SMALL RUMINANT PRODUCTION IN MIXED FARMING SYSTEMS: CASE STUDIES IN RESEARCH DESIGN

C. Okali and H. C. Knipscheer

INTRODUCTION

Although there are a number of texts describing farming systems research (FSR) methods (Gilbert, et al., 1980; Byerlee, et al., 1980; Perrin, et al., 1976), these are still the subject of debate. The debate essentially revolves around two issues. First, the necessary link between the social and technical sciences that determines the success of the systems research approach. Connected with this is the willingness of each science to adopt unconventional data sets and methods of data collection. The second related issue concerns the importance of on-farm work and the methodological problems raised when undertaking research in the context of the farm.

Since on-farm research, frequently defined as research on farmers' fields (Byerlee, et al., 1980) but used here to mean involving farmers in the research process, is the principal distinguishing feature of FSR, this paper is largely concerned with the design of on-farm work. The relationship between experiment station and on-farm work has been discussed elsewhere (Okali and Sumberg, 1986).

One basic assumption in the paper is that both farm and experiment station activities involve social and technical scientists. In practice, it is often only biologists, breeders, animal scientists, agronomists, and economists who are regarded as essential farming system team members. Agronomists and economists are frequently the only team members working directly with farmers. Collinson (1982), when reviewing on-farm activities, refers only to the biologists' and economists' contribution. The view of on-farm research as carrying out replicated trials on farmers' fields and livestock, and an associated narrow view of relevant data for technology development and testing, contributes to the exclusion of other disciplines. This narrow definition and interpretation is also reflected in the stylized research pattern of baseline surveys, and researcher-managed and farmer-managed trials, which has become institutionalized as FSR. Experience still has to show that this is useful in practice, or even as a tool for teaching purposes. For example, the stages in FSR represent a top-down approach to technology development that basically excludes farmer involvement beyond baseline surveys.[1] While Menz and Knipscheer (1981) attempt to circumvent this problem by linking different types of research methods with various stages in technology design, they also conclude with a top-down approach, farmer involvement being included only as a final stage in the research process.

This paper first describes two small ruminant production systems, one in Java, Indonesia, the other in the humid zone of West Africa, to highlight key features of small farm systems that should determine the way in which on-farm research is designed. Second, the experiences of two small ruminant research teams working in these areas, and of other research programs

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working in similar farming system contexts, are used to demonstrate problems in conventional trial designs and the value of a broader view of on-farm research (Table 1).

THE SMALL RUMINANT SYSTEMS[2]

Generally, in both the humid zone of West Africa and in Java, Indonesia, small ruminants are indigenous, unselected breeds that are highly variable, both in size and productivity (Mack, 1983; Sabrani, et al., 1982). Ownership is widespread and average flock size small. Small ruminant production is a subsidiary or minor enterprise; it is not specialized livestock production and it provides a comparatively small proportion of total farm income, although the proportion increases for smaller farmers. In West Africa, contrary to many other farm resources, small ruminants are frequently owned by individuals for whom they might represent a major income source. They are also a convenient source of bulk income. Lagemann (1974) associates the increasing importance of livestock income relative to total farm income in southeast Nigeria with off-farm employment.

The main features of the systems in the two locations are summarized in Table 2. Small ruminant production is a typical, small farmer activity attracting minimum investment in housing, feed, and health care, and largely sustained by the potential of the indigenous breeds themselves. Sharecropping,[3] which reduces cash/capital requirements further, is common to both areas. Crop by-products, kitchen wastes, and in Java, crop residues, are important feed supplements, but in both cases these are not fed systematically. The amount fed and its importance varies significantly between producers and according to season. In general, the actual and potential role of these supplements appears minor. Under confinement in both areas, feed is collected from surrounding vegetation. The end product of these systems is meat production. Livestock are in general kept for sale, although they are widely consumed at religious festivals and during ceremonies.

