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CRITERIA FOR RE-APPRAISAL AND RE-DESIGN: INTRA-HOUSEHOLD AND BETWEEN-HOUSEHOLD ASPECTS OF FSRE IN THREE KENYAN AGROFORESTRY PROJECTS

Dianne E. Rocheleau

INTRODUCTION

Farming systems research methodologies and experience (Chambers, 1981; Collinson, 1981; Hildebrand, 1981; Rhoades, 1981; Zandstra et al. 1981) have served as the basis for system-level methodology development at ICRAF (Raintree, 1983). An interdisciplinary team, led by an anthropologist, adapted the rapid appraisal and technology design procedures to agroforestry applications. Much of the initial development of the method and its further refinement were based on field experience in Kenya in cooperation with Kenyan government institutions[1] and non-governmental organizations (NGO's).[2] Field tests have also been conducted at several sites in Asia, Africa, and Latin America through collaboration with national and regional institutions.

The diagnosis and design (D+D) methodology takes a problem-solving approach with an emphasis on farmers' priorities for fulfillment of basic needs (ICRAF, 1983). The major needs categories are: food, water, fuel, cash, shelter and infrastructure, savings/investment, and social production. Initial rapid appraisal and technology design focussed on the individual farm as the management unit and on individual heads of household as farm managers. Agroforestry designs for prototype farms were intended to serve the needs of the household-as-a-unit within farm boundaries. Recently ICRAF has devoted more attention to the division of labor, difference in interests, differential access to resources, and distribution of benefits within households and within communities.

THE INSTITUTIONAL CONTEXT

The need to look closer within the household and at larger-than-farm community and ecosystem issues surfaced in some of the rapid appraisal exercises for collaborative projects outside Kenya (Costa Rica, India). However, continuous contact with farmers and the surrounding community at two Kenyan sites in Machakos District has provided the stimulus and the opportunity to refine the diagnoses and to re-design technology trials to reflect within-household and community level criteria.

In the case of the Kathama Project, ICRAF was the lead institution

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[1]Kenya Agricultural Research Institute (KARI), Ministry of Agriculture Katumani Station (DFSRS), and Machakos Integrated Development Project (MIDP).

[2]Mazingira Institute, CARE Kenya, and Kenya Energy Non-Gov't. Organizations (KENGO).

and conducted field work in collaboration with Wageningen University within the context of a small methodology development project based on farming system surveys and on-farm trials of agroforestry innovations (Raintree, 1983; Rocheleau and Hoek, 1984; Vonk, 1983). ICRAF is continuing the project (on a limited scale) as a vehicle for testing implementation approaches and variable scale diagnosis and design.

In the second project (Kakuyuni Dryland Agroforestry Project) three Kenyan institutions (KARI, MIDP, NDFSRS) are conducting on-farm and on-station research for a small semi-arid prototype catchment, with technical backstopping from ICRAF (Hoekstra, 1984; arap Sang, 1984). The project began with parallel approaches to watershed management and farm production, and has developed into an integrated treatment of sustainable production throughout the catchment and the larger community that depends on its water yield to the Kakuyuni Dam. Research and extension are linked, as are group and farm level activities.

In both Kathama and Kakuyuni, on-farm trials and group activities have demonstrated the importance of off-farm resources for farm production (varying by farm and family type), the common use of private property, the role of group labor in farm management, the variable effect of individual farm management on the community resource base, and the participation of women in all of the above. The field experience at these sites has changed the researchers' perception of the clients and their farming system, and the lessons from these two sites are being incorporated (and tested) in the planning and early implementation of a third project, the CARE-Kenya Siaya Agroforestry Project. The latter includes a research component within a development context, and combines community nurseries, self-help groups (predominantly women), and farm trials of AF technologies. As such it provides an excellent opportunity for testing/development of variable-scale, participatory research methodology for AF projects. The contrasting physical and social environment and the district level scale of the project also provides an excellent contrast with the Machakos sites, to broaden the scope of case study comparisons.

CASE STUDY RESULTS

The experience from each case is presented separately, in order to demonstrate the empirical and practical basis for the methodological and research policy conclusions which follow. Kathama is treated first, Kakuyuni second, and Siaya third, reflecting chronological order as well as a progression from exploratory research carried out by ICRAF, to testing/application of methodology in a collaborative role, to application/modification of the approach by an independent project with ICRAF as an interested observer/consultant. The sequence of surveys and trials in the Kathama project is treated in greater depth, to set the stage for comparison with the other two cases.

The Kathama Case Study

The case of the Kathama Project illustrates the evolution of the methodology-in-general (Figs 1 and 2) and the self-correction of the

project and technology designs in response to social, economic, biological, and physical performance criteria. The experience in this community also illustrates the general importance of social factors in existing production systems, and in the planning, testing, and dissemination of new technologies. In particular, the project has called our attention to the need for designs that transcend farm boundaries, both within and without, according to both social and ecological criteria. Although the case described below deals specifically with agroforestry technologies, many of the methodological and substantive issues apply to farming systems research in general. Moreover, agroforestry technologies *per se* have relevance to a broad range of farming systems and commodity-based research programs.

Initial Surveys and Trials

Preliminary studies included a descriptive survey of the local farming system(s) (Gijlen 1982) and a botanical inventory of local trees and their uses (Fliervoet, 1982). Following these baseline studies ICRAF initiated a two year test of the D + D methodology (Vonk, 1983). The rapid appraisal diagnostic survey identified farm-level potentials and problems that could be addressed by agroforestry interventions (Figs. 3 and 4, Table 1).

The farmers' objectives, basic household needs, current strategies for problem-solving, and available resources guided the design of promising agroforestry technologies (Raintree, 1983). Ten farmers agreed to test these "best-bet" options on their farms (Vonk, 1983). The technology trials included species elimination trials of promising multipurpose (exotic) trees, methods of tree establishment in cropland and grazing lands, hedgerow intercropping of *Leucaena leucocephala* and *Cassia siamea* with maize and pigeon pea to improve soil moisture and fertility, and fodder/fuelwood lots to produce high quality fodder at the end of the dry season.

While most species failed to establish with direct seeding under the drought conditions which prevailed during most of the two year study, several species of exotic and indigenous trees and shrubs (Table 2) showed high rates of survival when planted as seedlings. The study incorporated monitoring of labor inputs for establishment and farmer's reactions and suggestions during establishment and early growth. The changes suggested by farmers reduced labor for land preparation and provided a simple low-input alternative for rehabilitation of individual plants in small plots of grazed woodland (Vonk, 1983). A combination of drought and normal time-lag for tree establishment prohibited monitoring of the productive/service roles of the hedgerows and fodder lots within the two year study.

During this same period four additional special studies were carried out by Wageningen graduate students on: nutrient balance in the cropping system (Nijssen, 1983); stickwood increment in the grazing lands (Boer, 1984); potential role of local voluntary organizations in agroforestry activities (Wijngaarden, 1983) and a landscape analysis and design for the surrounding watershed (Hoek, 1983). The first two studies provided quantitative information to refine the farm level diagnosis, while the

latter two helped lay the foundation for a sliding scale of AF diagnosis and design. They called attention to the role of women in self-help groups, the role of those groups in farm production and watershed management, and the interaction between watershed degradation, farm production, and management of off-farm resources and public spaces.

Follow-up Study

The project continuation built upon the results of the original farm trials and special studies, with emphasis on farm trial monitoring/implementation and on larger-than-farm D+D and trials. The landscape analysis led into a watershed scale D+D and a follow-up project with self-help groups on AF in soil and water conservation (Rocheleau and Hoek, 1984).

Farm Trials.

As information began to filter back from the continued monitoring of the 10 farm trials, there were strong indications of interaction between on-farm AF technologies and management of the surrounding environment. Three of the participating farmers attempted to propagate their own new seedlings for independent continuation and expansion of species trials, fodder lots, and hedgerow intercropping. Two of the three failed (and others refrained from trying) due to water shortage and difficulty of access to permanent water sources. The one participating farmer who succeeded in growing his own seedlings had prior experience with a home citrus nursery and has a permanent water source on his property. The same is true for the other two farmers in the community who raise fruit and multipurpose tree (MPT) seedlings. For most other families, access to water involves use of public sources.

Water rights in the area range from private ownership and exclusive use of open shallow wells on-farm, to free public access to low-yielding hillside springs and flowing rivers, to temporary shallow wells in dry river beds dug and fenced by small ad hoc groups that may also share water collection and stock-watering trips. Access to water is a major determinant of location preference and is reflected in the location of the largest and/or the most prosperous landholders. The latter are concentrated along the base of the Kanzalu Range (Figs. 5 and 6) where permanent shallow open wells are easy to establish and maintain. These are usually reserved for exclusive use by the owner's household and are considered to be property held and controlled by the head-of-household. Proximity to the Athi River (Figs. 5 and 6) is also advantageous, as is proximity to the springs on the upper slopes of the range. Both of these are considered public domain, with ease of access influenced by location of owned property and means of transport. This implies a need to consider such differences between farms in planning for plant propagation, which may in turn influence AF technology designs and/or choice of species. Alternatively, plant propagation for some or all of the farms might be organized at the group or community level, on either a private or public basis.

Further discussions with farmers also raised the issue of within-household distribution of labor for plant propagation. While men

were the main participants in the farm trials, women were required to collect and transport the water for seedlings in the farm nurseries, and the women were unwilling to continue this extra task when water shortage forced them to obtain the domestic water supply from the Athi River (2-5 km distance), carrying water on their backs in containers. This demonstrates the need to involve women as individual beneficiaries/clients, and to consult them about feasibility if they are to play the role of water-bearers for plant propagation.

Other issues of major importance that surface in farm trials included pest control, browsing damage by domestic and wild animals, and the need for protected fodder reserves. All 10 farms experienced problems with termites and/or other insect pests, and all of the trials were affected to some extent by browsing, which varied with the degree of protection at the planting sites. Seedlings placed in grazing lands fared very poorly (up to 100% mortality), while those established in cropland showed higher survival rates (70 to 80% survival) and more vigorous growth during the first six months. The importance of a protected fodder bank was demonstrated by the decision of one farmer to allow controlled dry-season browsing of the Leucaena l. in his mulch hedgerow by his own cattle and goats. He requested help to expand the fodder-tree planting and refused to replace the Leucaena l. with a superior mulch tree. He clearly prefers to use hedgerows in cropland for fodder, rather than to improve soil moisture and/or soil fertility for crop production. Two other participating farmers also requested more seedlings and assistance for establishing fodder trees in marginal cropland. As in the case of water for nurseries, fodder production and animal management involves use of off-farm[3] resources and the cooperation of other farmers (control of herds and more careful management of gathering). Any interventions of this type would require a closer consideration of land tenure, use rights and terms of access to land, water and plants.

While most of the land in the study site was adjudicated over 10 years ago, exclusive use by one household applies only to cropland (permanent, terraced), home compounds and small grazing plots. Woodlands and large holdings of wooded grazing land are controlled by single households but are perceived as conditionally available to the larger community or to sub-groups thereof (Cantor, 1984). Many smallholders occupy plots that have been reduced to a minimum area required for subsistence food crops, and they depend heavily on this system of discretionary common use of private land. They obtain most or all of their fuel, fodder, timber, thorn-fencing, and minor forest products from off-farm sources. Access is unevenly distributed between households and also varies with seasonal and periodic drought, the latter being an emergency and considered just cause for granting broader privileges than usual. Use of such lands and terms of use vary considerably.

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[3]The term "off-farm", as used here, refers to the use of land outside of a given (consumer) farm, even if it involves sharing or "borrowing" of resources on someone else's farm.

Gathering rights for fuelwood are seldom compensated, although some farmers report buying trees from neighbors for charcoal or fuelwood. More commonly the practice is referred to as "borrowing", but the indebtedness one incurs has to do with social status and deference to the donor. The usual understanding is that "borrowers" take deadwood, small stickwood, and the least desirable species. Some gathering without permission also occurs in the denser, more remote woodlands (Cantor, 1984). While fodder and fuelwood are almost free goods, fencing material, timber and charcoal trees are perceived as commodities to be purchased directly. In some cases charcoal makers may rent access to land for tree harvesting and burning (Hoek, 1983). The favored species for charcoal and timber also produce pods and/or leaf fodder, so these activities impinge strongly on actual carrying capacity of shared lands for domestic animals.

Both cattle and goats are confined in corrals at night, both for protection and for easy collection of manure. During the day, management of grazing and browsing varies from tethering to careful herding to almost free range. Social pressure to control grazing is strongest when grain crops are vulnerable to attack, but "social fences" fade during the dry season. Animals are driven long distances to water holes or to the Athi River. Off-farm fodder sources play an important role during this period. Roadside and gully sites provide grass, shrubs, and high-protein pods to supplement on-farm fodder. Many larger landholders also grant grazing and browsing rights to several other households based on kinship or other social ties or in exchange for cash or services. Changes in animal management for fodder tree protection would necessarily involve the community-at-large. Enrichment planting in public lands and common-use private lands would also require group decisions and maintenance.

Watershed Trials.

The D+D for the community and surrounding watershed identified excessive runoff and soil erosion as major problems (Table 3) limiting individual farm production as well as threatening water supply and road networks throughout the area (Rocheleau and Hoek, 1984). Overharvesting of valuable multipurpose trees (*Acacia tortilis*, *Terminalia brownii*) for single-purpose exploitation (charcoal) has also depleted common-use and shared sources of fodder and forest products for the community-at-large. Overgrazing, overstocking, and lack of alternatives for cash earnings and savings/investment also contribute to economic hardship and ecological instability throughout the Kathama sub-location (Table 3).

The drainage network emerged as the predominant structural landscape feature in need of stabilization; it formed the basis for further stratification and detailed study at the Kathama site. A more detailed qualitative analysis, including informal interviews, cartographic analyses, aerial photographic interpretation and detailed field observation, was conducted in three small catchment sub-units (Fig. 5 sites 1, 2 and 3). The detailed landscape analysis identified the major sources of excessive runoff, points of concentration, and sites of sheet and gully erosion (see Hoek, 1983 and Rocheleau and Hoek, 1984 for detailed maps, discussion and technology designs). The grazing lands on

the upper slopes of the Kanzalu Range (Fig. 6), and along the slopes to the Athi River were both major sites of prior sheet erosion under annual cropping) and currently major sources of runoff, due to soil compaction and poor infiltration of rainfall. Home compounds also contribute to rapid runoff. The points of concentration included roads and footpaths, drains from grazing lands, home compounds, and bench terraces, often along property lines (Hoek, 1983; Rocheleau and Hoek, 1984).

