained only in conventional scientific paradigms are able "to penetrate the inner logic of the farmers' complex systems and ... to understand the terms of reference they use in talking about their cropping decisions" (SHARMA 1985).

To the extent possible at this early stage, the personnel of ecofarming projects require training in participatory action research, drawing on the experiences of innovatory research teams which have already started to explore this path toward sustainable agricultural

development. This should include training in skills needed for effective dialogue with farmers, for stimulating discussion between farmers, for recording what is heard and observed, and for using these notes to guide future activities. A step in this direction has been taken by CIP with the aid of training documents such as *The Art of the Informal Agricultural Survey* (RHOADES 1982).

Priorities in terms of regions and activities

The survey of ecofarming activities referred to previously revealed that efforts have been focused primarily in favourable climatic zones and on maintaining and improving soil fertility. Relatively little is being done for the semiarid and arid zones. The zonal emphases influence the emphases in terms of type of measures being promoted. In the decision-making situation of smallholders, the climate-related production risk is far greater in the drier areas. Here, the central issue is conserving resources, i.e. combatting erosion and desertification.

In future, greater attention must be devoted to less favourable climatic zones, and measures aimed at reducing climate-related production risks and improving water utilization must therefore be given equal status alongside soil fertility maintenance.

The specific ecofarming measures to be promoted will depend on the characteristics of the particular location. Given the vast range of agroclimatic and socioeconomic conditions in developing countries, the measures and associated research needs will be highly diverse. In each case, these will be revealed by a joint analysis by scientists and local farmers of the constraints within the given farming system. During this analysis and attempts to overcome the mutually recognized constraints, gaps in scientific knowledge will become evident which will require further research.

The following list merely gives examples of the type of topics which still need to be investigated, if we are to deepen our understanding of agroecosystems and make them more productive and sustainable. The list does not cover all aspects of ecofarming and is expressed in fairly general terms. More exact formulation of research topics will be necessary, depending on the site-specific conditions. The priorities in ecofarming research activities will be dictated by the most urgent problems of the local farmers.

Agroforestry:

- Effect of multistorey farming on the microclimate and yield physiology of food crops (CO_2-assimilation, photosynthesis etc.), as well as on key parameters of soil fertility (organic matter, structure, pore space, biological activity, water balance etc.);
- Suitability of promising tree species for use in agroforestry systems (light transmission, competition of roots with food crops, allelopathic compatibility etc.);
- Locational suitability and ecological requirements of tree and shrub species valuable in agroforestry terms;
- Biomass production (for mulch and fodder) and nitrogen production of various shrub legumes grown as hedges (*Leucaena, Calliandra, Sesbania etc.*).

Multiple cropping:

- Further development of traditional multiple cropping systems by introducing additional crops, using improved varieties (e.g. lower-storey crops with a high degree of shade tolerance) and applying improved cultivation techniques (better plant or row spacing, contour planting etc.);
- Performance of traditional and improved multiple cropping and sole cropping systems (labour productivity, output per unit area, physical yield, farm income etc.);
- Interactions between crops (e.g. allelopathy, N_2 fixation of legumes as influenced by a companion cereal);
- Plant protection by means of multiple cropping.

Green manuring:

- Locational suitability of specific green manuring plants and mixtures (biomass production, fertilizing effect, nutrient and water requirements);

- Undersowing of green-manuring crops, e.g. in maize, sorghum, upland rice (shade tolerance, degree of competition for water and nutrients, N_2 enrichment capacity etc.);
- Integration of green manuring periods into existing crop rotations;
- Labour efficiency, particularly with regard to working green manure crops into the soil;
- Combination of green manuring with, e.g. farmyard manure, compost and/or mineral fertilizers;
- Long-term changes in soil fertility (humus content etc.) as a result of green manuring;
- Selection and breeding of fast-growing green-manuring legumes;
- Crop/green-manure geometry in intercropping and sequential cropping patterns.

Composting:

- Long-term effects on yield and soil fertility of compost on its own and combined with other fertilizers (green manuring, rock phosphate, lime, mineral nitrogen) in all agroclimatic zones;
- Heap versus pit composts where both methods are possible: rotting process and quality of final product (aerobic/anaerobic fermentation, rate of conversion, N_2 assimilation, formation of humic substances etc.);
- Dung/plant composts versus pure plant composts;
- Economic efficiency of compost making and use (labour efficiency, opportunity costs of materials composted etc.);
- Antiphytopathogenic effect of compost application to various food crops.

Mulching:

- Mulching versus composting using the same base materials (organic wastes): yield function, labour efficiency, nutrient balance and dynamics, biological activity of soil;
- Decomposition rate of various mulching materials, chopped differently and applied in different quantities, in selected agroclimatic locations;

- Weed control by means of mechanical tillage versus mulched plots without tillage: weed infestation, effects on crop yields, erosion hasards, efficient use of labour.