While this describes the systems in general, two distinct types of management have been distinguished by both research programs: free roaming (extensive) or herding, and confinement of animals. In Java, only sheep are herded, whereas both goats and sheep may also be confined. As in West Africa, owners rarely keep both species (Ashari and Petheram, 1983; Okali, 1979). In most areas in the humid zone of West Africa, the system of production of both sheep and goats is extensive. Two exceptions have been identified to date, the southeastern parts of both Nigeria and the Peoples Republic of Benin, where sheep and goats may be confined. Under confinement, which is associated with more intensive cropping and land scarcity, more investment is required, if only to provide feed, and ownership is more restricted. In Nigeria, the fact that sheep need more attention than goats deters producers from sheep production and restricts ownership to older men who appear to have the time to supervise the grazing. Although similar labor with low opportunity costs (young boys) is used for grazing flocks in Java, sheep are more popular than goats. Lack of time appears to be a constraint on feed collection for confined animals in both

areas.

Differences between the systems in the two locations are relatively small, and this is true also of the extent to which development programs have influenced production. In Java, there has been some introduction of "improved" breeds, while in West Africa there have been attempts to introduce larger breeds from northern savanna areas. Other "developments" in both areas have included the provision of new inputs ("dropping schemes" in Java [Sabrani, et al., 1982]), fattening schemes involving the provision of manufactured feed and factory by-products in Nigeria, and *bergeries*, intensive small ruminant systems in francophone West African villages. None have been introduced on a large scale and small ruminant production systems have, in general, been neglected.

ON-FARM RESEARCH

The Problem

The most important features of these livestock systems for on-farm research is the character of ownership and management of the livestock, small flock sizes, presence of small ruminants in the farming system as secondary or minor enterprises, and variability in the production system. These now well-recorded features raise methodological problems which strike at the core of the debate on what is on-farm research and how the objectives of FSR can be achieved. The problems largely derive from viewing on-farm research as the trial of technologies by individual producing units. In most FSR programs, the involvement of farmers in the actual design of innovations is largely restricted to baseline surveys which may include detailed monitoring of existing production systems. It is from an analysis of these surveys that scientists identify system constraints and subsequently withdraw to design an innovation or seek an already developed technology. The most usual approach once an innovation is identified or developed is for on-farm trials to be instituted by agronomists and economists. The trials are made on a plot or plots within farmers' fields or on a selection of animals where the newly developed system can be contrasted with the existing system.[4] The trials are formally designed to measure productivity differences and, in some cases, move almost imperceptably into demonstrations of finished technologies rather than technologies undergoing a process of adaptation. Other approaches involve farmers working through a complicated series of trials or "kits" (fertilizer, variety, demonstration and production) during which process a whole package of technology is assembled. Both approaches have been utilized by the ACRE project in Sierra Leone for example (Jindia and Tuthill, 1985). The use of "kits" was popularized in West Africa by the International Institute for Tropical Agriculture (IITA) through its involvement in the National Accelerated Food Production Program (NAFPP) in Nigeria.

For a trial to be acceptable scientifically, some control of variables is required, and replication. The trial also has to run to the end of its

course. The method requires that the same design be used on each field (or set of animals), and a sufficient number of observations has to be made for meaningful statistical analysis. Various models demonstrate actual trial findings. Gomez (1977) identified a 60% yield gap between experiment station and farm yield and attributes only a small proportion of this to environmental differences. All other, what we might generally refer to as "socioeconomic", intervening variables that affect trial yield are identified as constraints. While these are clearly constraining a particular trial yield, they are frequently interpreted as constraints to farmers' production and become the focus of a much wider package of technology incorporating credit facilities and other inputs (Table 3). To overcome "traditional" attitudes (conservatism of individual farmers/herders), producers may be encouraged to form groups. The rationale behind the formation of groups emphasizes using group pressure and a sense of group commitment to overcome hesitation/conservatism.

Methodological problems begin with the identification of units of observation as families, households, and farms, all of which have been used interchangeably, frequently to the exclusion of wider units. They proceed with attempts to classify these units according to differences in enterprise management, labor, and the livestock/crop components themselves, for instance, for sampling purposes. They end with large but narrowly focused data sets whose interpretation is based on assumptions about individual production units functioning as independent but unified decision-making units whose primary objective is to achieve substantial increases in total cash income. Rarely is the research designed to respond to producer needs, and most research agenda are set by scientists, research institutions, national governments, or donor agencies (Knipscheer, 1984) rather than the producers themselves.