Residents interviewed cited the following causes of gully erosion on mid-slope to footslope sites: compaction of grazing lands; new construction of upslope homesites, terraces and drains; and re-alignment of farm drainage toward parallel boundaries along the slope (following the pattern of roads laid down by the land survey). Some residents have constructed cut-off drains and check-dams in gullies to prevent or contain gully erosion, and most farmers have terraced their croplands; much of the construction on and off-farm has been carried out by self-help groups. Gully and drainage control structures appear on private, public, and boundary lands, usually at or near the site of damage to roads, paths, homesites, or cropland. In spite of interest and awareness, the overall drainage network is ad hoc and represents the cumulative (and often unanticipated) effect of many separate decisions and actions by groups and individuals upslope on the private and public land and water resources immediately downslope.

Gully reclamation, coupled with more intensive management and increased fuel/fodder production emerged as a priority for exploratory trials, given the existing involvement of self-help groups in gully reclamation, the importance of the disrupted drainage, and the relationship between overgrazing, soil compaction, depletion of woodlands, and apparent decline of favoured species. The watershed level D + D exercise indicated additional needs for multipurpose trees aside from the soil and water conservation aspects. Discussions with individuals and women's groups about fuelwood and fodder availability and management revealed that smallholders rely very heavily on off-farm fuelwood and fodder sources and many consider fuelwood supply a problem. The current role of gully sites as off-farm grazing lands and fuel wood sources for many households, further strengthened the cause for maintaining these productive functions at such sites under a sustainable system.

Other "leverage points" for application of AF or combined AF/soil and water conservation technologies included: the degraded hillslope grazing lands (sources of excessive runoff and sources of fuelwood and fodder for many households); the roadsides and boundaries (often points of concentration and channels for runoff); soil conservation structures on croplands (often unstable and/or unproductive); and home compounds (points of concentration for runoff, convenient for closer management/protection of plants).

The development of AF designs for these niches focused on the Kanzalu range catchments (Fig. 5 Sites 1 and 2) because of the higher activity level of self-help groups, the higher population density and the diversity of problems and potential solutions concentrated in one area. The landscape design emphasized structures along linear features such as

gullies and several types of planting on areas and on linear features (see Rocheleau and Hoek 1984). Designs for treatment of grazing lands included enrichment planting (grasses, shrubs, trees) combined with soil and water conservation structures. Designs for improved vegetation on existing structures and features ranged from alley cropping or planting on bench risers in croplands to planting of more productive tree, shrub or grass combinations on boundaries and around home compounds. "Filler" planting along and in gullies was also suggested, as well as live supports for temporary gully structures and productive border plantings on roadsides (especially in/around drains).

The resulting integrated landscape design in cross-section view (Fig. 7) shows the fit of these technologies into a productive sustainable agricultural landscape. The before-and-after oblique view design sketches (Figs. 8 & 9) show the extrapolation to the larger study site along the Kanzalu Range. The current condition and the ideal implementation of the design are juxtaposed to illustrate the scope of the potential effects.

In order to better evaluate the feasibility and probable effects of the proposed design, a parallel ecological and spatial analysis was conducted to quantify some of the existing conditions and potential changes. A representative small watershed was chosen on the Kanzalu Range (Fig. 10) including the Kalama catchment. Results included areas of different land use and land cover categories (Fig. 11, Table 4), the total length and area of various linear landscape features (Table 5), and the relationship of various land cover types (including linear features) to runoff, erosion, and production problems and potentials (Table 6). The analysis also extended to the functional relationships between various structural landscape features, land uses, land tenure, and family composition.

Household surveys (Cantor, 1984) indicated a marked division of labor, control, and interests within and between households, with respect to present and future management of fuel and fodder supplies and the wooded grazing lands in general. Based on qualitative and quantitative analyses of the survey (Rocheleau and Cantor, forthcoming) two major criteria differentiated the households with respect to needs, priorities, and available resources for AF technology development: size and quality of landholdings (eg. land value and productive potential), and family composition (male vs. female-headed, male vs. female-managed, and number of resident family members of working age).

The land size and quality was closely related to the division between "borrowers" and "lenders" of fuelwood and grazing land. There is a general division of interests between the two groups, with the former needing to integrate subsistence production of fuel and fodder into intensified food and cash crop production on their limited smallholdings, and the latter tending toward conversion of lands currently used by borrowers into crop production or private fodder-and-woodlots (all semi-commercial enterprises).

Cutting across this land-based division of interests are three types of households with labor-based differences. Within this watershed 33% of

the households are headed by women, 47% are headed by men, and another 20% are managed by women. In the latter case the male head-of-household lives and works away from home, returns at intervals ranging from monthly to annually, and retains varying degrees of decision-making authority in the household. The women are farm managers and make most or all of the day to day operational decisions, but consult or defer to the men in planning decisions (e.g. new cropping systems or land uses). These types of households would usually be designated "male-headed", but have very distinct needs, constraints, and resources compared to households with resident male heads. With few exceptions, woman-headed and woman-managed households have less labor available than those headed by men, have different priorities for allocation of labor (subsistence vs commercial; domestic vs whole-farm; group vs farm), and have different types of labor exchange and other reciprocal arrangements for use of grazing land, fuelwood, and draft power.

Smallholder households headed or managed by very young or very old women present both a challenge and a special opportunity to AF research and extension in this area. These women are extremely limited by labor (often only their own) but even more so by lack of mobility and time. Mothers of very small children, and older infirm women were particularly interested in concentrating fodder and fuel resources (currently gathered off-farm) on croplands, home compounds, small lots, and boundaries. The additional real labor for establishment and management (including fodder lopping) would be more than compensated by the accommodation of their mobility and time constraints for off-farm activities.

These household types are more than academic categories; they imply distinct sets of technology designs and landscape niches at the farm level, and set the context for reconciliation of conflicting interests at the community level in watershed scale designs, land use plans, and project organization. While men-headed largeholder households want timber, cash crop trees, and living fences to better protect their croplands and grazinglands, the smallholder women-headed households want fodder and fuel close to the home and low-input cash crops that can combine with food crops and that can also be consumed on-farm. The first group may well lead the way in grazing land improvement, sylvopastoral technologies, and development of commercial tree crops, while the latter group are the logical choice to pioneer intensive production of fodder and fuel in croplands and on boundaries, and introduction of multi-purpose cash and food crops into subsistence cropping systems. These two contrasting groups with conflicting interests illustrate the potential for design of complementary technologies at the watershed and community scales. Recognizing that the conflicts may not always be easily resolved, and new ones may develop later, the survey information was used for grouping clients, stratifying designs, and integrating research and project management to serve the groups separately, within a larger context of landscape design.

In this landscape, especially given the interest of all groups in boundaries and live fences, linear features can play a major role in production (Table 5) as well as in soil and water conservation. The most prominent linear features are the drainage and transportation networks (Fig. 12). Interpretation of aerial photographs revealed the importance

of property and internal plot boundaries as well (Fig. 12). Based on relative area occupied these features have a high potential as production sites; 1.8% of the total area is in gully and stream borders, 0.7% in paths and roadsides, and 2.3% in property and internal boundaries, which places 5% (nearly 5 ha) of the total area in linear features (Table 5). The greater availability of water in gully and stream channels and in roadside or boundary drains also represents a production advantage over many block planting sites, such as grazing lands. Moreover, internal boundaries in croplands and home compounds offer the benefits of existing fences and protection and ease of access for maintenance.

Conservative estimates for fodder and fuelwood production potential for drainage, transport, and boundary features (Table 5) indicate that more than 50% of current fuelwood and almost 40% of fodder needs can be met by planting trees, grass, and shrub combinations along these ribbons and corridors of land. While the same production could be allocated to blocks, hedgerows, or dispersed plantings in grazing and croplands (Table 4), the real or perceived opportunity cost of land utilized may be much higher in croplands, and the real costs of establishment and maintenance would be much higher in grazing lands. The need to protect young fodder trees from browsing may tip the decision in favor of small well-protected fodder lots in grazing plots close to the home compound, depending on available space, species used and proximity to wildlife habitats or cattle and goat trials. In upslope plots the added incentives of reclamation, soil improvement or water harvesting would, however, often weight the decision in favor of some area treatments on strategically located grazing land (Table 6), in combination with carefully chosen placement of road, path, and farm drains planted to productive vegetation.

While the potential benefits were estimated during the first cycle D+D (Table 5), several questions remained as to feasibility, and distribution of costs and benefits, given the existing conditions and practices in Kathama. These questions were left to the second cycle of D+D, on-site trials with self-help groups and selected households (to complement the continuation of the second cycle of the original 10 farm trials).

The team initiated a small pilot project within the Kalama catchment to further explore the research methods, technologies and organizational activities necessary to implement the landscape design within the D+D context. The exercise also provided a practical context in which to test and evaluate the method, the design and the component technologies for application in similar environments in the Machakos District (ranges and hillslopes, Zone 4). The specific objectives of the pilot project were: 1) to develop AF methods suitable for implementation, monitoring, and evaluation of larger-than-farm scale group projects; 2) to build rapport with the groups and assess their organizational and technical capabilities and potential; and 3) to modify AF designs and implementation plans to fit "2".

The implementation consisted of weekly work sessions with five self-help groups at the two sites (Fig. 5, 1 and 2) chosen by the team and the groups respectively. An analysis of the time and labor (Tables 6

and 7) required to implement the original design revealed a vast discrepancy between group capabilities within the public works context, and the demands of the overall plan. However, the entire emphasis on public works was repudiated by the qualitative information from observation of, and participation in, group work sessions.

The groups were found to be small associations of individual households (20-50) engaged in exchange/rotation of services and pooling of resources for the benefit of individual members and their households. While the results of the household survey confirmed the importance of group labor for individual management, they also revealed a de facto exclusion of some types of households from participation in group activities and benefits. Women-heads of small households (usually very young or elderly women) who were isolated geographically from relatives and/or the community-at-large, reported being unable to attend group activities due to limited mobility (due to sole responsibility for child care and domestic work, or due to ill health). By contrast, some of the wealthiest and/or largest households found group membership unnecessary. The self-help groups are thus not fully communal in either objectives or in composition. As in other AF studies (Dove, 1983) the difference between communal groups and associations of independent households proved critical to project and technology design.

The groups requested changes in the work schedule, organization and choice of sites, because too much time was being spent on the property of non-members. Even on members' farms the groups cannot spend several consecutive sessions at the same site, but must maintain some semblance of rotation. While they might undertake gully repair at any site that impinges on members' lands or at sites where public roads and schools are threatened, the groups still find continuous long term investment at any one site unacceptable. Moreover, the group leaders insisted that future activities be limited to one or two groups, rather than the combination of five groups as was the arrangement for the first season. They blamed much of the problems in the group trials on inter-group rivalries (Mwendandu, pers. comm. 1983).

During the course of the group work the participants requested seedlings for their own farms and negotiated group soil conservation labor as an exchange for 15 seedlings (sampler package, multiple species) for each member (Table 8). On-farm and group follow-up during the subsequent planting season (no public works at that time) resulted in requests for a switch to nurseries for individual groups (located near water, at a member's home), to supply seedlings for group members' farms. Farm planting results showed that while most people planted all of the trees they were issued, they reserved the cropland sites and special care for fruit and fodder trees. Timber and shade trees planted on the home compound also received special care in some cases.

Trees planted at soil conservation sites were protected, if at all, by property owners, not by the groups as such. Since one of the two sites (Fig. 5, site 2) was badly degraded, poorly protected, and traversed by water collection and cattle paths, most of the planted seedlings died. However, the small water-harvesting structures made by the groups did foster improved growth of the natural vegetation

(especially grasses and small Acacia tortilis trees). The property owners also managed to protect some of the planted grasses and seedlings located close to the home. At the other site (No. 1) the owner took full responsibility for planting and protection. He converted a small plot just adjacent to the group site into an individual farm trial of AF for fodder and wood production and rehabilitation of a gullied grazing land.

The results from this first cycle of group tree-planting influenced the choice of species and planting sites for the seedlings produced in the group nurseries during the next season. After the focus of the group activities shifted to plant propagation for members' farms, two more self-help groups asked to join the project. While some groups continued to ask for advice on placement and construction of soil conservation works, they gave priority to nursery construction and plant propagation activities (fruit trees and a mixture of fodder, fuelwood and timber trees). Some groups also recruited new members interested specifically in seedlings and grasses for their farms, including one farm trial participant who expanded his fodder lot.

Integration of Group and Farm Trials.

Although it was not originally planned, the farm trials and group activities became closely linked as a result of actions and decisions taken by the individual farmers and the groups themselves. They established complementary domains of group-based and household-based AF activities (tree propagation and planting is a new class of work) and they set limits on the scale of community-level group collaboration (one nursery per group, with some joint training and evaluation activities and occasional joint public works activities with tree-planting and soil conservation). This, in turn, established the social terms of reference for the further development, testing and dissemination of AF technologies in the area.

Farm trials combined with group activities had several advantages. It allowed the farmers (especially women) to speak more freely as part of a majority, when dealing with researchers or with their own families. It also stimulated new ideas and sharing of new technologies suggested by group members.

The nursery activities served to train individual farmers in the full cycle of plant propagation, and at the same time provided a forum for training and discussion re: tree planting, choice of species and sites, and management of AF technologies on-farm. The farm trials, on the other hand, provided a kind of AF "sampler" that allowed farmers (individually and in groups) to observe and discuss results within the realistic context of a neighbor's farm. People were better able to choose species (indigenous and exotic) and to consider alternative planting arrangements and management techniques, once they could see what the new trees and shrubs looked like, and how these and indigenous trees performed in new niches on-farm. The group members also contributed to the farm trials by their honest appraisal and constructive criticism of the trials; they often helped to elicit suggested modifications from the more timid or biased individual farmers.

