SMALL GROWER COMMERCIAL TIMBER SCHEMES IN KWAZULU

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EXECUTIVE SUMMARY

Since 1983 more than 3 800 Black farmers have joined, under contract, the small grower commercial timber schemes administered by SAPPI Forests, Mondi Timber and Lima Rural Development Foundation.

The aims of this report are to examine costs and benefits associated with these schemes, and to provide guidelines for developing the small grower industry in a way that is both economically viable and socially acceptable.

Data were collected in 1992 from discussions with foresters, secondary information provided by the companies, a household survey of 80 growers and 31 non-growers in nine tribal wards of KwaZulu, and group meetings with community members.

Benefits of the schemes

Schemes provide farmers with timely inputs, a secure market, capital and technical expertise. The companies operate in isolated and neglected rural areas and, unlike state extension departments, have a vested interest in seeing that woodlots are successfully cultivated and profits are acceptable to farmers.

Advance payments allow even those farmers with meager cash incomes to participate. Women appear to be able to participate in the schemes on an equal footing with men.

Costs of inputs are low relative to most other cash crops, However, the relatively long time taken to reach maturity increases risks of loss by fire or drought.

Woodlots do not appear to compete seriously for household resources (arable land and labour) but rather rationalize the farming system by diversifying risks and spreading labour inputs more evenly through the year. They are also a rational enterprise for marginal (especially steep) lands.

Costs of the schemes and associated guidelines for future development

The proposed expansion of woodlots within land allocations may reduce food production in the future. Some woodlots have been planted on arable lands which are suited to the production of

more profitable cash crops. Once trees are established, costs of destumping will prohibit farmers from switching to these crops.

There is a need for a comprehensive map of recommended land use systems in Natal / KwaZulu, giving the relative profitability of each system. This should be undertaken by the Department of Agriculture. Recommended crops should be actively promoted with adequate support for supply inputs and marketing.

Existing hydrology guidelines are inadequate (particularly with regard to stream runoff in mini catchments), and largely ignored by farmers and the timber companies.

There is a need for guidelines to estimate the effect of afforestation on stream runoff in mini catchments in the Bioclimatic Regions of KwaZulu. Some of the cost of researching these guidelines should be borne by Timber companies under their environmental conservation budgets. Academic institutions (e.g. Department of Agricultural Engineering, University of Natal) have the capacity to perform this research. Water demand and stream flow should be calculated for the critical winter months under various percentages of afforestation. Afforestation should not proceed beyond the proportion which causes stream flow to drop below expected offtake, unless the forestry companies supply residents with earth dams. As afforestation effects hydrology beyond the boundaries of individual farms, it is justifiable to enforce hydrological recommendations by law.

Profitability of woodlots in some areas is questionable because schemes have been promoted in areas too far from the pulp mills, promises have been broken regarding the provision of access roads to woodlots, poor site preparation, fire, drought and livestock damage have reduced yields among many woodlots, and private contractors have on occasion charged excessive fees.

Every attempt should be made to increase final yields without increasing the level of inputs. The use of clones and higher levels of fertilizer may be justifiable. Advance payments should be manipulated to allow more hired labour for site preparation and making firebreaks. Payments should be made immediately after the work is completed to facilitate hiring labour.

Access roads should be built by the companies to all woodlots Alternatively, trees should not be supplied to farmers who intend to plant on highly inaccessible land. Costs of transport and expected profits under conservative yields should be calculated by companies before expanding into areas far from mills.

Government subsidy should be given for the transport of trees from the inland areas which have in the past suffered more than the coastal areas from lack of development initiatives and infrastructure. This may also help promote rational land use on steep slopes.

Companies should negotiate with large contracting firms for cheap transport. Where local contractors are operating, farmers should be informed of reasonable prices for felling and transport. Aspirant contractors should be provided with training in skills needed for this task (felling and business management). Collection depots and rail transport should be provided to growers where possible.

Expectations of profits are unreasonably high in places.

A comprehensive system of receipts and balances owed with realistic estimates of final profits is needed for farmers to make informed decisions about increasing areas under trees, replacing existing crops or hiring labour.

The terms of contract have never been negotiated with farmers and some clauses may be harmful to future development of the small grower industry.

Terms of contract need ultimately to be negotiated by growers. As an interim measure aspects of the contract should be reviewed by independent parties (e.g. Legal Resources Centre) and recommendations enforced by government legislature.

Farmers associations are weak and presently under the control of the companies.

Growers associations should be encouraged by external organizations which have personnel with the capacity and experience to work with these associations (e.g. TATU). Their functions should be expanded beyond merely facilitative actions (communication and solving disputes). Growers associations should aim at negotiating new terms of contract, and forming cooperatives to transfer ownership of the schemes into the hands of farmers. Funds to develop associations should ideally be collected from growers, timber companies and Government.

The schemes have caused tensions particularly amongst communities with a past history of land dispute, where rapid expansion has taken place (often under pressure of annual targets), and where companies have embarked on an aggressive promotion policy.

Companies should proceed slowly with expansion in new areas (relying on word of mouth from farmer to farmer to promote enrollment). Extension efforts should concentrate on skill transfer to existing growers rather than active promotion.

Most block plantings have proved unpopular with local residents since land is reallocated to relatively few beneficiaries, non-growers lose access to communal grazing and youth become concerned about space for the establishment of new households. Block planting may also result in elitism as the politically powerful are more likely to procure land than other members of the community.

Trees should only be grown on land already allocated to households, block plantings should be avoided unless the majority of those using the designated communal land will remain beneficiaries after the scheme has been introduced (Lima has not encouraged block planting).

SMALL GROWER COMMERCIAL TIMBER SCHEMES IN KWAZULU

1. INTRODUCTION

Since 1983 more than 3 800 Black farmers have joined the small grower commercial timber schemes administered by SAPPI Forests, Mondi Timber and Lima Rural Development Foundation (a non government organization contracted to SAPPI). Farmers join the schemes under contract and are provided with technical assistance, subsidized inputs and loans for the establishment and maintenance of small *Eucalyptus grandis* plantations. The average size of these plantations is 1,2 hectares. Trees are planted in plots on land allocated to individual homesteads or in large blocks on land previously allocated for communal grazing. Individual farmers have rights to plots within these blocks. After a growing cycle of either six years (coastal areas) or eight years (inland areas), the timber companies expect to purchase all trees subsidized by the schemes and they retain first rights to the coppice. The cost of loans and certain inputs are then deducted from the gross profit paid to the farmers.

The schemes inject capital into under developed areas and provide farmers with timely and appropriate inputs, professional advice, an assured market and local employment spinoffs.

In return, the timber companies gain free access to land close to their mills. Responsibility of labour management and certain production risks are delegated to the farmer, the risk of expropriation of land is reduced and the public image of the companies is enhanced.

However, problems in the small grower industry have not been fully resolved (A'Bear, Friedman and Pollet, 1991; Friedman, 1991). The schemes have been unpopular in certain areas of KwaZulu where several hundred hectares of block plantings have been burned or uprooted.

Furthermore, although tribal authorities have generations of experience in land use planning and control, a host of new issues arise from the introduction of a perennial cash crop such as timber. Procedures to resolve conflict between timber growers and stock owners, or between individual growers (whose land rights borders become crucial) have not been entirely successful. The welfare of communities may be adversely affected if timber begins to compete with food crops for arable land and household labour. Local elites may dominate the industry, causing social instability and poverty in the long term. Future expansion needs of new households, particularly those of the younger generation are ignored.

Despite the injection of capital that the schemes provide, there are no mechanisms to encourage integrated development planning to deal with issues such as funding community projects (schools, boreholes, dams, roads) from woodlots, mixing commercial and subsistence woodlots, agro-forestry and reducing the export of raw products from the community.

There is no legal aid to assist communities in negotiating terms of contract. There is presently no form of insurance available to small growers. Companies also have problems finding responsible signatories, particularly where communal blocks have been planted.

The aims of this report are to examine costs and benefits associated with the schemes, and to provide guidelines for developing the small grower industry in a way that is both economically viable and socially acceptable.

2. RESEARCH METHODOLOGY

Data were collected from:

i) participation in early discussions regarding the introduction of the schemes between a local community in the Nkandla district and a company forester (current drought curtailed further activity by the company in this area);

ii) a household survey of growers and non-growers living in nine tribal wards in KwaZulu;

iii) community meetings in four districts of KwaZulu;

iv) discussions with company foresters; and

v) a review of secondary data provided by the companies.

The household survey included a two stage cluster sample of 62 growers and 31 non-growers from nine clusters in KwaZulu. Growers were grouped into thirty eight regions (sub-wards) from lists provided by the timber companies. Eleven of these regions were then selected at randomly. Two areas (north of Richards Bay and west of Mandini) were later excluded from the sample because of violence in those places. Seven growers and three non growers were selected at random from each of the nine remaining areas.

Twelve growers in the sample had already harvested their trees. A further 18 households who had felled trees, were forced into the sample. These households were randomly selected from lists supplied by foresters.

Descriptive statistics in this report apply only to those households which were selected from the original two stage cluster sample (n = 93). Multivariate techniques (regression and factor analyses) apply to the total sample (n = 111). Statistics concerning the profitability of trees apply to those households who had felled their trees (n = 30). Plantation areas and planting dates were derived from total population data supplied by the companies (N = 3 862).

Certain valuable insights were provided by foresters during a course on communication skills which was organized for a timber company by the Centre for Adult Education of the University of Natal.

The ACRU agro-hydrological model was used to evaluate the effect of afforestation on runoff and groundwater at two sites in KwaZulu. This work was subcontracted to the Department of Agricultural Engineering of the University of Natal.

3. RELATED THEORY

3.1. Historical context in South Africa

Gandar (1994) reports that the first woodlot to provide firewood and building material for rural Blacks was established in 1893 near King Williams Town. Woodlot development continued especially along the eastern seaboard, driven primarily by environmental concern. These fell into four main categories, Traditional Authority (TA) woodlots, institutional woodlots (under the control of the state or a parastatal), private woodlots (grown by homesteads), and farm woodlots (grown by farm labour).

Bembridge (1989, cited in Gandar) recounted generally poor management of TA woodlots, which was concentrated on control of access, collection of revenue, and maintenance of fences but neglected silvicultural practices. Local people were often confused about the status of these trees with regard to ownership and maintenance.

Institutional woodlots were normally established to provide firewood for small towns, or to provide an alternative source of wood near protected indigenous forests. Management of these woodlots was generally better, from the point of view of a silviculturalist. However, ownership was taken entirely out of the hands of local farmers. A nominal rent (Gandar reports R2/ha per year in Lebowa) was paid for land and the state appears to have the right to operate indefinitely in many of these woodlots.

Small homestead woodlots date back at least 60 years. Sizes generally range from 0.1 to 2 hectares. Establishment and management are entirely in the hands of the family. Cattle are often used to prevent the spread of these trees. In KwaZulu / Natal about 2000 private wattle growers have registered as bark producers. Their woodlots are generally 1 to 5 hectares in size.

Labourers have access to fuelwood on about 20% of white owned farms. These woodlots are usually 10 ha or less in size.

In 1986 the Local Energy and Forestry Programme (LEAF) was initiated in the Transkei. Under the auspices of this programme the Transkei Appropriate Technology Unit (TATU) was to test and develop approaches to community based projects. It was the first time that social forestry had been incorporated into a large scale programme. TATU aimed to build capacity of local committees to make decisions and solve problems. However, these committees lacked

authority and decisions concerning woodlots were often frustrated by Tribal Authorities. The community woodlots were also hugely expensive with hidden costs in time and travel of extension staff. They have also not proved to be self propelling so far.

Gandar reports a growing disillusionment with woodlots in South Africa in the latter half of the 1980s. "By 1990, woodlot development was virtually at a standstill apart from the conspicuous exception of the small grower schemes in KwaZulu" (Gandar, 1994).