Units of Observation

The first concern of researchers is to define the units of observation, initially arable, tree crop, livestock producers, and their enterprises, which are the ultimate focus of the research effort. While it is possible to define producers for specific areas and products, the customary procedure is to assume the existence of families that function as single management units. Most of these assumptions also include a man as the head of the unit and key decision maker. The fallacy of this description is now well documented and need not be detailed here.[5] Family farms are multi-product enterprises within which individuals may be responsible for a single product or a group of similar products. They are frequently linked in a management sense with other similar, possibly neighboring, units. The small ruminant systems described are typical examples of such enterprises in West Africa owned by individuals and, in both areas, linked through exchange and management with other systems.

The commonest errors reported in data collection techniques arise from ignoring role sharing within and between production units. In some cases, this leads to a total loss of information. There is still a dearth of information on individual incomes from small ruminants because researchers

insist on merging data at the household level. The Benchmark surveys (Knipscheer, et al., 1980) of the NAFPP in Nigeria excluded information on cassava marketing because only men were interviewed, although women did the marketing (women also frequently owned the crop, but most trial farmers were men). The problem is not restricted to non-social science disciplines. Orlove (1986), an economic anthropologist discussing fishermen and their vendor relatives, who are largely wives, around Lake Titicaca in the southern uplands of Peru, writes, "One cannot really speak of fish as being exchanged between the fisherman and the vendor. Although the incomes of the fisherman and the coresident vendor are not directly pooled, they do form part of the same household budget." This kind of argument reflects a concern with final products rather than with how the products are produced and utilized, whereas to predict effects of policies/projects, the mechanics of production and use should clearly be our concern.

Whole communities can usefully be the focus of trials. In Nigeria, ILCA Ibadan involved two communities in their program to develop an alley cropping model. In their case, farmers were encouraged to experiment with what was called a "working model" (Okali and Sumberg, 1986) and the research in year two was expected to be on the multiple use of foliage by various individuals from the farms. The trial of an already developed technology is also focused on whole communities: annual vaccination with TCRV to control a rinderpest-related disease, *peste des petites Ruminants* (PPR). The testing, started in 1982, involves the use of control and experimental village flocks. Most of the data collected so far are standard livestock productivity data which have already been used to demonstrate the viability of the technology in these terms (ILCA, 1984). Increased livestock production has led to a doubling of flock numbers rather than to increased sales in the experimental villages, and this reaction still has to be explained. The explanation is obviously relevant for policymakers who need to know at what point sales might increase, and for biological scientists who need to be aware of actual rather than potential effects of "improved" production techniques. Meanwhile, of equal importance is the effect of the increased numbers on the environment and any consequent changes in flock management.

In situations where animals are exchanged between owners, as in these small ruminant systems, the whole community of exchange might more appropriately be the unit of observation rather than the individual production unit or even a single community. For purposes of monitoring livestock productivity over time, such a strategy would appear to solve the problem of data loss following the exchange of an animal before a cycle of data collection is complete. There will be problems in identifying these more dispersed communities of exchange.

Reported problems of total data loss often reflect a concern with limited data sets focused on input/output flows from a particular technology. All family/community property is subject to changes in management and may be subdivided or merged with other properties, at which point there is frequently a loss of input/output data, if only due to interruptions in production. Understanding how rights in resources are transferred and under what circumstances they occur, i.e., investment strategies, represents

valuable information that is comparable with numerical data when observed in detail over a number of cases and/or linked with other supporting data, for example, the "field hearings" in Java (Knipscheer, et al., 1986). Such events are not restricted to livestock producers. Okali (1983) describes the transfer of cocoa farms at the death of one participant in her "cost route" farm management survey. While this led to the termination of the farm management data collection on these farms, the details of the property transfer were linked with information already available on how the farms had been operated until that point. She arrived at conclusions about how offspring and wives might acquire rights in cocoa farms from fathers and husbands, and gained insight into how these rights might affect investment in these same properties.