Out of this consultation and testing came a suggested change of emphasis from alley cropping for mulch to alley cropping for fodder and fruit, with wider spacing between hedgerows. To improve soil fertility most farmers prefer concentrated mulching of cattle pens (pre-composting) with tree biomass from fencerows and dispersed trees in grazing land (a few are still interested in widely spaced hedgerows for mulch). The groups and project team also began a search for indigenous wild fruits and exotic drought-resistant marketable fruit compatible with food cropping systems and/or live fences (on inside of living fences or on internal boundaries). Both groups also initiated a search for tree-based pesticides available in the area, with the help of KENGO foresters and local herbalists. The relationship of these and other research lines to the original D-and-D are outlined in Table 9. Aside from these specific prescriptions for research, several general conclusions can be drawn from this experience.

Lessons From Kathama

Both farm and watershed (group) activities converged on the gap and false dichotomy between treatment of farm and larger-scale units. These themes were common to both activities:

1. the need to mobilize group labor, group skills, group learning and shared access to land and water, to support productive AF technologies on-farm (for the benefit of individual members and households);

2. the need to better integrate women into the initial D+D and farm trials and to better serve their interests in technology design and in organization of group trials/activities;

3. the need to better address questions of shared use and sustainability of farm production and to consider the production benefits to individuals from off-farm, public and shared lands;

4. the need to adjust technology designs for different production objectives and different levels of access (within households and between households) to the means and fruits of production (on and off-farm);[4]

5. the need to plan with farm families and community groups for technology and landscape designs that can adapt to[5] land subdivision,

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[4]One approach would be to design separate AF options for each level of access and domain of control. Another solution would be to integrate complementary resources of different groups, whether at farm or larger-than-farm scale. Feasibility of separate vs. integrated designs will vary, depending on the existing distribution of resources, control over them, and access to them.

[5]In many cases the technology and landscape designs can also help to determine the future of the system by stabilizing development cycles, particularly with respect to land subdivision and land use conversion.

labor pool fluctuations, land use conversions, migration, and other aspects of household and community development cycles.

Extrapolation To Other Cases

Can this type of research and its results make a difference in "real-world" research and development projects conducted by national institutions or non-government organizations (NGO's)? Will those differences matter to the real clients of AF research-for-development? Both the methodological and substantial lessons from the Kathama project are being incorporated (and tested) in the planning and early implementation of the Kakuyuni Dryland Agroforestry Project and the CARE Kenya Siaya Agroforestry Project. The highlights of project experience to date are presented to illustrate the relevance of the general D+D approach, the importance of within-household and between-household criteria for diagnosis, design, and monitoring, and the adaptation of this multiple-scale approach to the objectives and available resources of each project.

Kakuyuni Project

The project definition, technology designs, and research designs were all based on the D+D approach. ICRAF conducted the original diagnostic survey and reconnaissance work, in collaboration with MIDP and NDFSRS (Hoekstra, 1983).

The study area consists of a small watershed (<5 km^2) on the Yatta plateau (agro-ecological zone 5) in Machakos District, and was settled in the 1950's and 60's by Akamba people from the more densely populated (higher potential) areas in the hills and along the slopes of the isolated ranges, including the Kanzulu Range in Kathama. The soils and vegetation are similar to those of the drier plains in Kathama, while the population density and land use intensity are both low relative to the conditions in Kathama[6]. As such the diagnosis (Figs 13 and 14) was quite similar to that for Kathama, with less advanced land pressure and soil degradation. This diagnosis also included separate analyses for large and small farms (e.g. between-household stratification). The group diagnosed two clusters of problems amenable to AF solutions: 1) dry-season fodder shortage leading to land degradation and low cash income from animal sales; and 2) poor soil fertility and soil moisture conditions resulting in low food crop yields, and subsequent food and cash shortages.

This information formed the basis for a specific research project proposal, with research priorities outlined in advance (ICRAF, 1983). The collaborative team of KARI, DFSRS, MIDP, and ICRAF began two sets of field trials during the first year of implementation: 1) on-station

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[6] 65 persons/Km^2; Land cover 22% cropland, 2% fallow, 10% infrastructure, 66% grazed woodland

trials of alley cropping[7] for mulch (for croplands); and 2) on-farm trials of fodder tree establisnment and management (for grazing lands), and multipurpose (fodder and fuel) trees for living fences and block planting. Both sets of trials reflected farm and plot-level design criteria.

Toward the end of the first year the project personnel participated directly in a second D-and-D exercise at the site, as part of a training course for a larger group (Zulberti, 1984). The exercise benefited from the field experience of the Kakuyuni team and the diagnosis was refined to reflect the new information.

The same project team has also conducted surveys on the use of trees (Arap-Sang, 1984; Mwendandu, 1984), and has collaborated in household and group surveys on the use of water and forage on and off-farm, and the role of self-help groups in the management of private and shared lands (Caplan, 1984; Janssens, 1984). In some cases the issues arising in Kathama prompted surveys and meetings at Kakuyuni to determine if the same general conditions existed (household composition; role of groups in farm management; role of groups in resource management by women; role of women in use, management, and propagation of trees; common use of private property, and net conversion of grazing land to cropland).

HOUSEHOLD SURVEYS AND DESIGN IMPLICATIONS

Approximately 33% of the households at Kakuyuni are headed or managed by women and 67% are headed by resident men. As at Kathama there are marked differences between households managed by men and women, particularly with respect to labor constraints, mobility, and opportunity costs of time. There is also a difference between women who head large vs small families.

Within households headed by men, men's and women's interests in trees vary primarily with respect to fodder vs fuel. Men tend to be responsible for day-to-day management of the grazing land, and the women for both cropland and domestic work (fuel and water collection, plus child care and food preparations). Men also tend to take more interest in beekeeping, timber, charcoal, and carving-wood sources (all cash-based), whereas women know more about wild foods (fruits and greens), medicines, fibers for handicrafts, and dyes. Both might take responsibility for shade or ornamental trees on the compound, but men would be more concerned with establishment, and women with maintenance, of property line fencing. In the farms managed by women, all of these concerns would be addressed by the head woman but with different priorities, experience, and constraints.

All types of households want, and could readily benefit from, intercropping of fruit trees with food crops. Most households could also engage in some form of tree-leaf mulching, but labor constraints and

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[7]high-risk, least known option, relegated to on-station research for first two years

priority of fodder over mulch would rule out alley-cropping for small labor-limited households. The use of non-fodder tree biomass in boma mulching (corral pre-compost) would be more appropriate because of flexible timing and low opportunity cost of trees and land used. Since live fences are not yet widespread, the mulch would come from dispersed trees and shrubs (eventually from live fences as well). Intercropping of fodder/fuelwood trees with food crops, small fodder/fuelwood lots close to the home, and live fuelwood fences would also be appropriate for small households managed by women.

In larger households labor would probably be allocated first to cash crops and staple food crops, but surplus labor could be used for alley-cropping (or a spatial variant thereof) for high-fertility mulch to improve crop yield. Timber and fuelwood fences and grazing land improvement/intensification would also apply to larger households, especially those managed by men.

Group Surveys and Follow-up.

While land pressure is not as high as at Kathama, "borrowing" is widespread due to the uneven distribution of land. This applies especially to fuelwood and grazing, in some cases to charcoal trees, but not to timber. Labor exchange is also widely practiced, based on self-help groups. Groups weed, fix bench terraces, and make thorn-branch (deadwood) fences for individual members. The latter contrasts with Kathama, where fencing is done individually, and live fencing is more common. Groups also repair gullies and dig cutoff drains, usually as spot treatments and in public places. Given the nature of the project (watershed-based) there was a strong interest in working with groups on soil conservation activities.

The groups were consulted about their own priorities for project-related work, including: farm trials on members' land; community or group nurseries at the Kakuyuni Dam site; the use of vegetation (fodder, fuel, timber) in gully stabilization; and combination of physical structures with vegetation for grazing land rehabilitation on members' land. Group members expressed the most interest in three nurseries, and requested that vegetable plots be allowed at the same site.

Members of three groups worked with project staff to construct the nursery, vegetable beds, and fencing, with separate areas allocated to each group. Many of the women mentioned the possible sale of the seedlings and vegetables as goals of their nursery work. They also planned to establish fruit trees on-farm and to improve family diet with fruits and vegetables. This group activity gave many women access to seeds and other inputs that they would not have had the cash, or permission, to experiment with as individuals. It also provided access to a common water source and training. The management of the plots by groups, rather than individuals, also allowed for rotation of watering and weeding, which minimized the time and travel demands. This, in turn, allowed participation by women with time and mobility constraints (if they were group members). Yields and cash earnings from both seedlings and vegetables were low due to drought and unusual pest infestation

("army worms"), but the prospects are good for expansion of both nursery and vegetable plots, given the perf ance of the groups under adverse conditions (Mwendandu, 1984).

As at Kathama, AF for gully reclamation received low priority relative to other activities. Gully erosion is less of an immediate threat at Kakuyuni, although there are numerous small (treatable) gullies on private property that could serve as moist planting sites, if treated. Such work, however, is carried out on a short-term rotation basis in spot treatments. Long term treatment of gullied and degraded grazing land will be difficult to accomplish with group labor under the usual arrangement. While most households require weeding, bench repair, and fencing, the need for grazing land reclamation is not evenly distributed, nor is the size of plot or intensity of degradation. Some combination of paid and group labor might be more appropriate, or direct payment of the group by landowners, particularly large holders.

While members approved of group participation in farm trials, the actual involvement of groups in establishment of farm trials was sporadic, and constrained by conflicting commitments of group labor at peak demand period for several concurrent activities: nursery and vegetable bed preparation, bench terrace repair, gully repair, site preparation, and fencing for trials. Also, many farmers were prepared to dig their own planting holes and/or fence the plots. Group involvement could complement individual efforts and should be programmed for those activities which can be completed during "slow" periods for other forms of group and on-farm work. As in gully and grazing land rehabilitation, some form of direct payment or exchange (by owner, to group) may also be appropriate.

The surveys and follow-up provided information for the design of AF trials for grazing land improvement, soil and water conservation, live fences and small nurseries. Further inquiries about subdivision among sons, and future use of plots, will guide the technology design, placement, and species selection for live fences and contour-planting in grazing lands. Self-help groups have been incorporated as sources of information, participants in group nurseries (including vegetable plots at their own request) and participants in AF technology trials on group members' farms (Arap-Sang, 1984; Mwendandu, 1984). The variable response and performance of the groups also indicates which activities and technologies are of general interest, and which are appropriate for group vs individual participation. The explicit study of family and group participation has recently been integrated into all trials at the site (Hoekstra, 1984). The results will help to evaluate distribution of costs and benefits from existing trials, to modify designs of future trials and demonstrations, and to plan expanded research-extension programs.

THE SIAYA PROJECT

The Siaya Project differs substantially from the Kathama and Kakuyuni projects in that it is district-wide (spanning 4 ecological zones), it is an NGO effort in collaboration with government, and it is

primarily a development project with a research component. Project staff (Vonk, 1984) and consultants (Buck, 1984; Rocheleau, 1984) have modified the D+D approach to emphasize community scale activities in support of farm-level improvements. Research (on AF technologies and participation) is nested within extension and monitoring activities, except for the rapid appraisal surveys, which form the basis for subsequent technology design and project planning/adjustment.

The project is based on low material inputs and high (national and local) personnel input. The organizational approach is decentralized and relies heavily on extension workers and their constant contact with both clients (groups and farmers) and senior project staff (researchers and managers). Project management (2) and researchers (2-1 social, 1 technical) focus on supervision and documentation, respectively, and both act as trainers/consultants to first level extension staff (6). These in turn train and supervise second-level (local) extension workers (15) who are primarily responsible to consult and assist farmers and groups and to interpret their requests, comments, and suggestions. First level extensionists also collect information for technical and social monitoring and take responsibility for constant readjustment of project action to community needs and practical field constraints (Vonk, 1984).

The extension staff is also actively involved in evaluating and adapting the D+D methodology. During the first year of operation both community and farm level diagnoses have been conducted by first level extension staff, with training and assistance from the manager and consultants (Vonk, 1984; Rocheleau, 1984). Group interviews and meetings (Vonk, 1984) have provided the basis for detailed project planning, survey design, choice of community and farm trial sites. Conflicting interests aired in group interviews called attention to sexual division of labor and implications for planting priorities (fuel vs fodder trees). Further discussions revealed that "men, not women, should plant trees." Subsequent interviews with key informants have influenced the choice of species, planting sites, and terminology, so as to facilitate planting of some trees by women, and women's access to some of the other trees planted by men.

A wide variety of priorities, needs, and resources were identified, demonstrating the need for such exercises at subregional level (using extension-level personnel). Group interests ranged from fuelwood for smoking fish, to dry season fodder, to small timber (poles) for cash, to seedlings-as-cash-crops. Issues common to all groups were the importance of fencerows as a planting niche and as protection for plants in the enclosed area, and the need to resolve related tenure questions (adjudication, grazing rights, shared ownership of fences).

Based on this initial experience in Siaya and prior experience in Kathama (Kyengo, 1984), the form and content of the group interviews has evolved to allow for more reflection and internal discussion by the groups. This has had two effects: 1) to provide a one-week interval for the group, as-a-group, to consider their priority needs re: trees (fuel, food, fodder, shade, erosion control, building material, ornamental, soil fertility improvement/intercropping); 2) to allow the group to consider which species they want to best fill those needs, often resulting in

greater emphasis on known indigenous trees vs exotics (Vonk, 1984). A third effect (not documented) might well be that those individuals who are less vocal and influential would have the time and means to make their views known and to include them in the group's reply.

Following the continuing series of D+D exercises the project staff have built up a network of 70 small nurseries in one year (1/3 primary schools, 2/3 self-help groups mostly women), which are primed to produce 500,000 seedlings for the next planting season. As in Kathama and Kakuyuni, the groups are important not only for plant production ends, but also as means to involve and serve women farmers, and poor households.

The major criteria for project participation are: 1) that the group is established and already working (not necessarily on trees); and 2) that group objectives for nursery work place priority on plant production for members' farms, over cash income from sale of seedlings. Participating groups have diverse bases for organization, ranging from clan, neighborhood, occupational or craft groups, and self-help marketing cooperatives, to informal farm labor rotation groups.