3.2. Small grower timber schemes in the context of contract farming

In contract farming, a relationship develops between private firms (agribusiness) and the small farmer in which "the firm replaces or supplements company production of agricultural commodities with purchases from farmers through contracts. The contracts specify several conditions of sale and obligate the firm to provide technical assistance, agro-chemicals and other services" (Glover & Kusterer, 1989). The logic is basically to allow growers an assured market for their produce and firms an assured volume of material of consistent quality. This system has long been practiced in developed countries where it accounts for about 15% of agricultural output. A large number of contract farming enterprises have been initiated in less developed countries. Since 1965, many of these schemes have received assistance from the United States Agency for International Development (USAID) in accordance with its policy of working with the private sector to promote rural development.

3.2.1 Possible advantages of contract farming

There has been a polarization of approaches to contract farming. Advocates promote it as a "dynamic partnership" between agribusiness and small farmers which acts as a primary agent of change in less developed countries and brings substantial benefits to both parties (Williams and Karen, 1985). Table 1 shows the possible advantages of contract farming to agribusiness and growers.

Table 1 Possible advantages of contract farming to firms and growers (after Glover & Kusterer, 1989)

Advantages to firms	Advantages to growers
Assures volume	Assures market
Allows a degree of control over production quantity and quality	Establishes channels to international markets which are usually inaccessible to peasant farmers
Provides access to free land	Provides timely and appropriate input supplies and specialized extension (firms have a direct interest in seeing that inputs are used efficiently)
Delegates responsibility of labour management to farmer	Provides access to credit to cover expenses
Allows utilization of cheap forms of labour, which are not usually accessible (such as school children)	Crop may sometimes be used as a collateral for long term loans
Lessens risk of expropriation by locating fewer assets within the host country and contributing to formation of alliances with local businessmen who may defend the firms interests	May provide spinoffs to the local community by creating subsidiary employment opportunities
Permits maximization of economies of scale at each stage of the production process (by sub-contractors)	
Enables the firm to draw on specialized expertise of sub-contractors	
Promotes public relations and presents a progressive image	

3.2.2 Possible disadvantages of contract farming

However, critics claim that contract farming diverts resources from staple foods to cash crops with an inevitable reduction in nutrition (Lele, 1975) and that it promotes inappropriate technologies and risky farming systems (Feder, 1977).

Others argue that historical and political circumstances may leave few economic options for peasant farmers. Contract production often appears not as a choice but as a necessity. What follows is the inevitable subordination of peasant farmers to the interests of agribusiness. This occurs for a number of reasons.

First, peasant farmers are rarely able to negotiate the terms of contract. "Outgrowers may appear to have more independence than wage earners, owning their own means of production, and controlling their own labour. But their negotiating position with the company that controls access to the productive inputs and markets for the crop is weak. Smallholders often have almost no control over the terms of contract, are rarely collectively organized, and have no claim to minimum wages or adequate working conditions" (Heyer & Williams, 1991).

Second, outgrower schemes free agribusiness from labour management and "shift both risk and hazards of seasonally uneven labour requirements onto the contract farmer ... the costs of supervision ... are substantially reduced ... The farmer's labour may include both family labour and labour hired on advantageous terms which only a peasant can obtain ... [furthermore] ... sanctions against child labour, whether legal or based on public disapproval, do not apply to ... contract farmers ... who make use of their children's labour" (Clapp, 1988).

Third, outgrower schemes transfer the major investment burden and risks of weather, insects, disease, and fluctuating market prices to the outgrower (Levin, 1988).

Fourth, agribusiness tends to control the most profitable sector - the marketing of agricultural commodities while restricting the outgrower to the production process (Neocosmos & Testerink, 1985 in Levin, 1988).

Fifth, agribusiness often maintains a monopoly on supplies and a monopsony on markets. Clapp (1988) argues that this is a deliberate strategy on the part of the company to enforce the

terms of the contract in countries where mechanisms of direct legal control are weak and unreliable. The result is that outgrowers are bound into a long term dependency on the firm.

3.2.3 Variables in contract farming

Vaughan (1992) points out that extreme polarizations in the approach to contract farming are not particularly useful since they "do not permit a serious consideration of the possibility of influencing this form of production through policy measures".

What is needed rather, is a rigorous assessment of costs and benefits. This approach recognizes that the character and direction of contract farming may vary considerably and that "there is considerable room for conflicts of interest, exploitation and bargaining, with internal dynamics changing over time" (Glover & Kusterer, 1989).

Important variables are:

i) the degree to which the firm maintains a monopoly on supplies and a monopsony on markets, which in turn determines the extent of long term dependency of the outgrower on the firm;

ii) the terms of trade specified in the contract itself, which may differ in terms of the allocation of risk between the firm and the outgrower and the intensity of control that the firm exerts over the production process (Glover & Kusterer, 1989); and

iii) individual policies of management and staff, which have been shown to significantly effect the practical implementation of schemes even where contracts are identical (Vaughan, 1992).

3.3 Small grower timber schemes in the context of social forestry

Over the last two decades forestry programmes in Third World countries have shifted in emphasis away from large scale industrial - commercial plantations which were aimed at earning revenue and foreign exchange. Instead programmes focussed on "community forests" which aimed to help rural populations meet their basic needs (fuelwood and building poles).

This marked the beginning of "social forestry" initially defined by the Food and Agriculture Organization as encompassing "any situation which ultimately involves local people in a forestry activity for the direct benefit of those people" (FAO, 1978 in Cernea, 1985).

Some basic changes in the orientation of forestry are shown in Table 2.

Table 2 Changes in the orientation of forestry (after van Gelder & O'Keefe, 1992)

Classical forestry	Social forestry
Works for the interest of the forest department	Works for the interest of rural people
	Forestry extension
Forest management	
Protects forests against rural people	Involves people in management of woody biomass in and outside gazetted forest areas
	Facilitates local tree regeneration
Seedling production and distribution	Total wood biomass management
	Multipurpose trees and shrubs
Plantation management	
Timber and pulp trees	Systems built on locally existing knowledge of tree and forest management
Standard forestry management systems	

However, many social forestry programmes have failed because of a marked lack of participation by local people. In consequence, social forestry itself, has evolved from a largely technical, sectoral, top down approach to a process which attempts to consider the entire production system and build on the existing skills, knowledge and needs of local people. Several experiences of social forestry programmes may be pertinent to the future development of forestry schemes in KwaZulu.

3.3.1 Units of social organization

Of direct relevance to the small grower industry, are the attempts of social foresters to identify "units of social organization" in a community which are capable of sustaining a forestry plantation.

3.3.1.1 Community woodlots

"Until recently, the community woodlot has been widely accepted as the dominant model in social forestry ... Successful village woodlots in countries such as China and Korea, which had been supported authoritatively by the government, lent credibility to this approach" (Cernea, 1985). It was assumed that communities would act to influence their members to plant, mobilize labour, promote self help, collectively protect the plantations and ensure wide distribution of benefits.

However, attempts to replicate the Chinese and Korean programmes in Ethiopia, the Philippines, India, Tanzania and the Niger proved unsuccessful (Rao, 1980; Thompson, 1980; van Gelder & O'Keefe, 1992).

It is argued that problems arose from false identification of community units. Sociologically the term implies both residence within a defined area and common goals and purposes. However:

i) the interests of community members often differ to such an extent that unified action is impossible;
ii) communities are often split and stratified and unable to sustain large long term projects;
iii) where woodlots have been harvested and the income invested for common benefit (schools, improved roads, water supply), the poor have not benefited greatly;
iv) the tenure status of community land is often uncertain; and
v) communities lack grass root organizations to produce jointly (Cernea, 1985).

3.3.1.2 Family woodlots

In later projects in India, Nepal, Mali and Haiti, community woodlots have been either excluded from forestry projects or included merely for their demonstration effects. Projects focused instead on the individual farmer or family unit which "vests the management authority over the tree plantation in a real person rather than in a diffuse, amorphous entity ... For the

farmer the correlation between his inputs (labour or cash) and the output becomes direct, understandable, proportionate and less risky" (Cernea, 1985).

However, it is simplistic to assume that even the family unit has common goals. A migrant worker may decide to plant a large portion of his land to trees leaving insufficient space to provide food for members of his household who remain at home. Household heads sometimes overlook their sons' needs for future expansion. Women often do the major portion of work in the plantations while their husbands collect the profits. Forests may cause local streams to dry thereby increasing the workload of family members responsible for water collection.

3.3.1.3 Associations

Associations have been successful in supporting reforestation in certain provinces of Pakistan. Cooperatives are each responsible for managing a minimum area of 200 hectares in accordance with a plan approved by the Forest Department. They receive technical assistance, credit and the services of field officers. However, all other costs (nurseries, replanting, maintenance, extraction, transport) are borne by the cooperatives themselves. For this purpose they retain a minimum of 40% of revenue from the sale of trees (Cernea, 1985).

3.3.1.4 Other interest groups

Cernea (1985) mentions a number of other units of social organization.

Small groups for instance, may be "free from the inner conflicts of large communities, yet able to generate the synergy that makes groups more effective than the sum of their members" (Cernea, 1985). In West Bengal, groups of landless households were given usufruct of marginal public land for tree planting. There is tight group control over temptation to change land use or mortgage land. The area planted guarantees enough wood from offcuts to meet domestic requirements. The stem volume is then available for sale. Incentive payments are made to assist families during the early stages of the plantation.

Women's groups are not commonly involved in forestry. However, given the enormous time spent by women in fuelwood collection it may save an enormous amount of time to produce wood rather than to collect it. Furthermore, in the light of the feminization of poverty in rural areas, these groups may help to retain the control of farm resources and revenue in women's hands.

School children have successfully contributed to forestry projects in Kenya, Gujarat, Malawi and Haiti. "Although the nature of this age group limits its use for activities of long duration, it is perfectly suitable for short term, technical processes in forestry, such as the establishment of nurseries and the production of seedlings" (Cernea, 1985).

3.3.2 Trees as a livelihood strategy

Chambers and Longhurst (1986) note that trees play a significant role in the livelihood strategy of the rural poor.

Trees moderate climatic effects reducing wind speed and moisture losses. They provide leaf litter, shading and humidity which stabilize or improve crop yields. Composting and mulching can improve soil fertility. Shade is extremely important for both humans and animals in hot climates.

Trees often have different planting, weeding and harvesting cycles from those of annual crops, spreading labour demands more evenly throughout the year. Trees often produce edible fruit out of the annual cropping season, providing essential vitamins when most needed.

Trees which can be cut and sold are good savings banks and insurance for poor people (Table 3). They can be used to raise money to deal with contingencies through the sale of firewood, timber or charcoal. They can also sometimes be pledged or mortgaged.