Small and Minor Farm Enterprises

The identification of observation units raises one set of problems; the small size of production units raises another. While the investigation of smallholder family farms is difficult, the difficulty is enhanced when the enterprises are also minor in the system.

A major problem faced when monitoring small enterprises is how to make sufficient observations for conventional statistical analysis. Where the purpose is to monitor flock productivity or the value of production, the common solutions are to increase the time over which observations are made to ensure that infrequently occurring events such as births, deaths, sales, and purchases are recorded, and to take large samples. Mortality of livestock is one event which does lead to a total loss of production data, is especially disruptive in small farm enterprises, and is more likely to occur the longer the observation period. In ILCA's survey villages in southeast Nigeria, between August 1982 and February 1983, 65% of the households had smaller flocks at the end of the period, 14% had abandoned goat keeping, and 4% lost all their animals due to mortality (Mack, et al., 1985). Although livestock productivity monitoring continued, the program decided to innoculate all the animals with TCRV to protect them against PPR. At this point, the opportunity to demonstrate or test the viability of the vaccination was lost. In Java, a similar disease problem arose and in order to guarantee continuing cooperation of producers, the livestock had to be treated, in this instance against parasites. This again led to the loss of a control group of animals. The problem of discontinuous data sets can be avoided using single visit surveys by experienced researchers who are familiar with the production system concerned. Such surveys are frequently viewed as "quick and dirty" whereas in fact they are valid alternative methods. Knipscheer (1982) has proposed a comparative method for the collection of labor data for secondary crops which he describes as "rapid" but reliable.

Many production models are assembled from farm management data covering all activities surrounding all enterprises, and data analysis is frequently based on maximizing assumptions. This method tends to obscure minor and secondary enterprises. Okali and Cassaday (1985) propose another solution to the problem of how to collect information on small minor enterprises. They are referring to women who participate in numerous activities at

various times, each activity involving a minimum investment of cash or purchased inputs, including labor. Most of the women were unable rather than unwilling to unravel their various incomes or value their consumption from each activity. In order to establish these returns, the authors propose collecting individual items of information from different data sources. Individual women will be timed doing different processing operations for instance, while price data will be collected from markets. All the information will be collated to construct a single model instead of being calculated from observations of how much time, etc., an activity costs a particular individual.

There is also a temptation when investigating small and minor enterprises to identify larger than average flocks, and to collect additional information that may not be useful, and certainly is not immediately relevant, while waiting for other infrequent events to occur. Sempeho (1984) sampled small ruminant producers in southwest Nigeria with five or more animals for his farm management survey even though owners with this number of animals represented only 20% of producers. Upton's model (Upton, 1985) dealt with these production units as they often are, consisting of single breeding females, while Van Eys (1984) used total liveweight per farm to distinguish between production units in West Java. The small size of individual enterprises is not a problem when the community, or even wider area, is the focus of interest. Some production effects are only visible at this level when small production units are involved.

All the various methodological problems can be avoided by focusing the whole research effort on large-scale and intensive production units whose sole objective is to maximize meat/milk production for instance, rather than to achieve multiple goals by integrating with and thereby enhancing the whole farm system. This solution is tempting and not necessarily problematic[6] but is based on a one-dimensional view of the importance of a product. In their specification of criteria which establishes the importance of a given enterprise, Spencer, et al. (1979), uses its contribution to total income. In their case, they consider an enterprise to be important when it forms 10% of total income.

Variability of Product and Producers

One aspect of family farming that makes it almost impossible to classify producers in a meaningful way for purposes of sampling and trials is the variability between producers in their livestock, management, type, and use of labor.

Both research programs have attempted to use differences in livestock management to discriminate between individual producing units. ILCA Ibadan used levels of feed supplementation to stratify small ruminant producers, but no relationship was established between the identified strata and small ruminant productivity and the sampling frame was dropped. Similar attempts were made in Java, but it eventually became clear in both programs that the most dramatic difference in management was between producers who confined animals--more or less--and producers who either grazed their animals or

allowed them to roam freely. In both locations, while these practices varied somewhat within a single community, differences between communities and whole areas was greater, confinement increasing as cropping intensity increased. In Nigeria, the southeast was defined generally as an area where animals were confined and comparisons were made with the southwest. In Java, the comparison was between lowland, where confinement was practiced, and upland villages. Both programs subsequently demonstrated differences in livestock productivity between their contrasting sites, again demonstrating the value of using whole communities rather than individual units for observations and trials.