The Siaya team has also paid special attention to the character of the groups relative to the larger community (e.g. wealth, influence, educational level, language, special skills, and access to land). Extension staff have tried to assure that wealthy or influential groups do not dominate or exclude other groups re: project activities. Records of nursery activities also require an accounting of distribution of plants and/or cash earnings within groups to assure an equitable share to all working members. Care is also taken to stratify household level D+D exercises within groups, to include different types of farms and farm households in technology design and farm trials.

The application of D+D at both community and farm scales by both first and second level extension workers has had an impact on the quantity and quality of information available for technology design and continued project planning. The inclusion of intra-household and between household concerns into all facets of the project, from D+D to project management, has affected the baseline information as well as the way it is used. Hiring of both women and men in research and extension positions, and hiring of social scientists from the region has affected both the form and substance of the project, from organization and management of farm trials to the design of specific AF interventions (Vonk, 1984).

SUMMARY

All three projects demonstrate the empirical and practical basis for the inclusion of social science theory, methodology and practice in AF research and extension in Machakos and Siaya Districts. The observation and analysis of these projects has raised procedural questions about participation and nested client groups, as well as substantive questions on the adaptation of AF designs (or vice-versa) to tree tenure, tree rights, grazing rights, water rights, gathering rights, and distribution

and subdivision of land (within and between households). Some of these issues will be addressed in depth within a special project (Rocheleau, 1984) on AF technologies to replace or enhance use of off-farm lands by women of smallholder farms. This study will also focus on Siaya and Machakos Districts in Kenya, with some comparative discussion of other regions and extrapolation from the Kenyan examples. The objective of this type of research is to help design more appropriate AF technologies and to help define the way in which these are tested, evaluated, modified, and disseminated.

REGIONAL RESEARCH FRONTIERS IN AF/FSRE

The examples cited all refer to mixed farming systems practiced by sedentary populations in areas where land adjudication (by household) is recent, in progress, or imminent. However, the suggested combination of land-use planning with AF research and extension can apply to any tenure situation, provided that there is interaction of public (or group) and private resources in AF production for individuals, farm households, and the community. Such an approach may be even more important in cases where the community, rather than the household, directly manages some aspects of agricultural (or AF) production.

The development of a sliding-scale AF/FSRE approach for the "communal lands" of eastern and southern Africa presents a special challenge to interdisciplinary AF researchers. The mixed pastoral and agricultural systems of the semi-arid and sub-humid zones, and the shifting cultivation and bush-fallow systems of the humid areas are both changing rapidly in response to population pressure, land allocation, national economy, and new technologies. AF technologies for transition to sustainable intensified systems should build on existing local organizations and institutions for management of trees, crops, animals, water, and land.

Farming systems researchers have documented the distinct objectives and conditions of communal farmers for cattle (Avila, 1984; APRU, 1983; Hayward, 1984), crop production (ATIP, 1984; Kean and Chibasa, 1981; ARPT, 1983; Mugabe, 1984; Qasem, 1984) and land and water management (Peters, 1980; Roe and Fortmann, 1982; Silitshena, 1983; Harris, 1981; Castelli-Gattinara, 1984). In addition to the differences in resource base and objectives, the basis of control and ownership (Peters, 1980; Roe and Fortmann, 1982), and the codes of group decision-making in "communal systems" contrast sharply with both large-scale commercial farm management and individual smallholder practices.

Issues of community and intra-household resource management impinge heavily on individual behavior re: management of animals, fodder, fuel and water collection, land preparation and demarcation, and seasonal migration. While the extensive grazing systems are the most widely recognized examples of communal tenure and management, similar issues arise in the management of water-harvesting, small-scale irrigation, contouring, dry season fodder banks, tree crops, and introduction of new annual crops and practices. On-site work in communal systems will require interdisciplinary expertise, and an approach that goes beyond

ousehold-based research to treat community and within-household uestions of tenure, water rights, and grazing and collecting rights fuelwood, food, fodder, crop residue, medicine, fibre, dung). The hallenge is to integrate such information into self-correcting research nd rural development programs that can change to accommodate new nformation, new questions, and nested sets of clients-as-participants.

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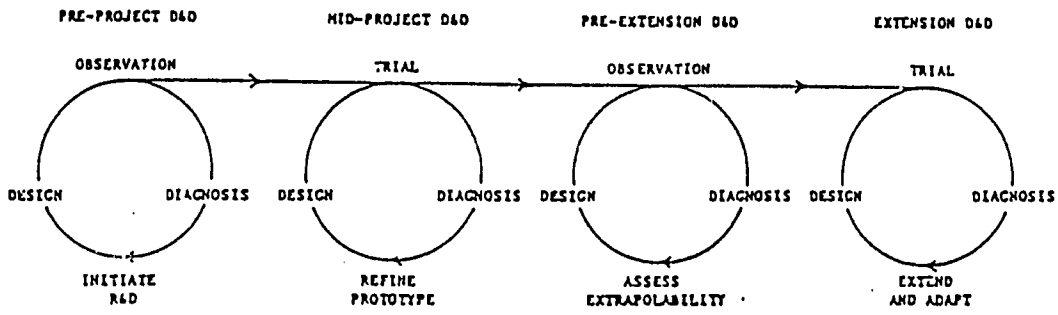


FIG. 1 : D&D AS AN ITERATIVE PROCESS IN THE PROJECT CYCLE
(Source: Raintree, 1983; ICRAF, 1983)

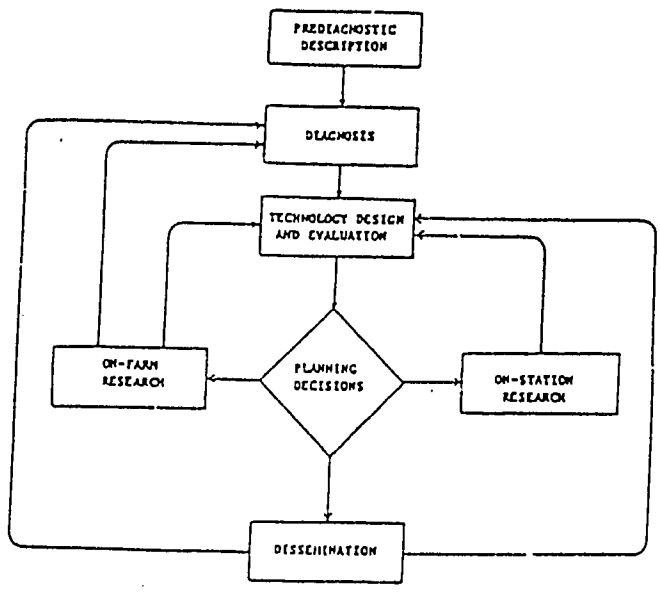


FIG. 2 : DIAGNOSIS AND DESIGN (D&D) PROCESS
(Source: Raintree, 1983; ICRAF, 1983)

D&D is an iterative process which continues throughout the life of a project as part of its internal guidance system. Note feedback linkages.

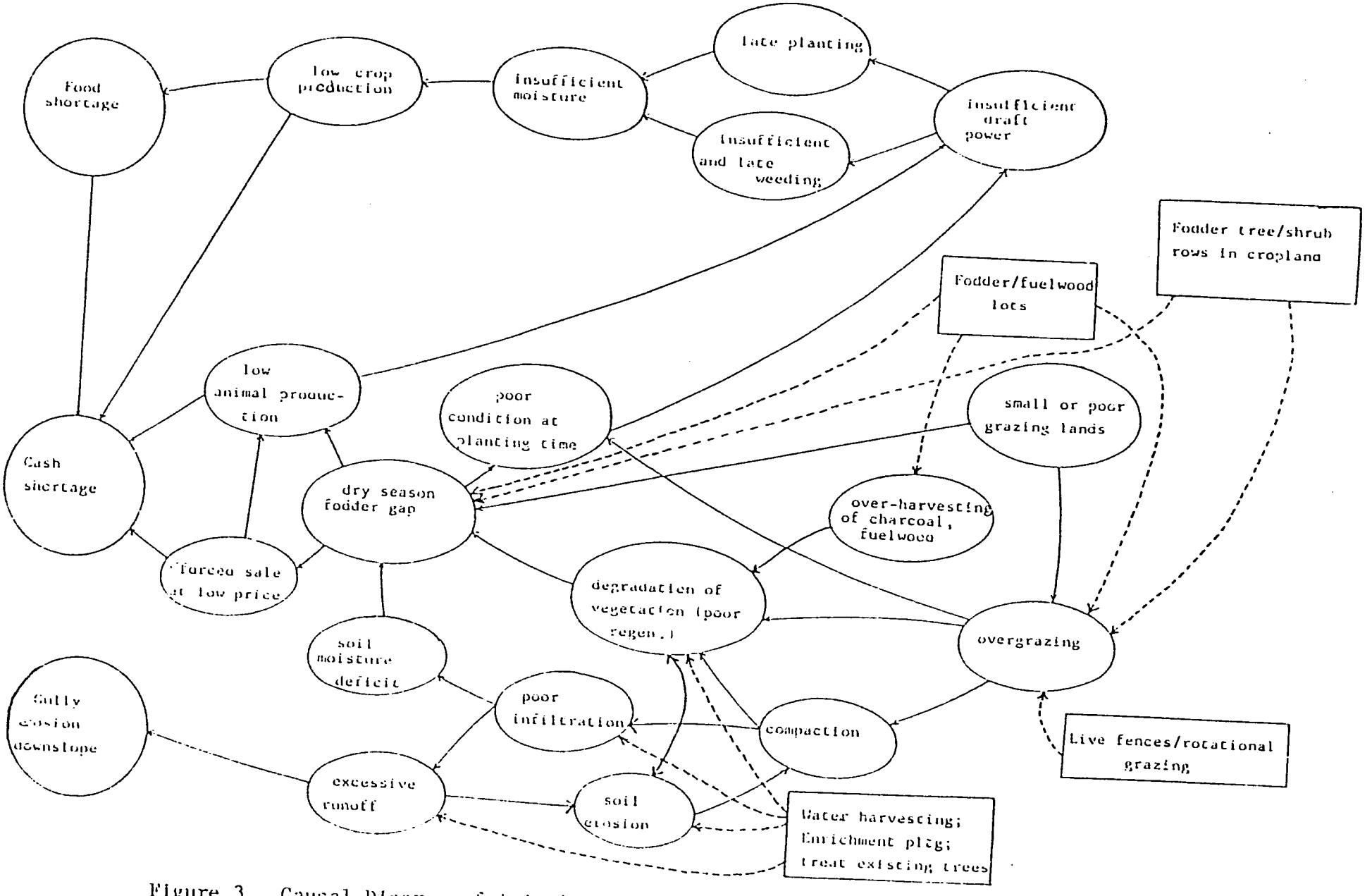
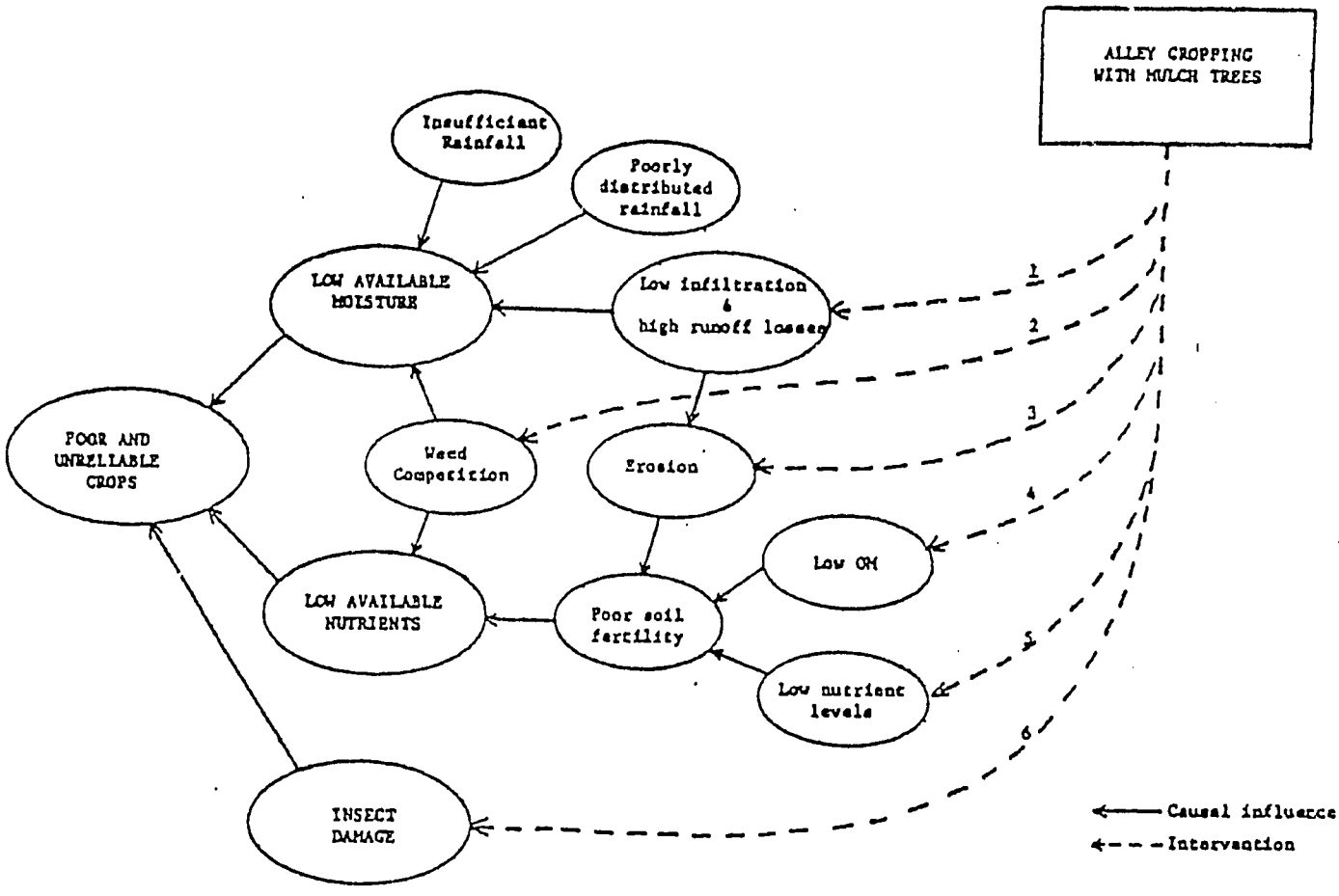


Figure 3. Causal Diagram of Animal Production Problems Affecting Food and Cash Shortages. Adapted/Updated from Vonk, 1983.