Table 3 Some assets of the poor: costs; risks; and benefits compared (after Chambers & Leach, 1986)

Value	Jewellery	Large stock	Small stock	Land	Bank Deposits	Trees
Costs						
Starting costs	-	-	0	-	0	+
Maintenance costs	+	-	-	-	++	+/-
Risks						
Disease, drought	++	-	-	+	+	+/-
Theft	0	-	-	+	++	+/-
Benefits						
Rises fast in value	0	+	+	+/0	-	++/0
Stores well	++	-	-	+	++	++
Easy to transport	++	+	+	0	++	-
Regenerates after disposal	-	-	-	-	-	+/-

- negative feature of asset
+ positive feature of asset
0 neutral feature of asset
/ feature depends on circumstances
0 feature not applicable

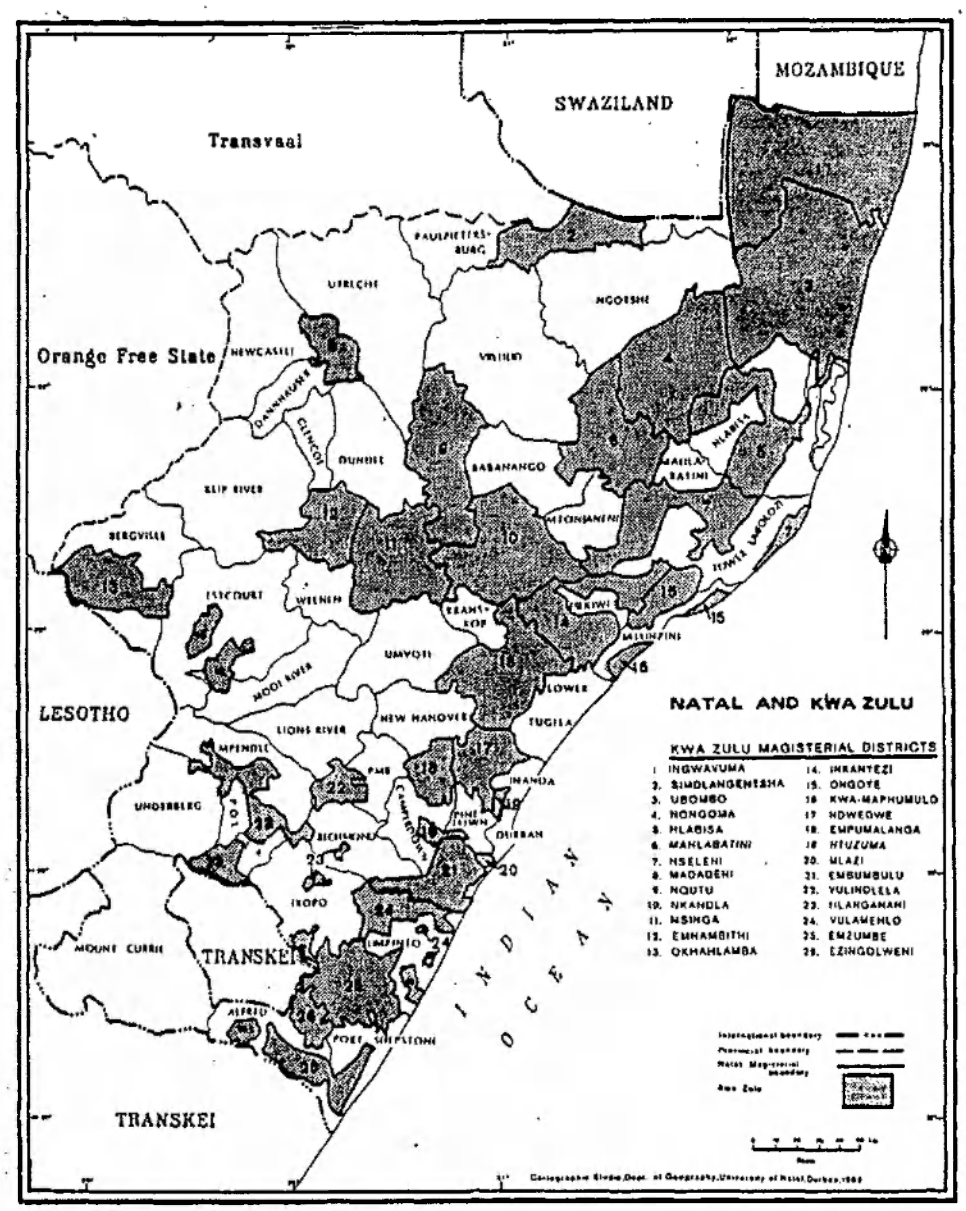
Trees are most effective as a livelihood strategy when:

i) a mix of species is cultivated (trees for fruit, fodder, shade, firewood, timber);
ii) they are grown as an integral part of the farming system (intercropped to prevent soil erosion, provide mulch and shading, reduce wind); and
iii) they may be harvested at any time in order to meet contingencies.

4. DESCRIPTION OF THE TIMBER SCHEMES

4.1 Scope of operations

The promotion of commercial woodlots in KwaZulu was initiated in 1983 by SAPPI in the areas surrounding their pulp mill at Mandini. Since then, over 1300 farmers have joined their "Project Grow" scheme which now operates in the Ingwavuma, Ubombo, Hlabisa, Nseleni, Inkanyezi, Ongoye and Maphumulo districts (Map 1).



Map 1 Map of KwaZulu / Natal

In 1987, Natal Tanning Extract (NTE) established a small growers scheme at the Biyela Integrated Rural Development Project near Nkwaleni which is run by the Institute of Natural Resources (INR). Their methodology was closely based on SAPPI's "Project Grow". There were 115 farmers growing commercial plantations under this scheme in 1990 when NTE was consolidated with Mondi.

Mondi initiated the "Khulanathi" small growers scheme at Mfekayi in 1988. The scheme aims to supply Mondi's pulp mill at Richards Bay. The main area of operation is now in Ubombo where Mondi hopes to establish 500 hectares of commercial woodlots per year. In 1990 Mondi commissioned a hydrological, biotic and socio-economic report on the effects of forestry in that area. Khulanathi also operates in Hlabisa, Nseleni, Ongoye and Nkandla. By 1992 the scheme had more than 1100 members.

Since 1989, SAPPI has contracted Lima Rural Development Foundation to recruit timber growers in the southern parts of KwaZulu. By 1992, more than 1600 farmers from the Emzumbe, Vulamehlo, Ezingolweni and Embumbulu districts had joined the scheme. The KwaZulu government has undertaken to build access roads to all plots in this scheme. These farmers will transport their harvest to the SAPPI pulp mill at Umkomaas.

Although the area under the small grower schemes is small relative to the area owned by the timber companies (less than 0,5%), growth rates of the schemes are rapid (Figure 1).

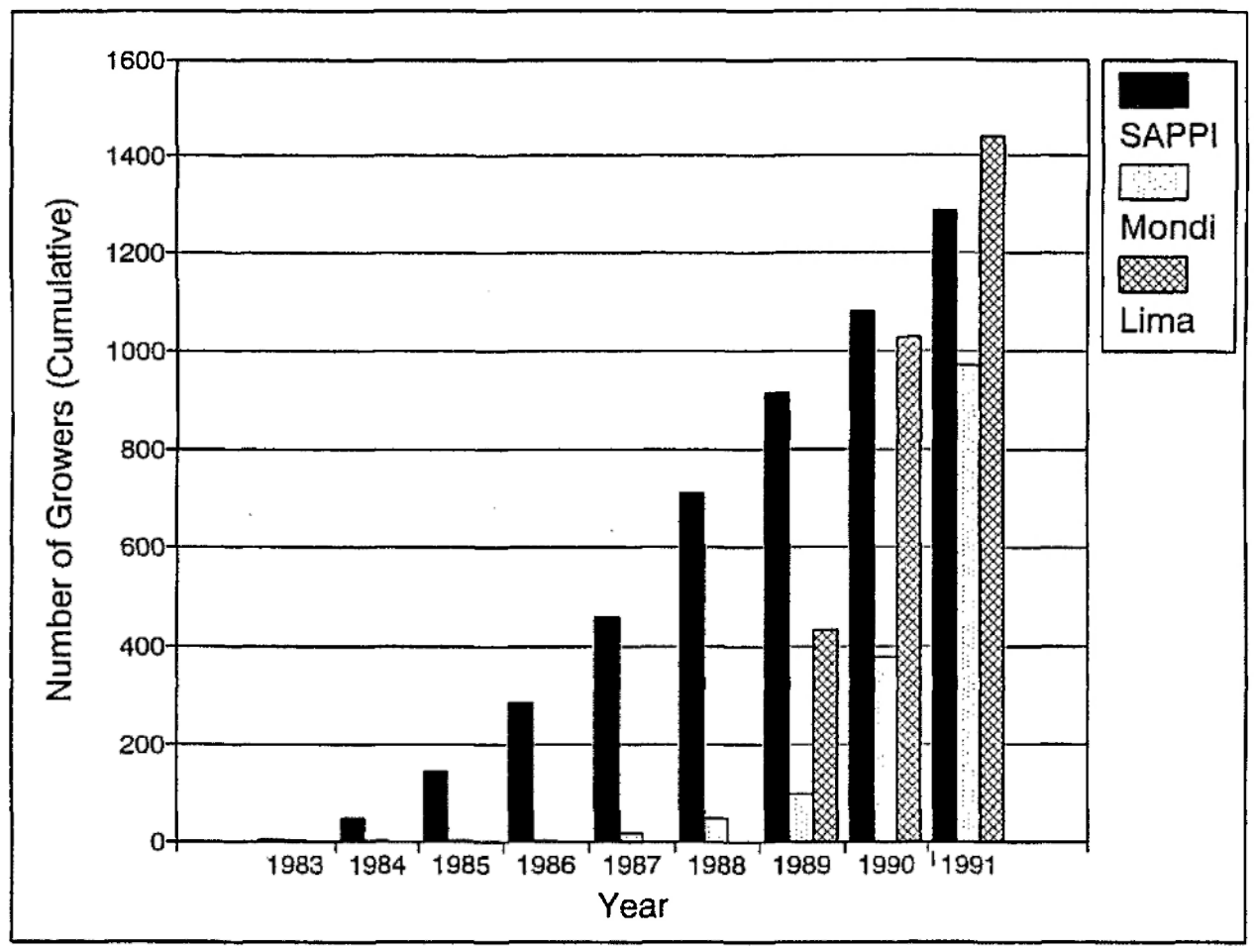


Figure 1 **Cumulative total growers by year (n = 3 862)**

4.2 Extension approaches

Mondi's Khulanathi is more commercially orientated than competitors. Membership is aggressively sought through Tribal Authority meetings and farmers days and annual planting targets are set to justify the expense of a relatively large field staff.

Mondi has also embarked on block plantings over fairly extensive areas in Ubombo and Nkandla. Most of these plantations have proved unpopular with local residents since large tracts of communal grazing land have been reallocated to relatively few beneficiaries. Young residents also lose access to land for the establishment of new households. SAPPI has also experienced difficulties in attempting to establish a large plantation in the Amatikulu area of KwaZulu.

Mondi also promotes higher levels of inputs (clones rather than seedlings, increased fertilizer and intensive site preparation), and interest is charged on loans. Risks for Khulanathi members are therefore higher but it is probable that profits from these woodlots will be greater than those recorded in SAPPI areas, due to higher yields.

In contrast the SAPPI Grow scheme is operated as a social responsibility programme. Interest is not charged on loans, seedlings are provided free of charge and arrangements have been made by SAPPI for the sale of trees to Mondi in areas close to the Mondi mill. Promotion of the schemes has been relatively low key and adoption has been slower in areas surrounding the SAPPI mill.

Lima has adopted a flexible approach to plot sizes, encouraging growers to start with small plantations and then increase areas according to household resources. They rely on local growers to promote the scheme and assist new members. This has provided local employment but in cases lead to misinformation particularly with regards to expected profit. Lima has managed to reach very isolated farmers. However, access roads to some of their plots are non existent raising questions about the future feasibility of woodlots in these areas. On the other hand Lima has expertise to assist in the building of access roads. Lima also presents other enterprise options to farmers (fruit trees, irrigation schemes, vegetables) which may help ensure rational land use. Loan advances are low in comparison to SAPPI and Mondi making site preparation and fire protection difficult for households with small labour reserves (small families and pensioners).

4.3 Description of the contracts

In each scheme the relevant timber company enters into a contract with individual farmers (or occasionally Tribal Authorities). In essence, growers are provided loans for the establishment and maintenance of small *Eucalyptus grandis* plantations. Permissible activities covered by payments are summarized in Table 4. However, farmers normally carry out only a subset of operations which includes marking, ploughing, pitting, planting, fertilizing, weeding and fire protection. Mondi also encourages manual watering and top dressings of fertilizer. The companies provide extension free of charge and fertilizer at bulk cost price. SAPPI and Lima provide free seedlings and interest free loans. Mondi subsidizes the cost of seedlings by about R170 per 1000 trees and charges a simple interest of 10% on loans. All schemes pay an annual advance if operations are carried out satisfactorily.

In return the companies expect to receive the harvest from all trees subsidized by the schemes after a certain period (six years in coastal areas and eight years in inland areas).

A comparison of 1992 payments is given in Table 4. It is apparent that Mondi subsidizes their scheme to a greater extent than SAPPI or Lima. By doing this, Mondi assumes greater risk and intervenes more in the seasonal operations with the hope of generating higher yields.