Researchers traditionally deal with problems of variability by standardizing the items being observed. The way different members of the labor force are often handled provides an ideal example of the procedures used. For years, economists have attempted to standardize labor units on small farms where most labor used is that of the farm family itself. As early as 1933, Beckett (1947) used the most popular solution of converting all labor into standard "man-days" for purposes of establishing returns to cocoa production. While this exercise may have some value, its limitations must be recognized. Sex- and age-linked role division is common to family farming systems and it is important to acknowledge this division when designing innovations. Small ruminants, for instance, are often owned by women in West Africa and their labor may be the only labor available for this activity. In Java, the system of herding depends almost entirely on the labor of small boys.

For trials, the standard way of approaching variability of the product is to introduce uniform planting material or livestock breeds. This enhances the researcher's control and allows comparability between trials. Alternatively, researchers may attempt to match individual animals, although this practice is more commonly pursued on experiment stations. Producers' experiments do not necessarily share the same methodological assumptions as those of researchers. Producers may prefer the variety inherent in local planting material and livestock to the uniformity of pure line selections.

Since replicated trials are popular, it is relevant to ask what happens when individual cooperators abscond or threaten the successful termination of a trial. We must assume that problems will arise since no single design can satisfy the needs of individuals even within a single community.[7] Producers frequently balk and need incentives for the trial to continue as directed. In this situation, producers might be paid to continue as in the SR-CRSP Program, Kenya. Alternatively, scientists may attempt to enforce discipline as was the case in a trial described by Okali and Milligan (1982). When Fulani pastoralists attempted to use feed supplements other than for selected animals in their herds, the researchers increased the supervision of feed delivery. The trial involved feeding supplements of agro-industrial by-products to selected animals in Fulani cattle herds and was designed to include control animals in the same herds. It was assumed that the innovation was "developed" because scientists had elsewhere demonstrated increased milk production over and above the cost of the supplements. The pastoralists attempted to use the supplements other than for selected animals, not even simply for lactating animals being used as

controls, but also for nonlactating animals. The first reaction of the researchers was to increase the supervision of feed delivery. This occurred because the researchers wanted to measure productivity differences as well as to demonstrate the value of the intervention to the herders. It soon became clear that while this strategy might permit measurement of production, it would not demonstrate a viable technology to the herders who had multi-purpose goals. In addition, while herds might be managed by one person, the animals were owned by many individuals and managers could not show preference for one particular group of animals, which the trial design demanded. In the end, the researchers had to design a broader feeding strategy, with more attention being given to the goals of the herders themselves.

The most successful conventional on-farm trial (in the sense that the scientists were able to control the intervention and measure changes in the conventional manner) described by the programs involved the evaluation of annual TCRV vaccination to control PPR already described.

Producers' Trials

Scientists, in their eagerness to satisfy conventional methods of hypothesis testing, have burdened on-farm work and the on-farm trial design unnecessarily. In major crop-based FSR, scientists have been able to develop this methodology, especially in areas of scarce high quality land where crop yield becomes the dominant parameter. In general, on-farm livestock trials, but also small farm plots, yield data with higher than usual statistical variance (Bernsten, et al., 1983), which should encourage scientists to look for alternative sampling and evaluation measures. Both small ruminant programs have developed ways: by focusing on whole communities rather than on individual production units, and by seeking alternative evaluation measures. In Nigeria, an alternative to actual tree measurement was introduced to evaluate tree establishment: eyeball observation by more than one person at a time combined with a simple checklist. In Indonesia, regular research field hearings were introduced and these provided a forum where farmers could give feedback. Both these and other livestock programs have also been concerned to broaden on-farm research beyond trials.