Potential Mulch Trees

N-fixing	Insect-repellent
Leucaena leucocephala	*Adhatoda vasica*
Mimosa scabrella	*Azadirachta indica*
Sesbania bispinosa	*Derris indica*

Potential Interventions

1. Improved infiltration, reduced runoff
2. Weed control with reduced labour
3. Reduced splash and runoff erosion
4. Increased organic matter
5. N-fixation and nutrient pump action of deep penetrating roots
6. Use of insect-repellent mulch species.

FIG. 4 . DIAGNOSIS AND DESIGN - CAUSAL DIAGRAM

The partial causal diagram depicts causes of food problems in the mixed farming system of Kathama, with suggested technological interventions. (Source: Raintree, 1983).

TABLE 1 SUMMARY OF FARM LEVEL DIAGNOSTIC AND DESIGN INDICATIONS FOR A TYPICAL FARM (3.5 ha) AT THE KATHAMA RESEARCH SITE. (From Vonk 1983, Raintree 1983)

KATHAMA
MACHAKOS DISTRICT
KENYA

SITE SUMMARY OF AGROFORESTRY DIAGNOSIS AND DESIGN INDICATIONS ON A REPRESENTATIVE FARM

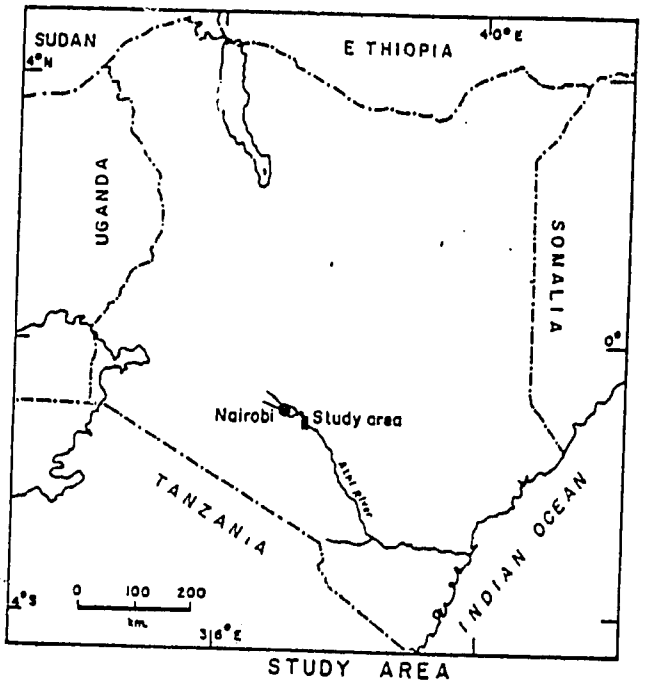
SYSTEM DESCRIPTION	LAND USE SYSTEM DIAGNOSIS		AGROFORESTRY POTENTIALS
	HOUSEHOLD SUPPLY PROBLEMS	PRODUCTION CONSTRAINTS	
Climate Semi arid-sub-humid **Soils** Sandy loams over sandy clay loam to sandy clay; imperfectly drained in places **Farming System** Mixed farming **Crops** Maize, beans, pigeon peas, cowpeas **Livestock** Zebu cattle, goats and sheep **Economy** Subsistence farming **Population Density** 172/Km^2 **Growth Rate** 3.4%	**Problems in Basic Needs Supply Sub-Systems** FOOD - Seasonal staple food shortages normal, must purchase; drought related crop failure on avg. of once in every five years; low milk and meat production due to dry season feed shortage for livestock FUEL - Insufficient production from own land, must purchase fuelwood for household and cottage industry uses; lack of large trees for brick burning. SHELTER - Lack of construction quality timber and poles, must purchase; lack of large tree for brick burning; lack of fencing and shade trees. RAW MATERIALS FOR HOUSEHOLD INDUSTRY Must purchase fuelwood for brick making. CASH - Low net household income due in part to cash outflow for staple foods, fuelwood, and construction wood; savings and earning potential of livestock enterprise limited by dry season feed shortage **CONSERVATION PROBLEMS** Erosion Declining Soil Fertility Degradation of grazing land vegetation	**Antecedent Causal Factors** **Crop Land** 1. Low fertility and declining yields 2. Lack of manure 3. Low available moisture 4. Oxen too weak for dry season ploughing/planting; hence inefficient use of limited soil moisture. 5. Soil erosion and water loss due to heavy runoff. 6. Waterlogging on low spots 7. Labour bottleneck at ploughing and weeding time: 8. Insect pests. **Grazing Land** 1. Small grazing area 2. Insufficient dry season feed production. 3. Insufficient production of fuelwood **DESIGN CONSTRAINTS** Low capital Low available labour Long dry season, frquent droughts Termites & other pests	**Specific Problem-Solving Agroforestry Potentials** 1. Elimination of dry season feed gap by planting of multipurpose fodder trees in grazing areas and as hedgerow in cropland with concomitant erosion control effects and fuelwood and mulch coproduction possibilities; improved feed situation should allow dry season ploughing/planting. 2. Cut-and-carry fodder trees for increased pen feeding and usable manure production. 3. Alley cropping/mulch farming with leguminous and other trees to control erosion, increase water infiltration, conserve soil moisture, improve soil fertility and structure, reduce the need for tillage and lessen the labour requirement for weeding, insect repellence 4. Hedgerows and living fences of high-yielding fuelwood species and fruit producing thorn bushes (as a hedge against famine in bad years, for supplementary livestock feed in average years). 5. Multistorey fruit trees with undersown grass-legume pasture.

	firewood	coppicing	poles/posts	timber	leaves animal feed	human food pods	animal feed	honey	conservation water and soil	insecticidal	thorns	living fence	N-fixing	mulch slow decaying	medicinal use	drought resistance	cropping alley	hedge in shamba erosion control	living fence	grazing area improvement	fodder fence & woodlot	shade tree	trees in shamba widely spaced	windbreak
Leucaena leucocephala 'K8'	x	x	x	x	x	x	x	x	x			x	x				x	x	x	x	x	x	x	
'K28'	x	x	x	x	x	x	x	x	x			x	x				x	x	x	x	x	x	x	
'Peru'	x	x	x	x	x	x	x	x	x			x	x			x	x	x	x	x	x	x	x	
Cassia siamea	x	x	x	x		x			x	x				x		x	x	x				x		
C. sturtii	x	x			x				x								x			x	x			
Atriplex nummularia	x	x			x			x	x							x				x	x			
Sesbania grandiflora	x	x			x	x	x		x			x	x							x	x			
S. bispinos	x				x		x		x				x			x				x	x			
S. sesban	x	x			x		x		x				x							x	x			
Stylosanthus scabra		x			x				x			x				x					x			
Zizyphus mauritiana	x	x			x	x	x				x	x		x	x			x	x	x	x			
Prosopis chilensis	x	x	x		x	x	x	x	x				x			x				x	x			
P. juliflora	x	x	x			x	x	x	x		x	x	x			x				x	x			
P. nigra	x	x	x		x	x	x		x				x			x				x	x			
P. pallida	x	x	x		x	x	x		x				x							x	x			
Grevillea robusta	x	x	x	x				x	x					x						x		x		
Acacia albida	x	x	x		x	x	x	x	x		x		x			x					x		x	
A. tortilis	x	x			x		x	x	x		x				x	x				x				
A. holosericea	x	x			x			x					x			x	x			x				
Parkinsonia aculata	x	x			x	x	x		x		x	x	x			x			x	x	x			
Croton megalocarpus	x	x	x	x								x				x			x					
Jacaranda mimosifolia	x	x	x																			x		
Tamarindus indica	x				x	x	x				x	x	x									x	x	
Azadirachta indica	x	x	x	x				x	x	x				x	x	x					x			
Melia azederach	x	x	x	x				x	x	x					x	x					x			
Acrocarpus fraxnifolia	x			x									x							x	x			
Casuarina equisetifolia	x	x	x	x	x				x				x			x				x	x			x
Balanites aegyptica	x	x	x		x	x	x	x	x		x				x	x					x			
Moringa oleifera						x									x									
Samanea saman	x	x	x	x	x	x	x	x	x			x	x		x	x				x	x	x		

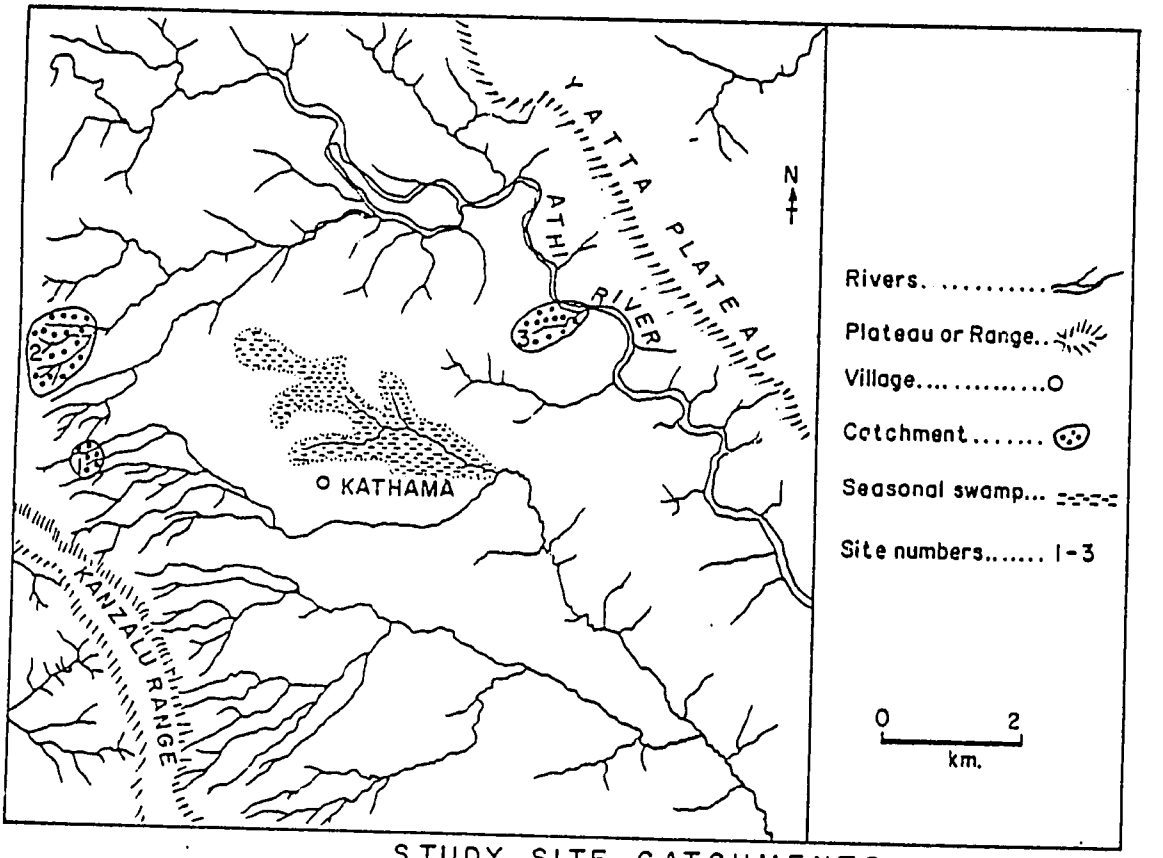
TABLE 2 RECOMMENDED SPECIES LIST BASED ON FARM TRIALS AND OBSERVATIONS IN SIMILAR ENVIRONMENTS

Excerpted from Vonk, 1983.

References: Fernandes, 1983.
Getahun, 1983
Haller, 1981
Barrow, 1982
National Academy of Sciences, 1980
Buck and Teel, 1983



STUDY AREA



STUDY SITE CATCHMENTS

FIG. 5: Location map of study area and work sites.

LAND UNIT	RELIEF	SLOPE
A. KANZALU RANGE	A1. ridge A2. dissected hilly slopes A3. steep slopes with rocks A4. rolling footslopes	A1.4. flat to very gentle A3.1. steeply sloping A4.1. moderately sloping
B. UNDULATING UPLAND	B1. undulating uplands B2. flat/almost flat depression B3. rolling slopes	B1.1. flat to very gentle B1.2. gently sloping B1.3. moderately sloping B2.1. flat to very gentle B2.2. gently sloping B3.1. flat to very gentle B3.2. moderately sloping
C. ATHI RIVER LANDSCAPE	C1. river island C2. floodplains C3. riverbed	
D. YATTA PLATEAU	D1. plateau D2. slopes	

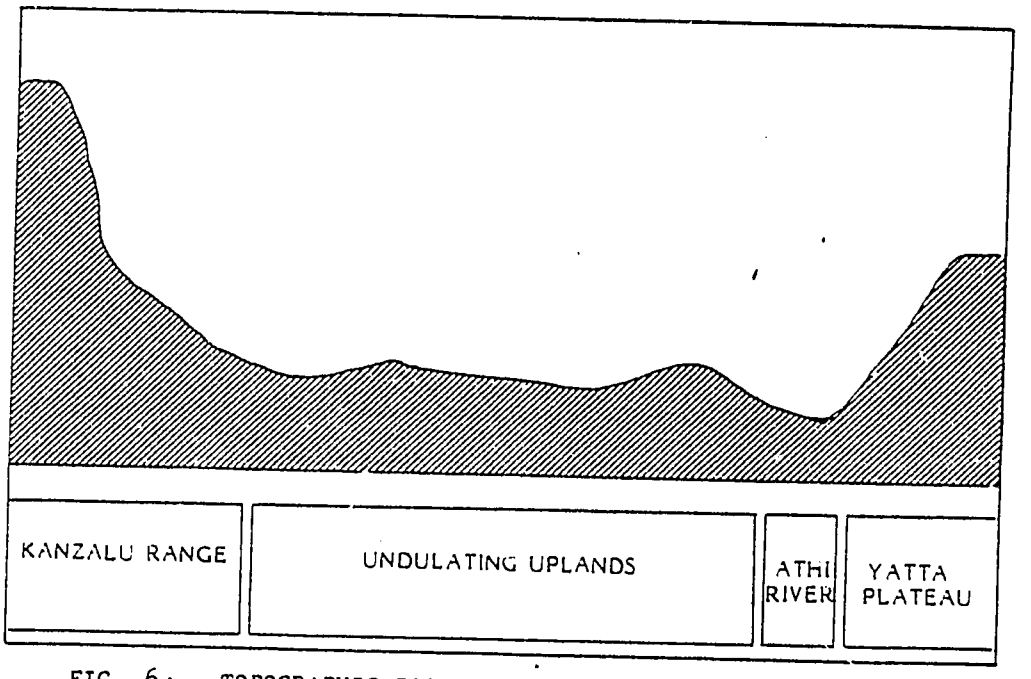


FIG. 6: TOPOGRAPHIC PROFILE WITH LAND UNITS
(Hoek, 1983)