Table 4 A comparison of the three schemes 1992 payments to small grower farmers

Activity	SAPPI (R/1000 spots*)	Mondi (R/1000 spots)	Lima (R/1000 spots)
Cost of seedlings	free		free
Cost of clones		165,00	
Marking		13,00	
Pitting	57,90	13,00	40,00
Planting	15,20	32,00	14,19
Blanking		32,00	
Manual watering		19,00	
Tractor watering		60,00	
Fertilizer	at cost	at cost	at cost
Fertilizing (at planting)	14,20	19,00	9,35
Fertilizing (4:1:1)		19,00	
Fertilizing (at 3 months)		19,00	
Fertilizing (agrofert)		19,00	
Spot weeding	21,10	40,00	28,31
Inter row weeding		40,00	
Fire protection	37,60	30,00	21,12
Ploughing & 2 discing	109,60	250,00	
Chemical weeding	93,90		
Destumping manual		15,00	
Coppicing	88,80	30,00	
Brashing		13,00	
Bush clearing	67,20	35,00	
Grass burning		10,00	
Burning tup		50,00	
Discing	36,60		
Advance payment	43,60	60,00	41,36

* **there are approximately 1754 spots (plantings) per hectare.**

4.4 Plot sizes

The frequency of plot sizes is shown in Figure 2. The median plot sizes are 2 200 spots (plantings of saplings) (SAPPI), 1 754 spots (Mondi) and 1 000 spots (Lima). Lima encourages farmers to begin with small plantations and expand if household resources are sufficient. The smallest plot size is 200 spots and the largest is 46 970. More than 70% of all households plant between 500 and 2 500 trees. Further summary statistics are given in Appendix A.

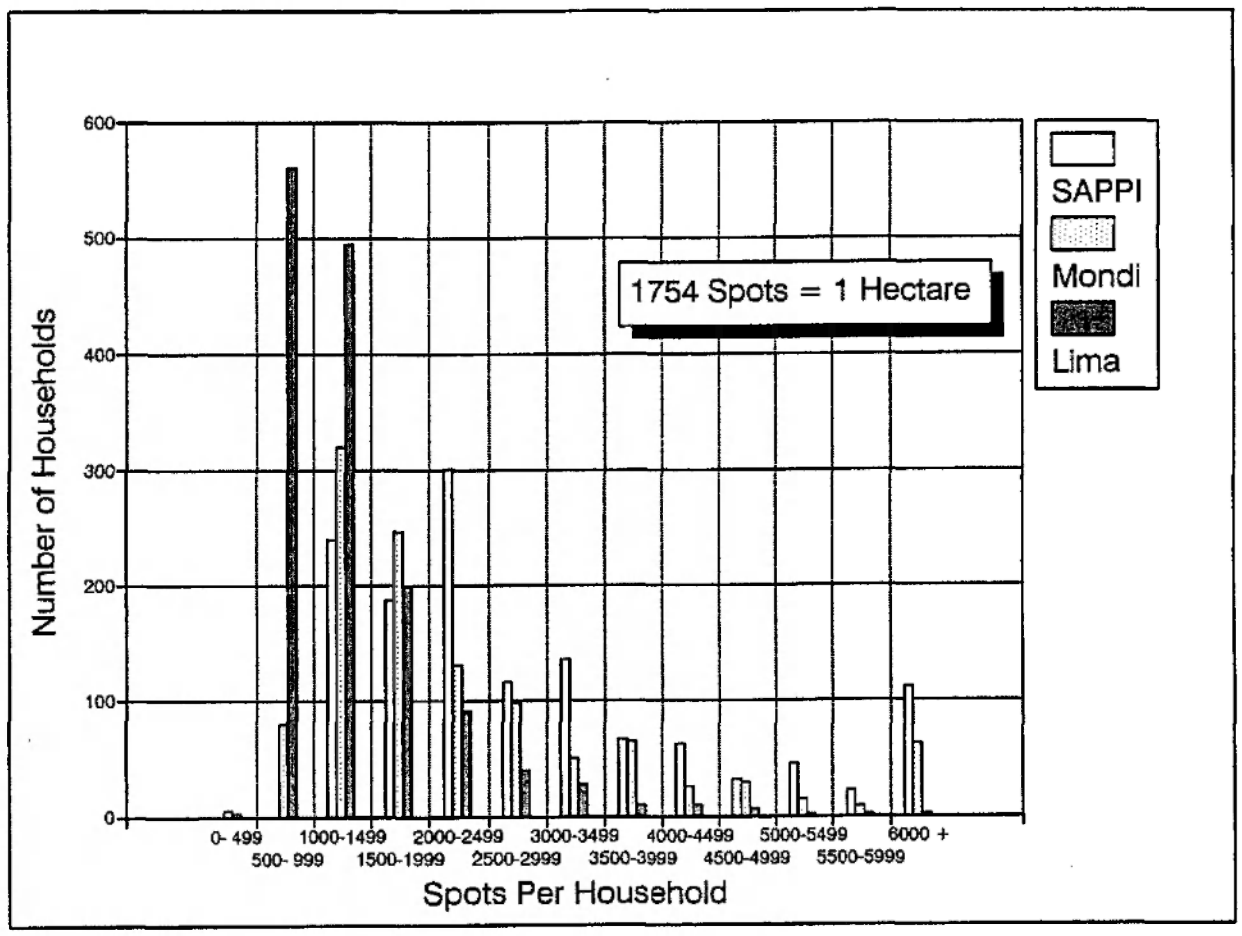


Figure 2 Frequency of plot sizes (n = 3 776)

4.5 Competition for land area

Figure 3 is a histogram of percentage total land allocation planted to trees. This is the amount of land under trees relative to cropping and grazing land allocated to the household. The average percentage of total land allocation under trees was 37%. About 77% of all households planted less than 50% of their total land allocation.

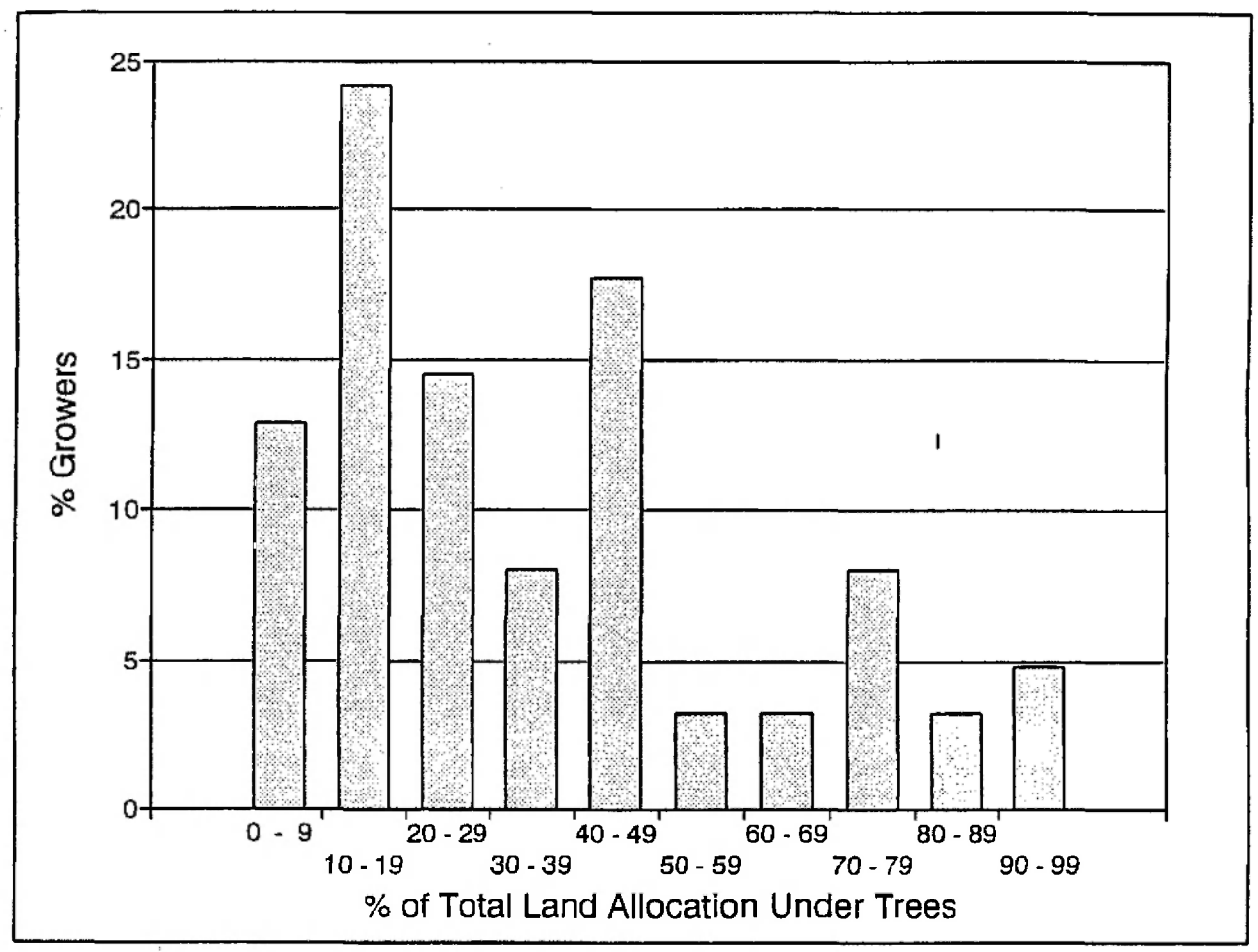


Figure 3 Frequencies of percentage total land allocation under trees (n = 62)

Figure 4 shows the previous land use of the total area under trees. Food crops (maize, sweet potatoes, beans, potatoes, groundnuts, *madumbes* and vegetables) were grown on roughly 20% of the total area. Cash crops (sugar and small areas of cotton) also covered 20% of the total area. The remaining area (60%) was previously grazing land.

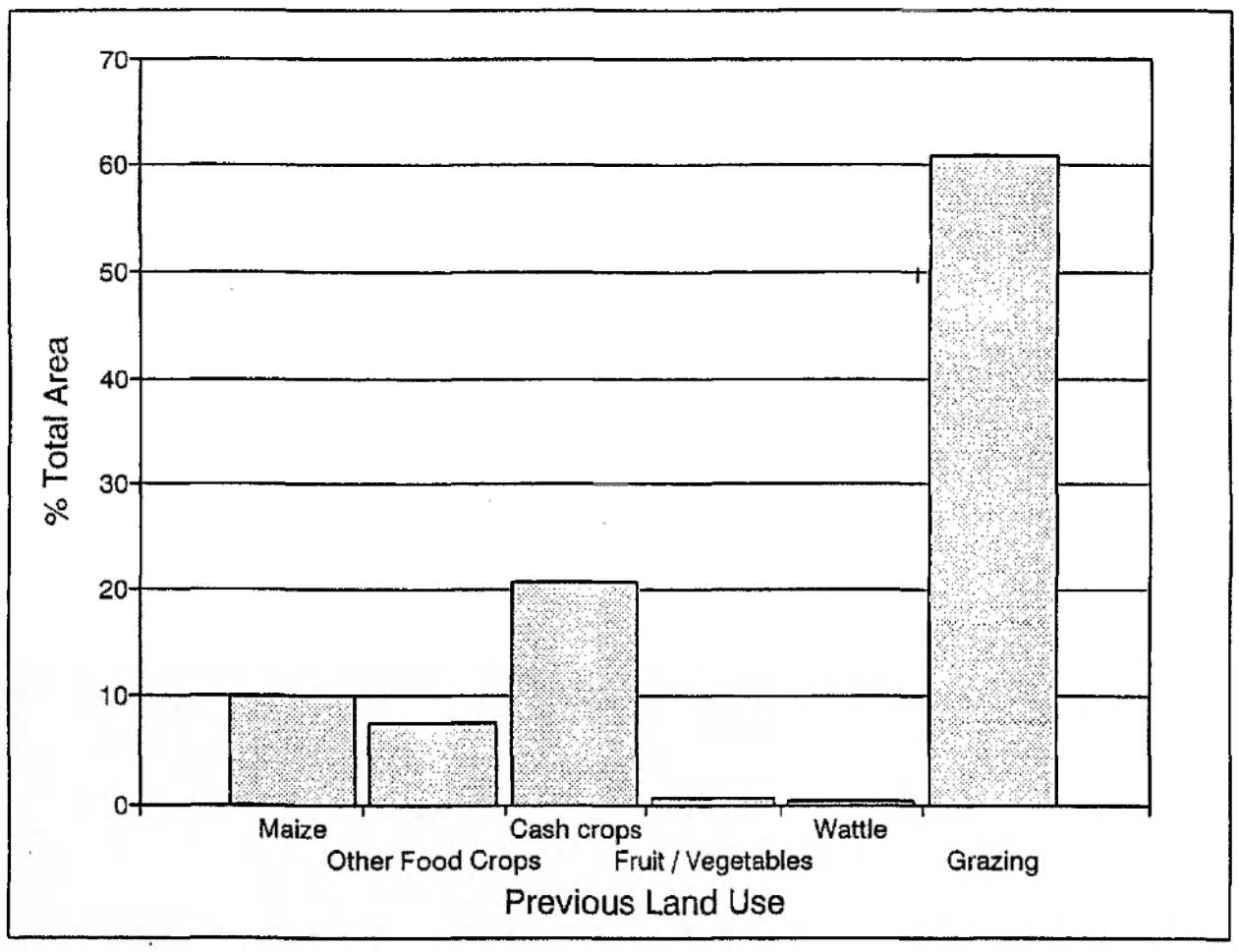


Figure 4 Previous land use of total area under trees (n = 62)