At a recent ICARDA workshop on livestock-on-farm-trials (LOFT) methodology, a heated discussion erupted about the need for replications. The issue broadly divided the social scientists--who argued that replications were not essential, from the biological scientists who held the opposite view. Unfortunately, there is often a tendency to assume that the only alternatives to replications are no replications. It is clear from examples given in this paper that alternatives exist. Their use frequently requires a shift in attention from the technology or trial itself to its interaction with the wider environmental, biological, and socioeconomic systems. It also requires a shift from viewing socioeconomic interactions as constraining influences to be controlled to viewing these as factors determining the type of technology to be introduced and the trial design. Using this approach, on-farm trials are, if appropriate at all, first designed by producers, as Zandstra (1984) and Norman and Collinson (1985)

acknowledge. In the small farm context with which most FSR programs are concerned, we predict that by using this approach there will be replication by farmers of the same design and, consequently, a wealth of information will be produced about the applicability and likely impact of a new technology being developed.

Footnotes

[1] Baseline surveys and subsequent farmer involvement in technology design are discussed in Okali and Sumberg (1986).

[2] These systems have been described in numerous publications by the two research programs. The most comprehensive sources for each of these are Sumberg and Cassaday, eds. (1985) and Knipscheer, et al., (1983).

[3] Sharecropping is a system whereby borrowers of breeding stock share offspring with owners and meanwhile incur all maintenance costs. The system makes it possible for people with no stock or capital to purchase stock, to enter small ruminant production, or increase their flock size. At the same time, producers with larger flocks distribute the cost of their own labor and spread their risks.

[4] For a description of farming systems research which implicitly assumes that this is a sufficient description of on-farm research, see Simmonds (1984). For a description of an alternative view, see Okali and Sumberg (1986).

[5] For a detailed review of the issues surrounding these concepts, see Guyer (1981) and papers presented at the November 1984 workshop, "Conceptualizing the Household," held at the Harvard Institute for International Development.

[6] This approach to development is not always viewed as problematic. As has been argued by Okali and Sumberg (1986), it reflects a choice in development approach that essentially is not concerned with incremental production increases on the part of large numbers of small producers.

[7] For a description of the various ways in which 65 farmers from two communities incorporated alley cropping into their systems, see Okali and Sumberg (1985). Ay (1978) provides smaller evidence of the variety of individual farmer needs and hence the differential effect of a single development program.

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Table 1. Conventional and alternative approaches to farming systems research problems.

Problem	Conventional solutions	Alternatives
No clear production/consumption decision-making units	Define/identify a family unit	Unit defined by problem-community interacting households
Small units	Large samples/larger than average units/long-term observations/group trials	Different data sets, parallel and sequential data collection
Variable livestock/labor	Standardize units/enforce replicated trials of complicated packages	Simplify introductions/allow farmer experimentation
Minor/secondary enterprises	Large-scale technology maximizing solutions	Integration in other components of farming systems

Table 2. Comparison between locations in small ruminant production.

	Nigeria		Indonesia
	Southwest	Southeast	West Java
AREA			
Population density	medium	high	high
Farming system	extensive	intensive	intensive
Cropping intensity	medium	high	high
Farm sizes (mean)	medium	small	small
Off-farm income	high	high	medium
SMALL RUMINANTS			
S:G	1:4	1:4	2:1
As percent farm income	1-5%	1-5%	10-25%
Feed (most common supplements)	Crop by-products	Crop by-products	Crop residue and browse
Population growth	stagnant	declining	stagnant
Management level	low	medium	medium
Type of management	open grazing/ minimal confinement	medium/total confinement	total confinement in lowlands
End product	meat	meat	meat
Flock size (mean)	2-4	2-4	5-7
Mortality	high	very high	medium

Table 3. Common agricultural development paradigms and their solutions.

Constraints in existing system	Solutions
Land tenure	Privatize/registration of titles
Labor shortage/implements/techniques	Work oxen/tractors/group farming
Credit/exhorbitant interest	Project lending
Soil fertility/slash & burn/shifting cultivation	Fertilizer/permanent cropping
Individual farmer conservatism/ traditionalism	Contact farmers/extension training/integrated rural development/group farming
Research extension gap	On-farm trials/adaptive research
Varieties/breeds	Improved breeds
Traders	Institutional marketing

Source: Okali and Sumberg, 1985.