Table: 3

SUMMARY OF AGROFORESTRY DIAGNOSIS AND DESIGN FOR THE COMMUNITY AND SURROUNDING WATERSHED

SUPPLY PROBLEMS	SUSTAINABILITY PROBLEMS	CONTRIBUTING FACTORS	AGROFORESTRY POTENTIALS OF COMMUNITY LEVEL
FOOD - Low grain yields throughout sub-location; dependence on imports from other districts, food relief in drought years.	Declining yields predicted on existing crop land; poor yields and land degradation anticipated for newly opened marginal lands.	High cost of fertilizers, inadequate supply of manure, and low soil fertility; inadequate labor for weeding at peak demand periods; introduction of grain crops inappropriate to ecological zone; expansion of grain crops onto marginal sites (steep, dry, gullied).	Promote fruit and nut trees to supplement diet through group nursery projects. Mix group vegetable gardens with tree nurseries. Promote mulch (green manure) strategy through group participation in farm trials to determine best species, management.
WATER - Inadequate supplies for domestic and agricultural use; uneven distribution of access by wealth, relative location; inadequate development of municipal sources.	Existing water sources subject to deterioration by siltation, flooding lowered water table.	Excessive runoff on grazed lands upslope reduces infiltration and groundwater recharge; floods and siltation plague impoundments, dry river-bed wells.	Use group contacts to locate nuseries, veg. gardens at permanent waterholes on group member's property. Combine water-harvesting with AF experiments using available materials, soil conservation groups; use MPT's and grasses to protect impoundments.
FUEL - Charcoal and brick-burning trees scarce throughout sub-location; high expenditure of time and labor to procure fire-wood; uneven distribution of quality, quantity by land facets, farm size.	Browsing keeps trees at shrub size; Degradation of source areas (soil compaction) is preventing regeneration of favored species.	Overgrazing hillslope woodlands and small plots downslope by all households on slope.	Promote zonation of fuelwood production on upper slope, trade for food; convert selected gullies to ravine woodlots (fodder lots if controlled access). Increase fuelwood production in boundary lands of finely sub-divided landscape.
INFRASTRUCTURE - Drainage roads inadequate to service sub-location; lack of integration within each network and between networks.	Existing roads, drains, crossings threatened by gully erosion, siltation individual (piecemeal) decisions to modify drainage and paths.	Frequent movement of cattle upslope causes severe gullies in midslope woodlands; flash floods remove even trees in gullies; use of sledges for water carts erodes roads, disrupts drainage.	Divert drainage from selected drainage channels to croplands and/or fodder lots. Use vegetation (MPT's, grasses) to define and stabilize permanent drainage and road network, while producing poles, fuel.
RAW MATERIALS - Commercial charcoal and brick-burning tree sources depleted throughout sub-location; shortage of construction poles - purchased from other locations.	Degradation of source areas in over-grazed over-harvested woodlands is preventing regeneration of pole wood species; degradation will hamper future efforts to re-establish favoured species.	Lack of training and infrastructure (physical and organizational) to propagate desired species within the sub-location.	Plant polewood trees on internal farm paths and along roads. Integrate charcoal and brick-burning trees into ravine woodlots, fencerows Develop nurseries, seed collection with self-help groups.
CASH - Reliance on charcoal as cash crop by poor small-holders; almost no off-farm employment; marketing disadvantage relative to nearby towns; remittance income from absentee men sporadic.	Remittance income dwindles, becomes less dependable with time away, and rising urban unemployment; charcoal stock being depleted in adjacent source areas - enterprise not sustainable as is.	Land cannot accommodate new full-sized holdings of young families, food crops given priority; promoted cash crops high risk for zone (cotton), market for other cash crops unreliable.	Integrate fruit (citrus, guava) and nut (macademia, cashew) trees into terraced cropland, with concurrent organization of market channels already used by a few farmers. Integrate training into group trials, nursery work.
SAVINGS/INVESTMENT - Dry season fodder gap forces untimely sale of goats, sale or loss of cattle; land prices prohibitive - shortage of arable plots.	Degradation and subdivision of grazingland; widespread conversion of grazing areas to cropland preclude maintenance of herd size under current practice.	Best dry season fodder trees (pod trees) have been harvested for charcoal; animals allowed to range freely during long dry season; land conversion to crops.	Use MPT's to sub-divide larger grazing lands for rotation. Use N-fixing species planted in strips or microcatchments to reclaim degraded grazing areas; Plant pole trees for cash on farm and along roads, with tree rights assured (group, individual, through chief).

FIG. 7 : INTEGRATED AGROFORESTRY SOLUTIONS NESTED IN THE LANDSCAPE

Tree, shrub and grass combinations

on the farm

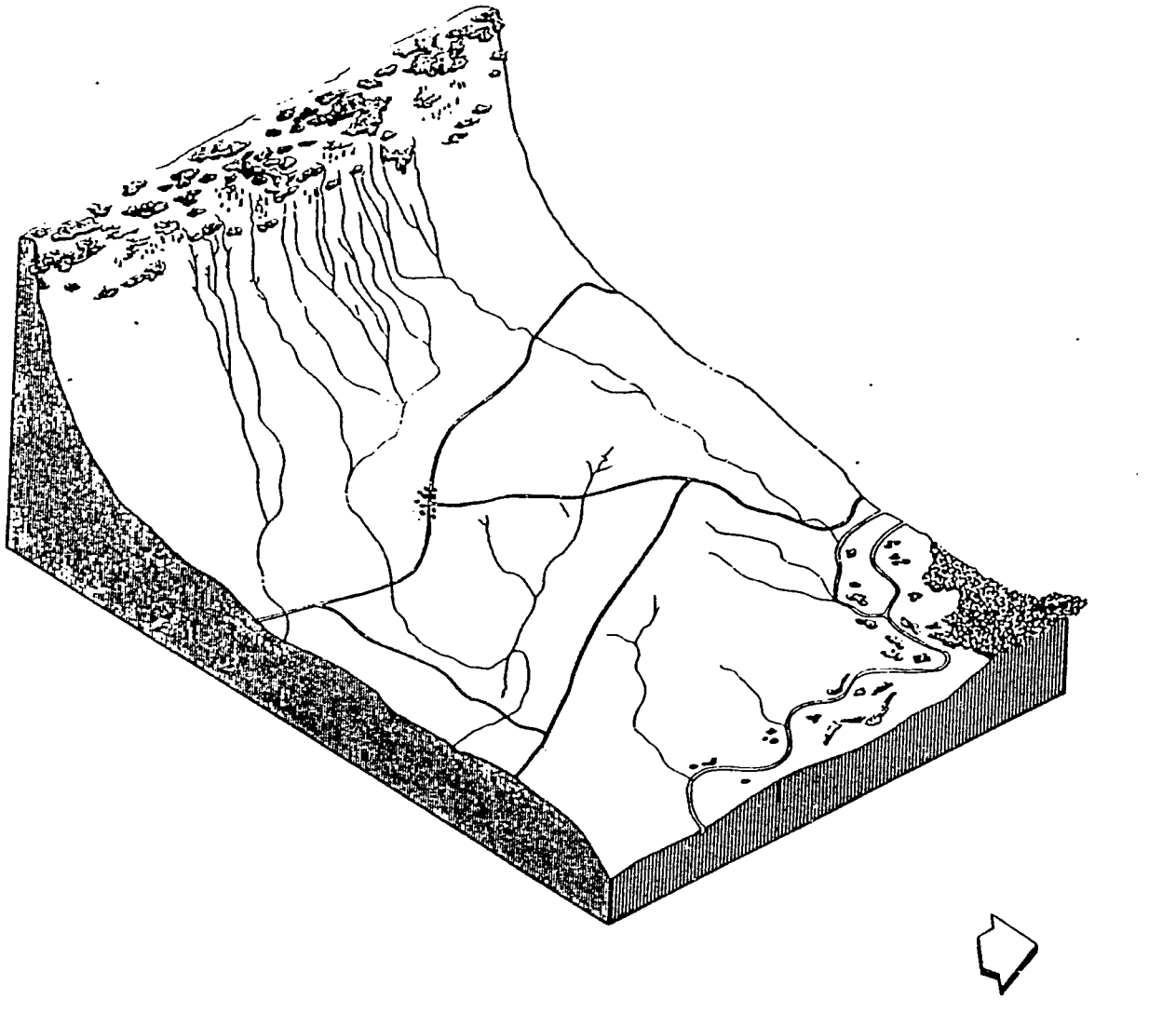
on boundaries, in gullies and along roads

Landscape Niche Affected:

Gully and grazing lands		Cropland	Home compound	Internal boundary zone	Cropland	Road
erosion control in gully and grazing land for: Improvement of the drainage condition by -checkdams and natural vegetation - control of grazing and improvement of grass, fodder and fuelwood production	Living fences	grass and fruit trees on the benches of the terraces for: -erosion control -improvement of fruit, fodder, wood and grass production	trees around the home and boma (corral) for: fodder production, shade, shelter and decoration	grass for: erosion control, production of fodder	hedgerow system: trees are planted in rows between the crops to: -provide mulch, fodder and wood -control erosion, improve drainage condition	trees along the road or path for: shade and decoration, improvement of drainage condition

(Hoek, 1983)

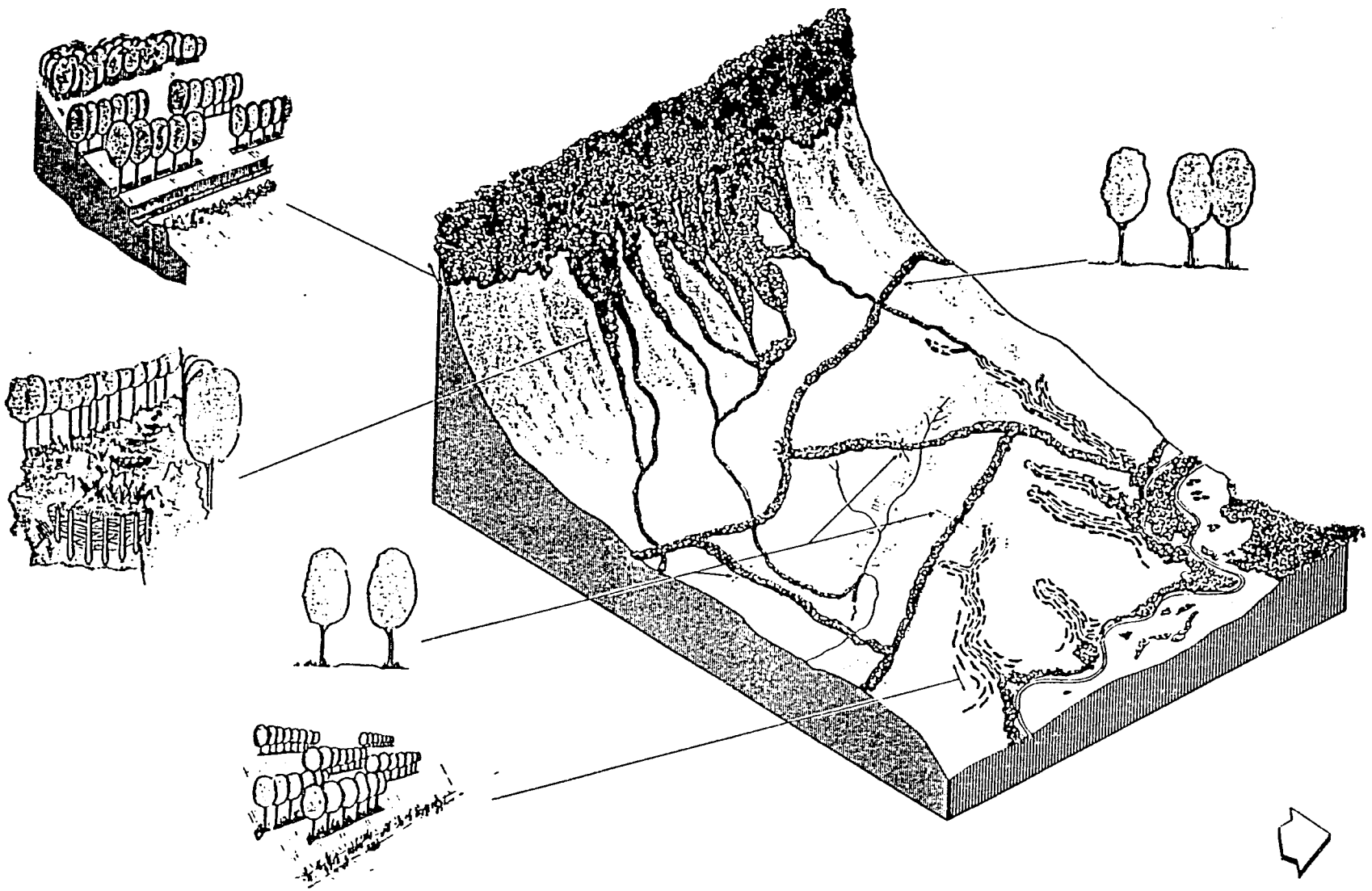
Fig. 8



PRESENT SITUATION

(Hoek, 1983)

Fig. 9 : Landscape Design Sketch



(Hoek, 1983)