Trees may therefore pose a serious threat to food and cash crops. However, 60% of farmers who replaced crops with timber continued growing these crops on other fields. In these cases, trees further diversified their farming system.

Farmers who replaced their entire cash crop with timber complained that cash crop cultivation required too much work (sugar) or produced low profits (cotton). Farmers who replaced all their food crops with timber complained of the unsuitability of soils for food crops, soil erosion on steep lands, poor or no yields, susceptibility to drought or frequent stock damage. These farmers also wanted cash returns from their fields.

4.6 Competition for arable lands

The timber companies have undertaken a "gentleman's agreement" with the KwaZulu Government not to plant on land with a slope of less than 12%. The purpose is to ensure that lands defined as arable (Scotney, 1971) are kept available for food and cash crops. However, there is no legal compulsion for companies to observe this guideline and about one third (33,6%) of the total sample area under trees was planted on land with a slope of less than 12% (Figure 5).

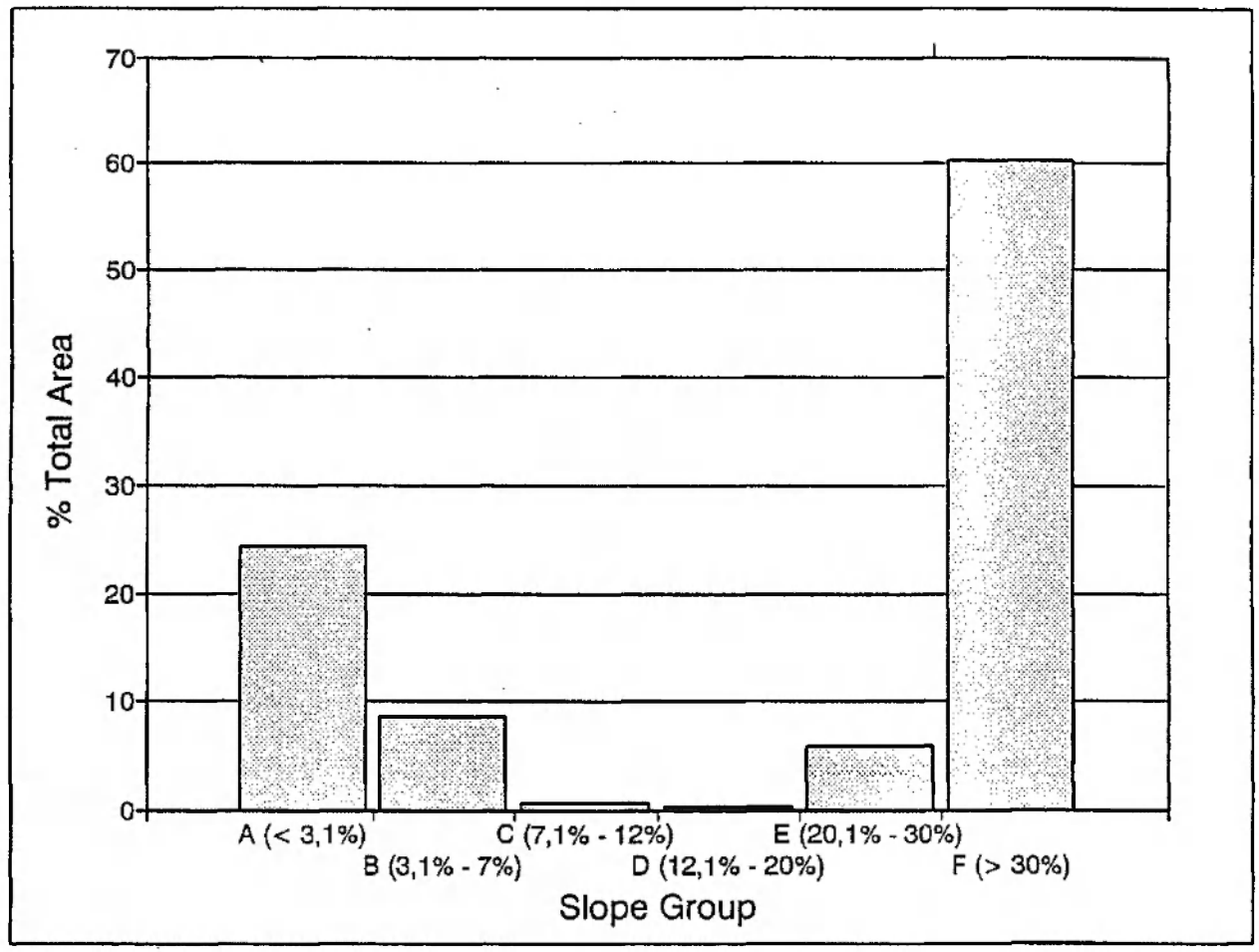


Figure 5 Percentage total area in various slope classes (n = 62)

This figure probably underestimates the total area of land with arable potential under trees, since more than 43% of all growers live in the flat coastal areas surrounding Richards Bay and Mandini.

However, soils in these areas are derived from the Berea System (Recent Sands) and are unsuitable for most crops due to rapid leaching of nutrients and aluminium toxicity in some

sites. Nematodes are a particular problem for sugar in soils of the Fernwood, Clansthal and Sandspruit series.

Furthermore, foresters pointed out the difficulties of refusing to plant on sites allocated for trees by the farmes. Enforced restrictions on land use which are based on considerations other than soil and water conservation pose a moral problem to agricultural planners since the final choice of cropping system must remain in the hands of the farmer.

What is needed is a rigorous mapping system which separates sites more suitable for other crops such as sugar from those suitable for trees. Farmers should be advised on the most suitable crops for their lands and given positive assistance in establishment and marketing. If alternative support structures do not match those offered by the timber companies, large areas of arable land in KwaZulu will be "lost" to trees.

4.7 Competition for labour

Planting may be spread throughout the year with peaks over spring and autumn occurring mainly in the inland areas (Figure 6). Firebreaks are generally maintained throughout the year. It is only weeding that competes with food crops for labour. Thus, the inclusion of trees in the farming system does spread labour requirements throughout the year.

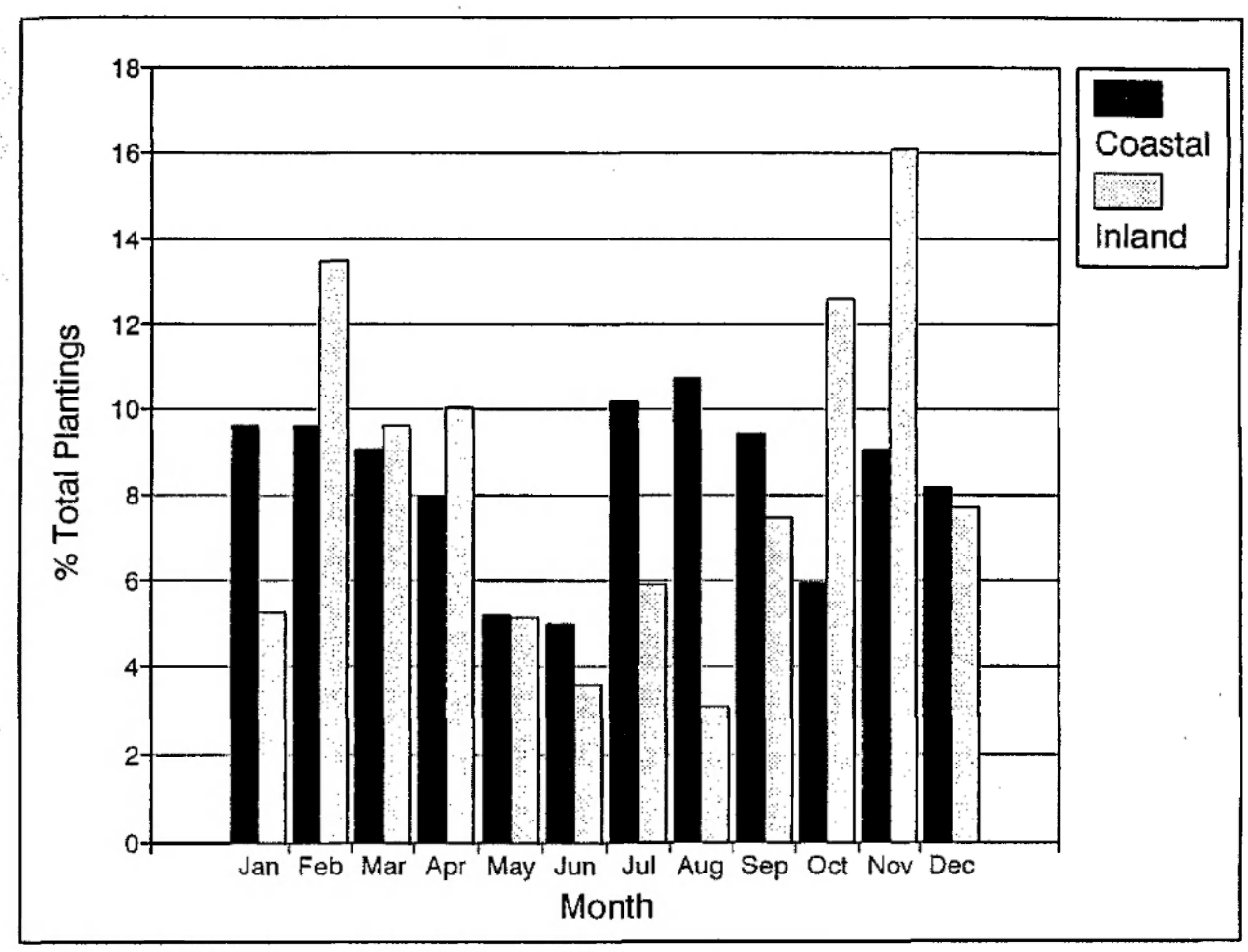


Figure 6 **Planting dates for coastal and inland areas (n = 3 504)**

4.8 Hydrology

The ACRU agro-hydrological model was used to determine the effects of afforestation on runoff and ground water at two study sites (Lorentz & Schultze, 1992; Kienzle & Schultze, 1992). Results are given in Appendix B, and summarized below.