Integrated animal husbandry:

- Importance of crop residues as livestock feed, and effects of removal of residues from fields on nutrient status of the soil, disease cycles in crops etc.;
- Role of manure in cropping; documentation of existing practices and evaluation of their effectiveness; improving nutrient supply by means of improved collection, preparation and application of manure;
- Effects of nutrient transfer from natural pastures to cropland on the stability of the former;
- Effects of expansion of cropping on feed supplies, particularly of ruminants; through more extensive cropping, feed supplies (crop residues) in the dry season may be improved, but wet-season fodder availability may then pose problems;
- Effects of changes in land use and vegetation geometry on epidemiology of animal diseases, e.g. trypanosomiasis;
- Development of cropping patterns including multipurpose forages and leys, which can improve soil fertility, aid in erosion control and provide a better animal diet, particularly in terms of energy and protein;
- Role, productivity, disease control and possibilities for improving husbandry and integration of animals with regional importance, e.g. buffaloes, camels, and small animals such as guinea pigs and rabbits within existing farming systems.
- Present and possible future sylvopastoral land-use systems and ways of ensuring their sustainability, e.g. use of afforested land for grazing or forage production.

Planning and organization of Technical Cooperation

Promotion of ecofarming through participatory R & D demands considerable adjustments in the project cycle and decision-making hierarchy within Technical Cooperation. "Intellectuals, development agencies and governments have all pursued environmental management problems at too high a level of abstraction and generalization" (RICHARDS 1985). To find solutions for specific locations, project decision-making must be decentralized, guided by direct contacts between project personnel and local farmers. Project planning must be flexible, involving continuous monitoring and replanning. Imaginative and unorthodox approaches in scientist-farmer cooperation should be welcomed by the Technical Cooperation administration. The experiences thus gained should be evaluated and mistakes frankly discussed and accepted. It is through such creative learning-by-doing and honest reflection that effective methods for ecofarming R & D can be developed.

Using the procedural cycle developed by the World Bank (1981) for agricultural projects as a basis, necessary changes would include the following:

- Project identification and preparation must be more closely linked, involve the participation of the intended beneficiaries, and be seen as a single "orientation" phase;
- In projects aimed at promoting ecofarming, to which there is no alternative for the development of subsistence farming and resource conservation, and which have been well-prepared, project appraisal as a separate phase can be eliminated; usual macroeconomic criteria will be of little value; economic criteria relating to the individual farms – above all, increasing the smallholders' income – must be considered in the preparation phase;
- With respect to project implementation, agreement must be reached during the orientation phase as to what extent necessary investments are compatible with the income expectations of the intended beneficiaries and can be their responsibility, or to what extent they should be provided with support; experiences gained during project implementation must be incorporated as quickly

as possible in the further course of the project and in the planning of other projects. This calls for close interlinkage of planning and implementation, and is one reason why these phases should not be administratively separated.

In contrast to the usual procedure, particular importance must be attached to ensuring that the project achieves a sustained effect with low follow-on costs.

A further question concerns the wider applicability of the results of site-specific ecofarming R & D. Which aspects of ecofarming can be generalized? To what extent can information be conveyed beyond the framework of individual projects and what methods would facilitate this dissemination? Would a suitable characterization of, e.g., the natural conditions of the location of one ecofarming project help to judge the applicability to other locations? Could individual ecofarming measures be classified according to suitability for particular circumstances, e.g. according to temperature and rainfall regimes, soil types, land-use systems etc? The answers to these questions affect not only the expedient scope and organization of work in ecofarming projects in the field but also the role played by head-office projects.

In all Technical Cooperation projects, the decisions as to project selection, design and execution are influenced not only by relevant specialist knowledge and corresponding project experience. Amongst the numerous influencing factors, the administrative and political decision-makers play an important role (RUTHENBERG 1977). By virtue of its very nature, project work with a specialist orientation aims to minimize the importance of nonqualified influences. One way of doing this is to pass on specialized knowledge and experience within the decision-making hierarchy also above the level of the rural communities; in other words:

Administrative and political institutions likewise require decision-making aids; the content and methods for advisory work must be prepared accordingly and made available.

The advisory material to be passed on to administrative and political decision-makers must be concise, logically structured and expressed in nonspecialist terms. To permit effective communication, the fields of development administration and politics must also become a subject of extension research. Administrative and political institutions, in developing just as in industrialized countries, often display a tendency to take no notice of relevant experiences, to regard as plannable certain areas which are in reality unplannable, to regulate processes which do not need regulation and, out of a mistaken conception of continuity, to resist changes which are, in fact, advisable. The efforts required to convince these institutions of the need to promote ecofarming will be far greater than the efforts required to convince the smallholders in developing countries.

Within institutions concerned with ecofarming development, recognition has grown of the need to decentralize activities, to reduce project size, and to consider the particular local conditions of each project. Nevertheless, development planners, researchers and project personnel in government departments and mainstream development agencies have still had to operate within highly centralized structures, bound by fairly rigid institutional requirements. A challenge still to be faced by Technical Cooperation is the modification of administrative structures and procedures so that development project personnel can work directly with resource-poor farmers in an iterative and flexible process of jointly recognizing local land-use problems and jointly developing solutions, including unexpected ones. Project work should be guided by the needs of the smallholders and their choices of ways to meet these needs.

The major role of Technical Cooperation in ecofarming is to participate in the locally-based efforts of smallholders to maintain and develop the resources on which they depend, and administrative structures and procedures are required which permit this participation.