MASTER PLAN

FIG. 10: STUDY AREA FOR DETAILED LANDSCAPE ANALYSIS AND GROUP WORK

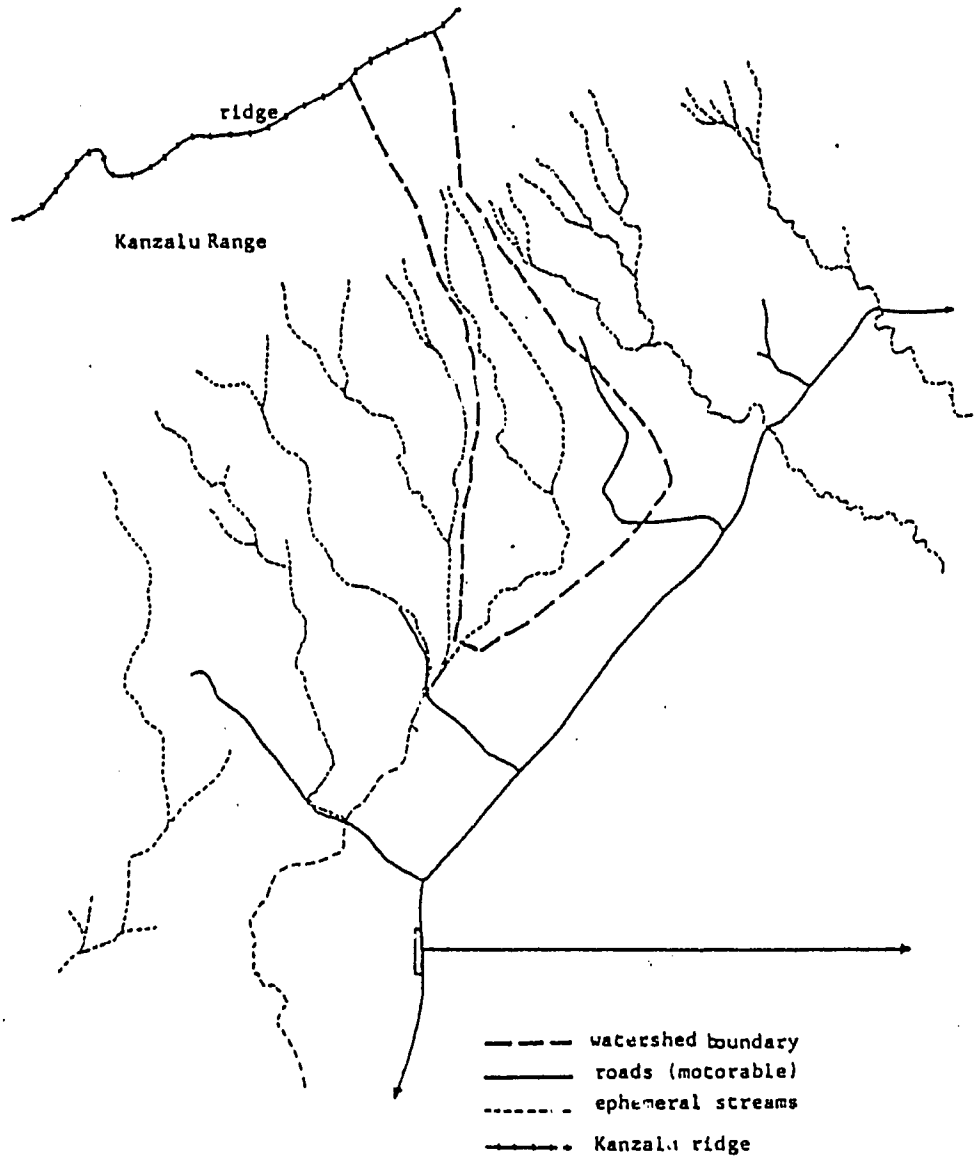


FIG. 11 : LAND USE IN THE WATERSHED

1. Woodlands - some grazing
2. Pasture - sustainable
3. Degraded grazing lands
4. Cropland
5. Public land, sparse cover

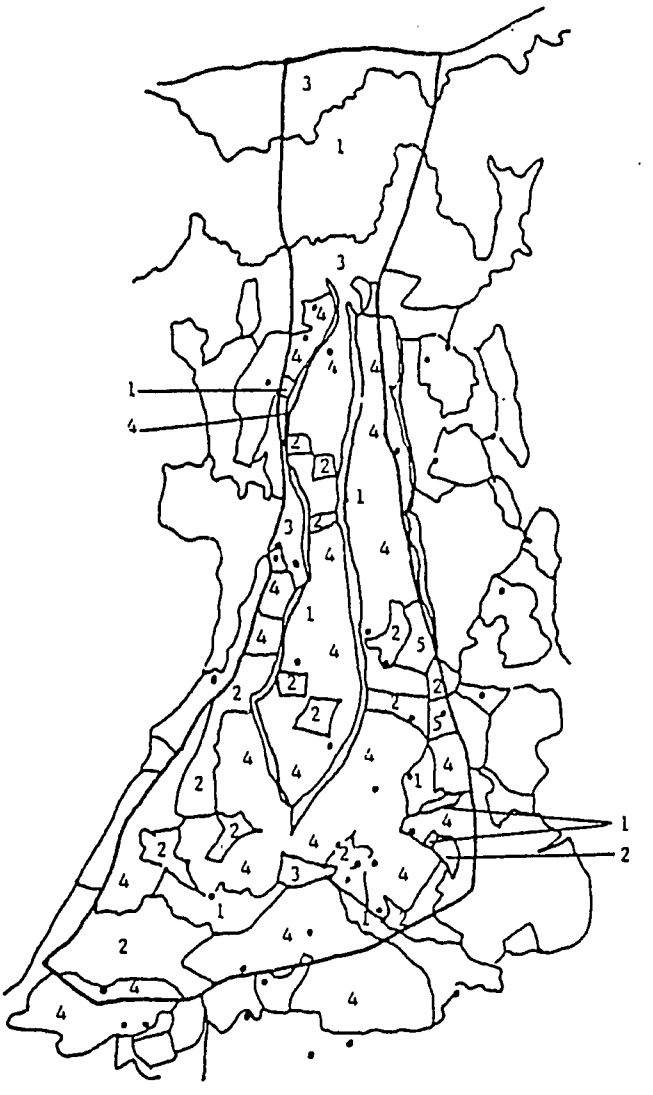


Table 4: Estimated Land Use in the Watershed Aggregated by Category

	Wooded Ravines	Grazed Woodland	Sustainable Pastures	Degraded Grazingland	Cropland	Public Lands	Total
ha	5.6	17.3	18.0	11.6	52.8	1.0	106.5ha
% of total	5%	16%	17%	11%	50%	1%	100%

Table 5 : Production Potential* Estimates From Length and Area of Linear Features and Boundaries

	Roads and Paths		Gullies and Channels		Property and Internal Boundaries		Total
	Major	Minor	Major	Minor	Existing	Bench Risers or Rows	
Length m	2,600	2,400	4,200	3,200	8,340	15,000[3]	35,740 m
Width m	2	1	3	2	1	1	
Area m^2	5,200	2,400	12,600	6,400	8,340	15,000	49,940 (5.0ha)
Potential fuel production kg yr^{-1}	10,400	4,800	25,200	12,800	16,680	30,000	84,880 (84.9t) - 100,000kg (100t)
% of demand in watershed	7%	3%	17%	9%	11%	20%	67%
Potential fodder production trees kg yr^{-1}	10,400	4,800	25,200	12,400	16,680	15,000	84,880 kg yr
grass kg yr^{-1}	4,576	2,112	12,600	6,400	6,458	6,000 (riser only)	38,746 Kg yr
Combined kg yr^{-1}	13,420	5,856[4]	16,632[2]	8,448[2]	20,943[4]	19,356	84,655 kg yr
Assume 5 kg A.U. day	6%	3%	8%	4%	6%	6%	39%

1. Estimated assuming 1 lopped tree per m^2 producing 2kg DM leaf and 2kg DM wood $tree^{-1}$ and .88kg m^{-2} yr^{-1} grass (1.44kg m^{-2} $season^{-1}$) and 1kg m^{-1} of Napier grass in gullies (based on rapid appraisal and data from Otarola and Ugaldi. 1983; Baggio, 1982).

2. $\frac{2}{3}$ area in grass strips, with $\frac{1}{3}$ area in fodder trees

3. Assume only 500m per farm 30 farms

4. Grass production reduced by $\frac{1}{5}$ to account for weeding near trees.

Table 6. Estimated[1] Ideal Requirements for Structural Treatments and Plants Within the Watershed

Gully repair with related land treatment

	Major channels	Minor channels	
	4200m	3200m	
No. Check Dam Structures	250[2]	250[2]	
Length of Drains, Diversions		450m	
Volume of storage[3] in pits or micro-catchments in grazing-land upstream		4500m^3	45,000 structures of 0.1m^3 storage each
No. trees and shrubs[4]		25,000	
Napier grass (initial beds for seed, demo.		3,000 units (slips)	

1. Based on rapid appraisal and rough calculations
2. Assume direct treatment of 1,000m. at the upstream end, small structures every 4m
3. Assuming 5cm rainfall storage
4. Assuming grass to be seeded or naturally re-seeded.

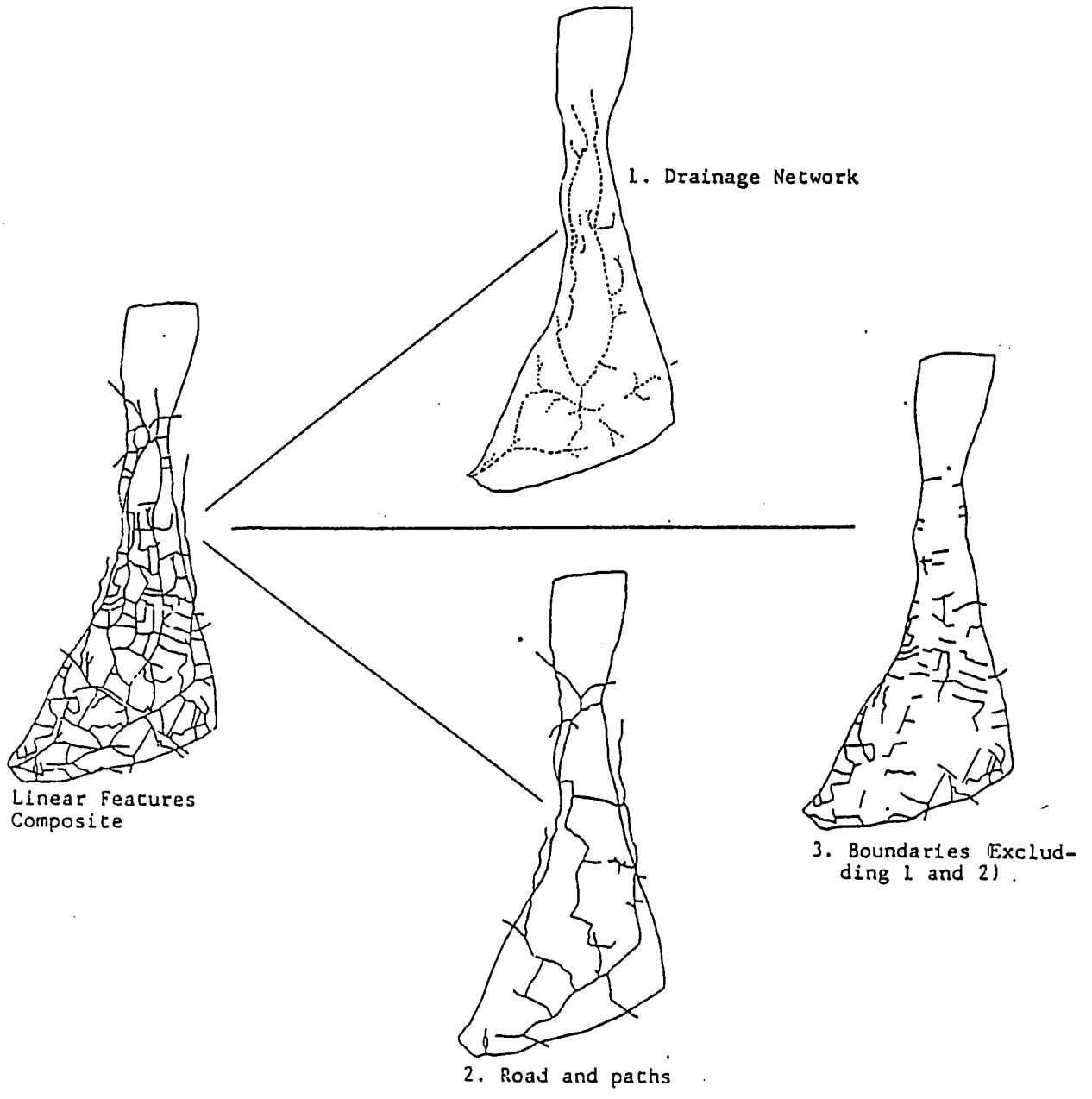


FIG. 12: LINEAR ELEMENTS OF LANDSCAPE WITHIN THE WATERSHED

Table 7 Time-and-Labour Estimates for Self-Help Groups Working in Watershed Rehabilitation[1]

Task	No.	Time[2]
Small checkdam	2	1 session
Cut-off drain (narrow)	40m	1-2 session(s)
Pitting	40	1-2 session(s)
	1 ha	25+ sessions
Microcatchments	60	1-2 session(s)
Fencing site	400m or 200 trees	1-2 session(s)
Planting Holes	400	1 session
Tree-planting	500	1 session

Realistic Goal for Planning One Year's Work, 4 sites at or near origin of gully, each with "package" of treatments:

5 small check dams with necessary drains, diversions; 500m^2 treated microcatchments or pits with trees and shrub planting and appropriate fencing or tree protection.

1. Based on 2 groups operating in this area, with 20 working members each at every session, 32 sessions per year of public conservation work, each session spanning one morning, with 2 full hours physical labour per person.

2. Varies with texture and structure of soil, condition of site.

Table 8. Species included in first round of tree-seedling distribution to group.

Citrus spp (rough lemon: 1 budded*, 1 plain	(2)
Anacardium occidentalis	(1)
Psidium guava	(1)
Cassia siamea	(2)
Carica papaya	(1)
Leucaena leucocephala	(2)
Acacia holosericae	(1)
Acacia albida	(1)
Azadirachta indica	(1)
Melia Azidirach	(1)

---

* with Washington navel orange

** all of the above had shown some promise in existing production systems or in previous farm trials in the area. In addition to the above selected species, some farmers agreed to plant rooted cuttings of *Cliricidia sepium*, *Albizia amara* and/or *Sesbania sesban* to test ease of establishment and survival under farm conditions. All three are potential components of fuelwood/fodder production technologies for small farms in Kathama.