4.8.1 Effects of afforestation on runoff

The model simulated streamflow at the outlet of a small (0.30 km^2) catchment situated 20 km northwest of Mandini. About 60% of the catchment is under Ngongoni veld (*Aristida junciformis*) and the remainder is under *Eucalyptus grandis*. Eleven households (approximately 143 people) draw water from this outlet.

Under 100% natural veld the mean annual steam flow is 93 600 m^3 while under *Eucalyptus* it is reduced to 43 700 m^3. During the critical winter months the long term reliable stream flow (flow during 90% of the time) is reduced from 400m^3 per month under veld to 100m^3 per month under timber.

Assuming that water requirements are 50 litres per person per day, a total of 214 m^3 of water are drawn from the stream each month. This means that the stream will provide sufficient water during 90% of the time providing the catchment is under natural veld. Under 100% afforestation a shortfall will occur during the critical winter months.

Dam storage would result in a minimum long term reliable withdrawal of 3 600 m^3 per month.

The model shows the significant effect of afforestation on runoff, particularly in small catchments where stream flow is likely to be highly variable. Stream flow is dramatically reduced in the winter months. However, water needs could be met with the provision of a small earth dam.

4.8.2 Effects of afforestation on ground water

The model was used to simulate ground water recharge under natural veld and afforestation in the Mfekayi area of KwaZulu. There has been a rapid expansion of forestry at Mfekayi and at present about 25% of the area is under *Eucalyptus* in a patchwork pattern. The remaining area is covered by natural veld, sugar and maize. A plantation exists immediately adjacent to at least one borehole.

It is predicted that 50% afforestation in a one hectare chessboard fashion will lower the general water table by two to five metres. At times of high water demand the water table will be lowered by as much as eight metres within the plantations causing lowering effects up to 150 metres from the plantation.

The report recommends that trees be planted a minimum distance of 200 m from boreholes, streams and wetlands. It suggests that a patchwork pattern of planting will be less detrimental than a single large plantation.

4.9 Grower characteristics

Characteristics of grower and non-grower households are shown in Appendix A. Possible discriminating characteristics of grower households were determined using a linear probability function and factor analysis (Appendix B).

Results show that households already dependent on agriculture or local employment are more likely to join the schemes than those dependent on migrant wages. These households are relatively wealthy in terms of land allocation, cattle and family labour, but are unlikely to earn a regular cash income from formal employment.

Pensioners, who may have political ties to the Tribal Authority and smaller land allocations are also likely to join the schemes. Pensioners are able to hire labour to perform the various operations.

Households with a high ratio of employed adults are unlikely to join the schemes.

Forty nine percent of all plantations were owned by women. Amongst male headed households (74% of the survey), 17% of the plantations were owned by women. In female headed households (26% of the survey) 100% of the plantations were owned by women.

4.10 External factors influencing the expansion of schemes

"Lateral filtration" is a strong factor in the expansion of the schemes. Roughly 60% of SAPPI and Lima growers joined the schemes after seeing neighbours planting trees. Only 40% joined after hearing about the schemes directly from the company forester or at a Tribal Authority meeting. (These proportions are reversed for Mondi growers, indicating the more aggressive

extension techniques used by this company). Almost 20% of non-growers stated that they would join the schemes if neighbouring growers reported reasonable profits after harvesting.

About 14% of all farmers had some prior experience with growing gum trees or had relatives working for timber companies. Growers who were the first to join the schemes in the sample target areas were all influential figures in their communities, either as religious (Shembe and Muslim) or political (Tribal Authority) leaders or as local businessmen (storekeepers).

4.11 Reasons for joining

The major motivation for joining the schemes (87% of growers) was to obtain cash at harvest. Thirteen percent of the sample joined to obtain the annual payments. Eleven percent joined in order to obtain wood for fuel, fencing and building, or to sell timber to neighbours.

Thus, the majority of growers understood before joining the schemes, that they would be required to sell their timber to the respective mill. Advance payments for labour inputs are not a major attraction.

4.12 Reasons for not joining

Fifty eight percent of non-growers were considering joining the schemes but were constrained by various factors. Shortage of land was given as the major cause of delay or reason not to join (Table 5). Other households were concerned about the profitability of trees, thought the growing cycle was too long or simply preferred sugar, vegetables or fruit trees. Stock damage, and community and family discord were also given as constraining factors.

Table 5 Reasons for delaying in joining / not joining the small grower schemes (n=30)

Reason for not joining	% Non-growers
Need to acquire more land	45
Want to know the exact profits from trees	19
The growing cycle is too long	16
Need to fence own cattle / would have to get rid of cattle	16
Prefer sugar	13
Do not know how to join	13
Afraid to plant because neighbours are burning forests	10
Prefer vegetables	10
Prefer fruit trees	3
Too busy with other crops	3
Need to consult absent family members	3
Concerned what would happen if timber companies no longer needed the trees	3
Trees die in drought	3
Once trees are planted you cannot change back to other crops	3
Too old to plant	3

4.13 Intended use of profits

Table 6 shows the intended use of profits.

Table 6 Intended use of profits (n=62)

Use	% Growers
Build house	16
Savings	16
Purchase vehicle	16
Childrens education	10
Daily household expenses	10
Buy tractor / plough	8
Build tearoom	7
Renovate house	5
Purchase cattle	3
Pay debts	3
Purchase chainsaw	2
Purchase fence	2
Help son get married	2
Don't know	10

Sixty two percent of households intended to spend their earnings on household expenses (building a new house, paying debts, renovating, purchasing a vehicle, daily expenses) or family needs (education, marriage). Twenty percent intended to reinvest money in other agricultural and non agricultural enterprises (purchase tractor, plough, cattle or fencing; build tearoom). Sixteen percent saw the trees as a form of savings. Only two percent intended to reinvest specifically in forestry (purchase chainsaw).

4.14 Family conflict

More than 80% of all growers stated that their spouse or children had been consulted about planting and 97% stated that the family was happy to belong to the scheme. However, it was impossible to tell the real extent of intra-family conflict caused by the trees as most respondents were not willing to discuss family disputes.

One grower complained that her husband had received payment for trees that she had cultivated. She was in the process of taking this matter before the Tribal Authority. In another case, a senior wife had received payment for trees planted by the junior wife. Their husband was deceased. Some growers mentioned that sons returning from migrant work after a long absence, had not approved of their parents decision to join. These men were concerned that the companies were stealing their land or were worried about space for future households.

4.15 Community conflict

Sixteen percent of non-growers and 18% of growers recounted actual cases of conflict with neighbours. These concerned stock damage, boundary disputes, and deliberate fire. Roughly one third of these cases had been resolved by the local Tribal Authority.

An example of one such dispute is as follows. Neighbours of a non-grower household claimed that its cattle were destroying their trees. The matter was taken before the Tribal Authority who ruled that since the land had previously been given to the neighbours by the grandfather of the household head, they were not entitled to complain. The household head died shortly after this dispute and the neighbours were suspected of using *muti* from the eucalypt trees to bewitch him. The relationship between the two families were described as unfriendly although members were still on speaking terms.

Most households could cite cases of community conflict in their own or neighbouring wards. In October 1991 in the Nkandla district, most of a 18 hectare block of trees was destroyed by cattle. The community did nothing to prevent this. In this ward the Inkosi was dying of cancer and had little control over tribal affairs. These trees were planted on land which had been a communal grazing site.

The event was mirrored in November 1991 by the destruction of about 200 hectares of timber in the Ubombo district by school children. The Inkosi of this ward is also afflicted by cancer. It is believed that younger members of the community were alarmed at the rapid rate of

expansion of forestry. Children feared that there would be no land left for future households. However, there is also evidence of political activism in the event. One respondent claimed that the children lived outside the ward and travelled to the area in hired buses.

Other households cited cases which centred around grazing rights and boundary disputes. Cattle belonging to non-growers had destroyed trees. Forests reduced traditional grazing lands, with the result that crops were increasingly destroyed by stock. Trees had been planted on what was previously considered communal grazing land. In some areas, pastoralists were now forced to herd their cattle all year round instead of herding only over the traditional maize growing period. One farmer complained that a number of tree growers had used his land for grazing and then objected when he wanted to grow sugar on this land.

Farmers reported community fears that the Timber companies were stealing their land or that they would be forced to move off the land once sufficient trees had been planted for Timber companies to become interested in their area. In one ward where the Inkosi had strongly supported the schemes, farmers worried that their land would be redistributed to other community members if they did not plant trees.

Others were concerned that trees would cause streams to dry, or that thugs would hide in the forests, making the area unsafe for women. In one ward, local discord had escalated when quarreling households began to set fire to their adversaries' woodlots.

Companies now ensure that boundaries are agreed upon by both a representative of the Tribal Authority and the relevant neighbour before trees are planted on a site. They (notably Mondi) are also in the process of encouraging tree grower and cattle owner associations in an attempt to resolve disputes over grazing.

4.16 Damage to woodlots

Sixty eight percent of growers reported some damage to their woodlots. Table 7 shows the type of damage experienced.

Table 7 Damage to woodlots (n = 42)

Type of damage	% Growers
Drought	19
Stock damage	26
Damage by wild animals	2
Veld fire / lightning	8
Deliberate fire (quarrel)	2
Deliberate fire (against scheme)	10

It is estimated that drought and animal damage caused minor die off in the woodlots (less than 10%). Fire caused major die off (between 50% and 100% of the woodlot). Households whose forests were burnt, were forced to fell, often at a loss.

Even where fire breaks are well maintained (notably amongst inland SAPPI growers), veld fires have swept through plantations. SAPPI has now increased the specified width for hoed fire breaks from two metres to three metres and allocated a greater percentage of loans for maintenance of breaks.

4.17 Future expansion

Fifty four percent of households were considering expanding their woodlots in the future.

Thirty four percent of households had decided not to plant any more trees due to land restrictions (18%), shortage of labour (7%), fear of fire (5%), problems with repayments (4%) or plans to plant other crops (4%).

Twelve percent of households were undecided about future expansion. These households wanted to see if trees were really profitable (8%), if access roads were to be improved (4%), or if stock damage could be controlled (4%).

4.18 Farmers' associations

Sixty-two percent of households belonged to tree growers associations. Two of these associations were started by growers and the remainder were initiated by company foresters.

Benefits of belonging to an association were perceived as assistance in conveying complaints and suggestions to the company (21%), help in building access roads (12%), easier acquisition of inputs and equipment (4%), and assistance with boundary and grazing disputes (2%).

Forty nine percent of members stated that the associations had been established too recently to perform a function, 9% complained that the organizations were disorganized (members or forester did not turn up to meetings) and 5% did not know the functions of their associations.

4.19 Trees for household use

Sixty three percent of households (including non-growers) grew trees for household use. Trees grown included various fruit trees (49%), gum (19%) and wattle (11%).

4.19.1 Perceived needs for other tree species

The majority of households (67%) saw fruit and nut trees as being the most urgently needed in their area. Trees for firewood (43%), and building (29%) were also regarded as important. Other species considered necessary included trees for fencing (5%), carpentry (4%), prevention of soil erosion (4%) and medicinal purposes (2%).

There were no significant differences in perceived needs between growers and non-growers.

4.19.2 Fruit trees

Twenty three percent of households who wanted fruit trees were not prepared to pay for them. The remaining households were prepared to pay an average of R 7,95 per sapling (amounts ranged from R1 to R30 per tree).

Respondents who were not prepared to pay for fruit trees complained that fruit was stolen or eaten by monkeys or that trees were destroyed by cattle.

4.19.3 Firewood

Fifty five percent of households gathered their firewood from surrounding areas or from their commercial woodlots. Other households obtained firewood from their non-commercial woodlots (24%) or from a local sawmill (2%).

Nineteen percent of households bought firewood locally. These households spent an average of R18 per month on firewood (amounts ranged from R2 to R50).

Respondents who did not grow trees for firewood claimed that firewood was readily available (38%), that there was insufficient land to plant trees for firewood (20%), that land was unsuitable for trees (4%), that trees had died (5%), that it was easier to buy firewood than to grow trees (1%), or that electricity was to be installed (1%). Thirty percent of these households stated that they would consider growing trees for firewood because they had to collect from distant forests or because local sources were depleted.

4.20 Problems with operations

Fifteen percent of households had problems with pitting and planting. Problems included lack of money to pay contractors, contractors planting too late or making holes too small, poor seedling quality, or seedlings dying directly after planting.

Fifteen percent of households had problems with weeding. These farmers complained that repayments did not cover expenses or arrived too late, or that weeding took far longer than expected.

Fifty percent of households that had felled trees complained of expensive, inefficient or corrupt felling and transport contractors, or difficulties in finding male labour for clearing.

4.21 Labour inputs

Median estimates of labour inputs were 26 labour days / ha (pitting, planting, applying fertilizer - first year), 83 labour days / ha (weeding - first two years), 133 labour days / ha (firebreaks - first to sixth year) (Appendix A). The median time spent on these operations is 3 hours per person per day.

4.22 Clearing felling and transport

Growers paid R per tonne per kilometre to convey their harvest to the mills (clearing, felling and transport) (Appendix A). In comparison large private contractors charged from R0,21 to R0,50 per tonne per kilometre to transport timber from Mondi plantations to Richards Bay in 1991. While access to small grower lands and economies of scale do increase the costs of extraction, it is likely that growers are being overcharged for this service.

4.23 Profitability of commercial woodlots

Frequencies of net profit per hectare for 30 households (age of trees at harvest ranged from one to seven years, households had all harvested within one year of the survey) are shown in Figure 7. The median net profit per hectare was R2 124 for the entire growing cycle of the trees.

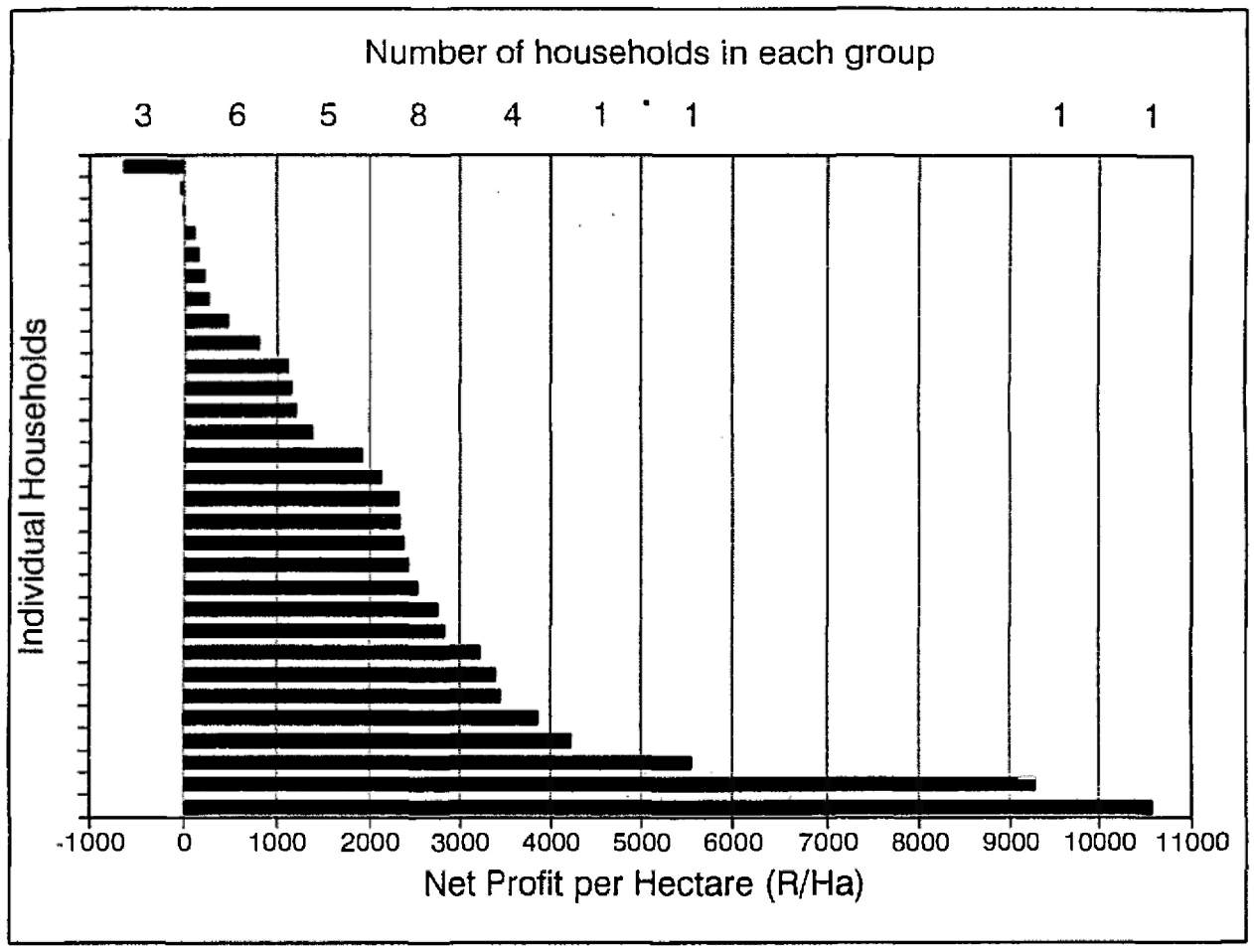


Figure 7 Net profit per hectare (n = 30)

The median return to labour is estimated at R8,77 per labour day (after loan deductions). This is based on median labour inputs over the entire growing cycle of 242 days and working for three hours per person per day (see section 4.21).

4.24 Expectations of profitability

Respondents were not willing to disclose the expected profits from trees. However, of those households that had felled, 20% claimed that they had received more than they had expected

from their harvest. Twenty three percent received what they expected and 43% received less than expected. Thirteen percent did not know what to expect.

It is the researcher's opinion that many farmers expected profits that were possible under optimum conditions but improbable under local circumstances (see also Table 6). In one area farmers held unreasonable expectations due to misinformation from a company supervisor.

4.25 Distribution of gross profit

The distribution of gross profit is shown in Figure 8. In theory, deductions cover the cost of inputs (including household labour). Clearing, felling and transport consumes almost 50% of gross profit.

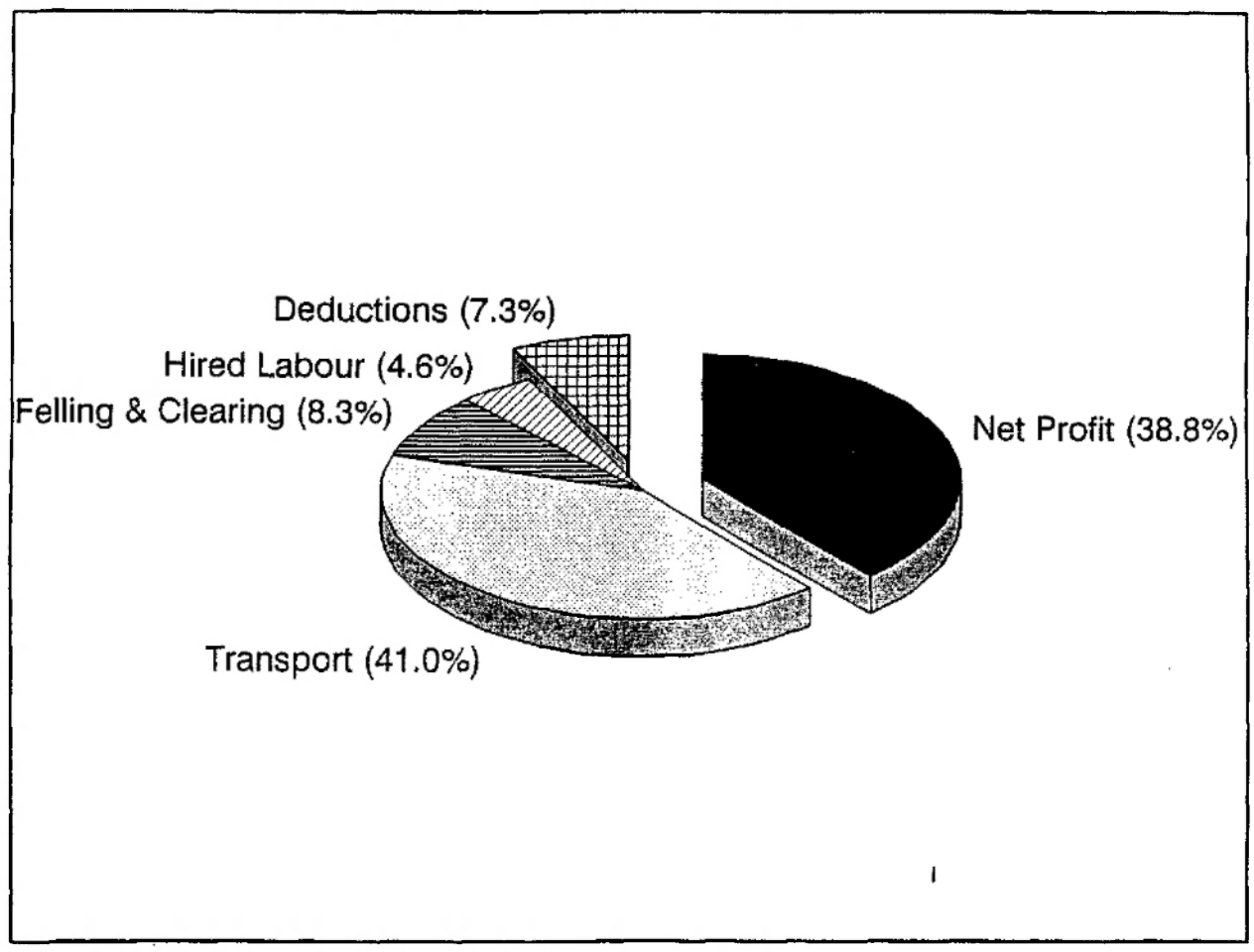


Figure 8 Distribution of gross profit (n = 30)

4.26 Factors effecting net profit per hectare

Table 8 shows the results of a regression of net profit per hectare on various factors. This refers to the profit obtained after the entire growing cycle of the trees (usually six years).

The results show that 80,4% of variance in net profit per hectare amongst households may be explained by factors affecting yield (site preparation, incidence of stock and fire damage and age at felling) and differing felling and transport costs.

Table 8 Results from a stepwise linear regression of net profit per hectare on various factors (df = 23; adj. R^2 = 0.80)

Variable	Beta	*t* ratio	Significance
Explanatory variable			
Site preparation (labour days / ha)	18.38	3.213	0.004
Transport costs (R/t)	-69.97	-2.541	0.018
Age of tree at felling (if no damage occurred) (yrs)	722.22	3.694	0.001
Damage (0=none; 1=damage occurred)	2527.14	2.023	0.055
Dependent variable			
Grower household (0 - not a grower; 1 - grower)			

By comparing the best achieved score with the average score for each factor (Table 9) it is possible to estimate the partial contribution to net profit made by optimizing each factor.

Table 9 A comparison of factors affecting net profit per hectare

Factor	Average score	Best score
Site preparation (labour days/ha)	73.8	300.7
Felling and transport costs (R/t)		
Hlungwini	43.63	25.12
Mfekayi	50.25	50.25
Port Danford	30.67	17.15
Amatikulu	131.50	18.40
Damage (0=No; 1=Yes)	0.48	0.00
Age at felling (if no damage occurred)	6.24	7.34
Estimated net profit (R/ha)*	2372.39	9370.14

* Estimated profit (R/ha) = 18.36 x Site preparation (labour days / ha) - 69.97 x Transport costs (R/t) + 722.22 x Age of tree at felling (if no damage occurred) (yrs) [or] + 2527.14 (if damage occurred)

Figure 9 shows the contribution made by each factor to net profit per hectare at best achieved scores.