Table 9a. Original D+D.

ORIGINAL DIAGNOSIS	ORIGINAL DESIGNS	RESEARCH PRIORITIES/PROGRAMS
FARM LEVEL		
Cash Problems		
Poor animal production due to dry season fodder gap;	Enrichment planting in grazing lands	Establishment trials, several spp; various site preparation planting, and mgt.techniques.
High seasonal cash outlays for staple food purchase	Fodder and fuel lots (cut and carry) on small unused plots	Same as above different spacing and land pup. technique
Off-season animal sales due to both of above.	Multistorey fruit tree stands over grass and legume cover(fodder)	(low priority)
FOOD PRODUCTION PROBLEMS		
Low yields and crop failures Soil capping - late tillage; poor soil moisture;poor soil fertility;soil erosion.	Hedgerow intercropping for mulch, (with N, O.M. additions and protective cover for better soil moisture,lower temp.) and stick wood as by-product	Cassia siamea and Leucaena leucocephala at 2.5 m between-row and 0.5 m in-row with maize and pigeon pea, on cropland.
FUELWOOD SHORTAGE		
High dependence on off-farm sources; fuelwood purchase,charcoal tree purchase by some.	see above, plus: Hedgerows and living fences with fruit bearing spp. and high - yielding fuelwood spp.	spp. trials along fencelines and in lots (low priority)
COMMUNITY LEVEL		
Cash		
No facilities for plant propagation marketing, and farmer training to support farm level technology tested (above) at farm level. Degradation of grazing lands.	Provision of "sampler" seedling packages (13 spp.) and some training to group members in soil conservation projects,	Follow-up to seedling distrib, on 60 farms re: survivsl and placement by spp. Qtrly follow-up at 30 farms re: performance, damage, maintenance,farmer assessment, farmer learning.
Net purchase of construction wood from other communities.	Involvement of groups in establishment of fodder and timber spp. upstream of gully sites.	
Food		
Inadequate storage & credit & mktg, facilities at community level.	Low priority	Not pursued
Degradation of gathering sites	See survey, below	Interviews with groups re: wild fruits and other foods preferred spp.? dwindling sap? (in amt.or access)
Fuel		
Depletion of favoured spp. for fuel and charcoal in Kathama itself, and uneven distribution of what remains.	Distribution of sample fuelwood spp. see survey below.	Follow-up of sampler seedlings as above, special attention to fuelwood spp: suvival? willingness to plant more? where on farm?
Savings Investment		
Need community-level support for improved savings mechanisms; alternative investments	Low priority	Informal polling of groups re: alternative investments, group savings,preferencea of farmers.
Disinvestment in land resources and infrastructure at community scale (degradat) of grazing and gathering lands,water supply, roads and paths)	Involvement of groups in resting AF(fodder and fuel trees with grasses, and living structures) into public soil conservation works. No design: Pilot survey on use of off-farm resources (water,fodder, fuel groups labor row materials)	

Table 9b. Revised D+D.

Feedback D&D

From Farm Trials

- Hedgerow intercropping is still risky mainly due to apparent water compe tition esp. with pigeon pea, but farmers interested in "Zonal mulch".
- Pest control, water harvesting and browsing damage problems on grazing land left most farmers with mgt. of existing trees as best option.
- Water supply for on-farm nurseries poses a problem for most individual farmers - public supplies or access to others' private supplies is needed for nurseries (if seedlings used).

From Groups

- Groups are not public works or purely communal in orientation; they are associations based on exchange/rotation of labor on members' lands to benefit individual members and families.
- Follow-up of "samplar" seedlings indicated greatest interest in fruit trees and fodder trees, both on croplands (for estab. and protection)
- Group requests for nursery project, participation and results show need for training plus simpler, cheaper methods of plant propagation, and pest control(confirms fruit and fodder priority; would consider local wild fruits)

- From surveys plus Interaction of Groups and Individual Farms:

- There are 3 main design client-groups;

1. Labor-short, land-poor, limited mobility families.
2. Largeholders interested in investment over long term .
3. medium-small holders interested in mixing fruit trees ,fodder,improved practice into cropland.

- Subdivision of lands is a critical issue, as is land conversion; we need to plan present placement and spacing of trees accordingly.
- Use of boundaries is especially important to smallholders, as is use of gullies; roadsides are also heavily utilized by same, but lack definition re: rights of use (for example, for new trees). Women and poor men may be able to use gullies and fencerows. Most are willing to start with fencerows.(for fuel, timber)
- Some members have tried boma-mulching(pre-composting with tree biomass in corrals) and some have pits for rough-composting; other group members interested in increasing "Manure" yield from corrals.

Changes in Research Programs and Priorities for Farms and Groups

Priority 1:fruit trees in cropland and internal fencerows. questions:spp? spacing? combinations?mkts? processing or storage? multiple uses? (food, cash; fodder and fuelwood by-products?

Priority 2:fodder trees in cropland, intercropped or in small plots (one terrace)

questions: spp? spacing on risers? or in lots? fodder production? effect on crop production? cut vs. once-a-year browse?

Priority 3:Use of tree biomass for pre-composting (" boma mulching") and composting.(combine with fuelwood production).

Question: fencerow or dispersed trees? best spp.? timing? quantities? labor input? nutrients and O.M. in mix? effect on soil? yields? farmer assessment.

Priorities for related systems research (support)

Priority - 1a. progagation methods with and without nursiries (e.g. cuttings, direct seeding; and bare-root and stumping)

1b. Pest control for propagation, establishment (local resources)

Priority 2:serves 1, 2, and 3 :should be included in each case. Landscape planning with families and groups, accounting for access to,and ownership of, different places within -farms and within - communities.

Time-series planning to account for tenure and access shifts, land subdivison and land use conversion at farm and community level. Develop and propose various components, mixtures, arrangements and social organization options, determine with clients most acceptable avenues to pursue, then monitor performance as-per-usual in 1, 2, 3 above.

Priority 3:also serves 1, 2, 3 and 2 above (landscape) Training and Extension approaches- assessment of alternative approaches and techniques (for Kathama and other similar areas) decision points, and decision criteria (usable by research, development, and extension field personnel).

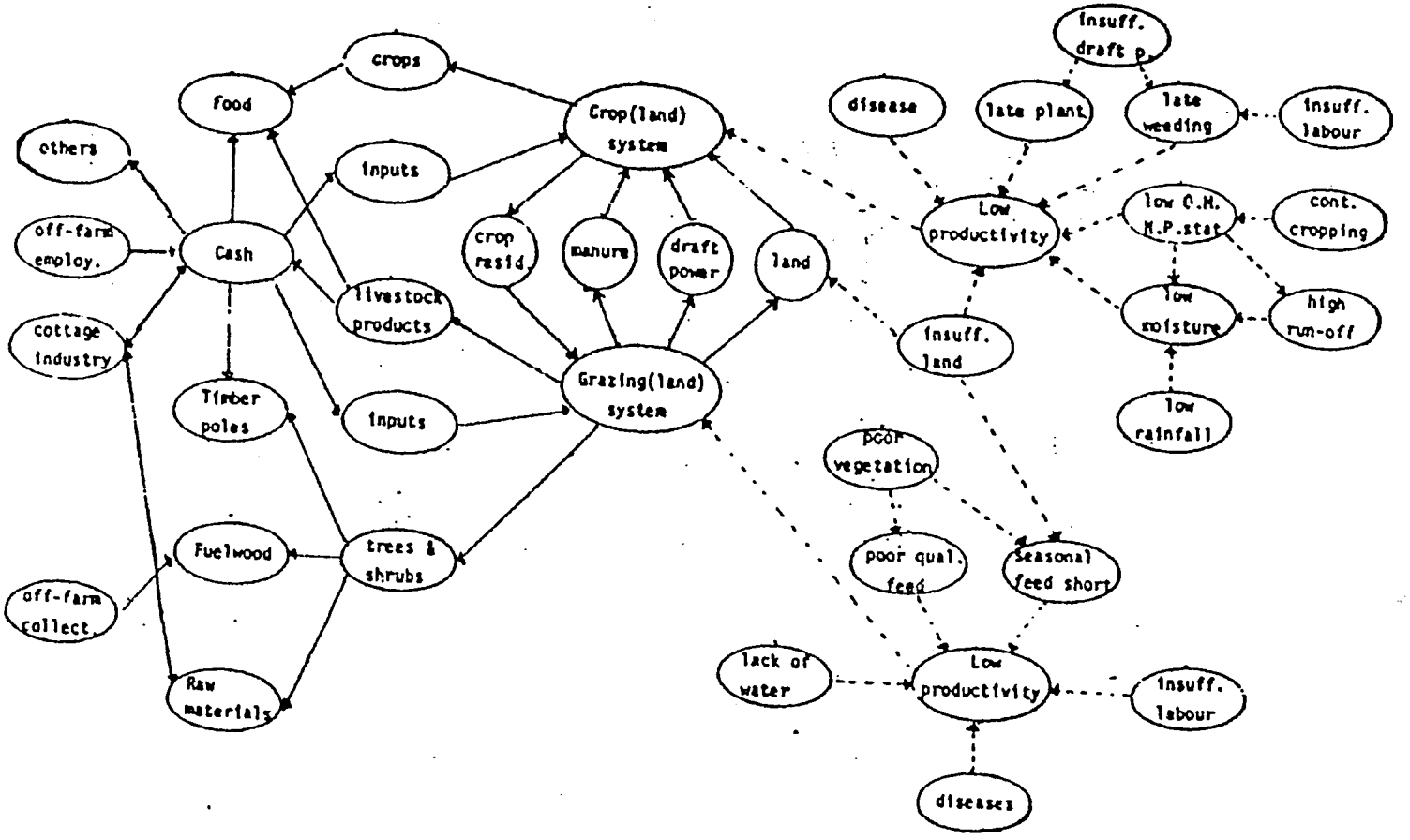


Figure 13. Combined input-output and causal factors diagram (small farms). Unbroken lines (———) indicate the flow of inputs and outputs within the farming system. Broken lines (- - -) indicate the chain of causal influences responsible for diagnosed problems.

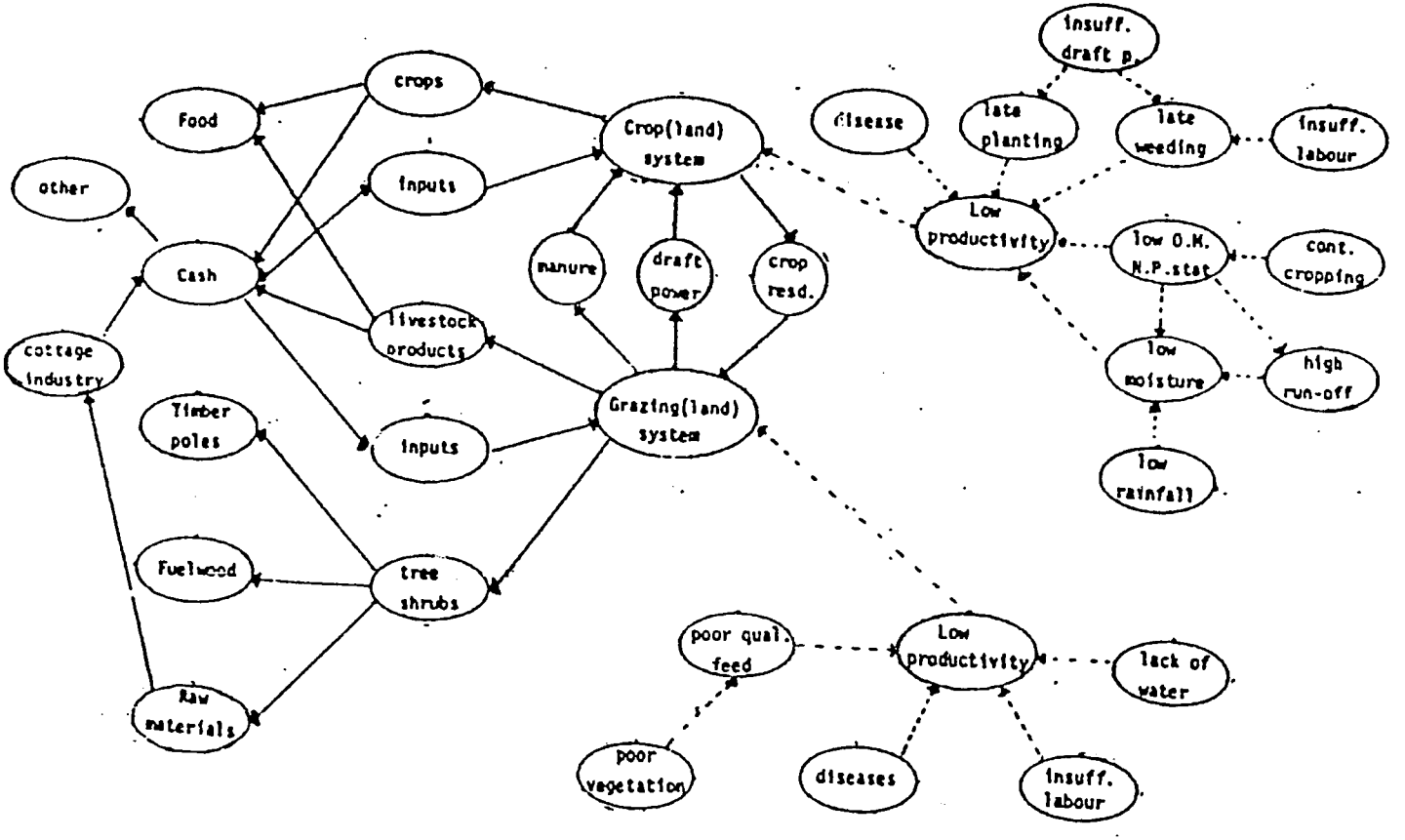


Figure 14. Combined input-output and causal factors diagram (large farms). Unbroken lines (——) indicate the flow of inputs and outputs within the farming system. Broken lines (- - -) indicate the chain of causal influences responsible for diagnosed problems.