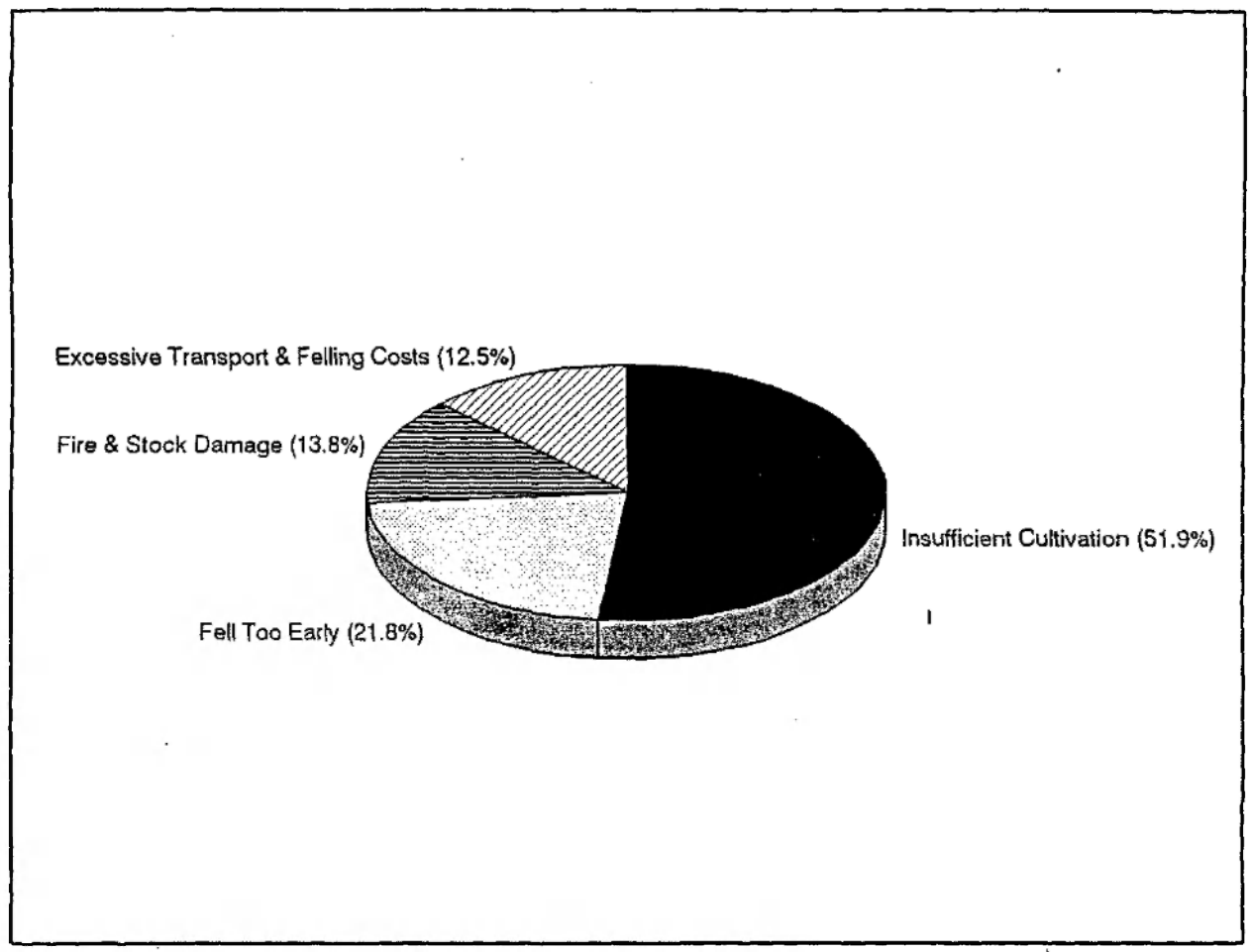


Figure 9 Potential increase in net profit per hectare attributed to various factors (n = 30)

Figure 9 shows that the greatest increase in net profit per hectare (51,9%) can be achieved by increasing site preparation and weeding in the first year from 74 to 301 labour days per hectare. Complete protection from fire and stock will result in a 13,8% increase. Using the cheapest available transport in each area will result in a 12,5% increase. Felling at over seven years will result in a 21,8% increase.

Further increases in net profit could be made by bringing in large scale timber transporters and providing depots and weighbridges at collection points.

4.27 Farmers' suggestions

Growers had many suggestions for improving the schemes (Table 10).

Table 10 Ways of improving the schemes (n = 62)

Improvement	% Households
Improve access roads	37
Company should provide / subsidize fencing	34
Company should provide / sell chainsaws, tools or second hand equipment	28
Company should organize cheaper transport	27
Company should provide loans	21
Repayments to be increased	19
Pay advances immediately after task is completed	12
Company should provide other crops / trees	12
Borehole	8
Need receipts / balance owed	6
Need inputs in time	6
Need depo and weighbridge	6
Need more more money / tractor / herbicide / equipment - to improve effectiveness of firebreak	6
Want to pay back loan and be free	4
Need to build up the local tree grower association	4
Company should provide tractor for ploughing	4
Need to meet forester more often / need advice	4
Don't like the interest charged on advances	2
Company should do felling	2
Don't know how to improve the schemes / we are happy	4

In areas where felling had already commenced, growers were aware of the costs involved in extraction and transport. These farmers wanted assistance in building access roads to plots and they wanted the companies to organize felling and transport on cheaper terms. Others

mentioned the need for a storage depot with weighbridge from which long distance transport could be arranged and tools to enable them to do the work themselves.

In areas where the schemes were newly introduced, growers were concerned about stock damage. They stressed the need for fencing either the trees or their own cattle.

Households were concerned about the long growing cycle. Many wanted the companies to provide them with loans using the forest as collateral. Others wanted assistance with annual crops or fruit trees.

Some farmers were unhappy with the operational structures of the schemes. They wanted to know exactly how much was owed to the companies and how much they could expect to receive after harvest. They complained that payments were delayed, forcing them to pay hired labour out of their own savings. Others argued that payments did not cover the costs of hired labour. Farmers were particularly concerned about improving firebreaks. Some mentioned that inputs (seedlings for blanking and fertilizer) had arrived too late and that they needed more frequent contact with the local foresters.

5 DISCUSSION

5.1 Competition for household resources

The contention that the scheme may divert resources away from food crops appears at present to be unfounded. Most houses (77%) plant less than 50% of the total land allocation to trees leaving the remainder for food crops. Trees are normally planted on lands previously used for grazing (60% of the area under trees). Where other crops have been replaced, there are normally rational reasons for doing so (section 4.4). However, since 54% of households want to expand their woodlots, diminishing food supplies may become a problem in the future.

As eucalyptus may be planted over an extended period in the rainy season, and as the trees regenerate after harvest and require weeding only for the first two years after planting or coppicing, labour inputs are low compared to most other cash crops. Furthermore, firebreaks normally require maintenance during periods of low agricultural activity. Thus, it is unlikely then that trees compete for household labour to the detriment of food crops. Rather, the adoption of commercial woodlots serves to diversify farming systems in a rational manner.

5.2 Eucalypts in the household farming system

The majority (87%) of farmers joined the schemes in order to obtain cash at harvest. Although trees were often felled too early, household heads were reluctant to allow plantations to be cut for household uses. Thus, trees are seen primarily as a form of savings for households.

Farmers are unlikely to need tree species specifically for firewood. Almost a quarter (24%) of households already cultivate woodlots for firewood, 29% claimed firewood was available from local sources (trees grow readily in the areas where the schemes operate) and 18% claimed that they had insufficient or unsuitable land to plant trees for household uses. Furthermore, while farmers were reluctant to use trees planted under the scheme for household purposes, the self pruning nature of eucalyptus does provide some firewood. Only 15% expressed an interest in planting trees specifically for firewood. (Promotion of fruit species is likely to be met with more interest as 38% of households wished to purchase these trees).

At present the companies do provide gum seedlings free of charge for household use. However, the commercial woodlots themselves are not in any way integrated into the farming system, i.e. as building poles, windbreaks, shade, fodder, prevention of soil erosion, soil enrichment. Companies have little interest in promoting trees for uses other than pulp and

commercial considerations such as ease of extraction and yield maximization will prevent the schemes from evolving into a true social forestry programme.

5.3 Alternate crops

It has been argued that a strength of contract farming is its ability to reach the poorest and most isolated farmers. On the other hand, it is precisely these farmers who have fewest alternatives and who are not in a position to choose the most profitable land use for their area.

It is therefore a source of concern that approximately 30% of land under trees is potentially arable and possibly suited to more profitable cash crops. However, problems with nematodes and poor nutrient status mitigate in favour of trees in many of these areas. Foresters have also pointed out the difficulties of refusing to plant on land allocated by the farmer for trees.

In the steep inland areas far from the mills, wattle may be more suitable than eucalyptus since only the bark is transported out of the region. Various subtropical fruits (mango, litchi) and nuts may be more profitable in the coastal areas. However, without active support in input supply and marketing, these options are not feasible for farmers.

There is a need for a comprehensive map of recommended land use systems in Natal / KwaZulu, giving the relative profitability of each system. While the final decision concerning land use should rest with the individual farmer, recommended crops should be actively promoted with adequate support for supply inputs and marketing. It may be justifiable for the government to subsidize transport of trees from the inland areas to promote rational land use on steep slopes.

5.4 Hydrology

Case studies illustrate the significant effect of trees on stream flow and availability of ground water.

Policy for the protection of streams and ground water has been developed for the Ubombo district of KwaZulu. However, while companies may be constrained by a desire for long term sustainability of woodlots or their own sense of responsibility, there is no guarantee that this policy will be carried out. In fact the survey indicates that present guidelines for minimum planting distances from streams and boreholes are largely ignored by the timber companies.

Furthermore, no attempt has been made to assess the effect of afforestation on runoff in the steep inland areas where the schemes operate. There is thus a need for guidelines to estimate the effect of afforestation on stream runoff in mini catchments in the Bioclimatic Regions of KwaZulu. Water demand and stream flow should be calculated for the critical winter months under various percentages of afforestation. Afforestation should not proceed beyond the proportion which causes stream flow to drop below expected offtake, unless the forestry companies supply residents with earth dams.

As afforestation effects hydrology beyond the boundaries of individual farms, it is justifiable to enforce hydrological recommendations by law.

5.5 Community and family conflict

While it was impossible to measure the extent or seriousness of disputes, it appears that discord and fears were greatest where schemes had been recently introduced, where trees were planted in large blocks rather than in individual plots and where there had been a history of community hostility toward plantations (state forests considered to be on tribal land) or interference in land ownership (bordering nature reserves, forced removals). In these areas it appears that many community members outside the tribal authority structure either do not understand the terms of contract, or have no platform to voice their objections at the commencement of the schemes. These problems point to a lack of communication not only between the growers and the company but among the members of community itself and occur despite efforts by the timber companies to communicate at all levels, including attempts to set up tree growers committees. Foresters working in these troubled areas may face personal danger.

Suspicion and conflict also appeared greater in areas where companies had embarked on a policy of aggressive promotion of their schemes. When the timber schemes are actively promoted by the local Tribal Authorities, farmers may interpret this as a muted command to join the schemes. Where afforestation is new or spreading rapidly there is widespread belief that the companies are trying to steal land. Expectations of profits may also be heightened in areas where public meetings have taken place to promote the schemes.

Where the expansion of woodlots has proceeded slowly through a process of "lateral filtration" (notably amongst certain SAPPI growers), it was common to hear that even those who first opposed the schemes are now planting trees, farmers are less wary of the schemes and

community tree growers organizations have sprung up voluntarily. It is possible that land use planning is more rational where farmers do not feel hurried into any decision.

It is suggested that community conflict may be lessened if companies were to concentrate more on skill transfer to existing growers rather than active promotion in new areas. It is also best to grow trees on land already allocated to individual households. Block plantings heighten tensions between stock owners and tree growers, raise fears of external control over land and may benefit politically elite members of the community.

5.6 Elitism

Results show that shortage of land is the greatest constraining factor in the adoption of timber. Well established households generally had access to more land and were therefore more likely to participate in the schemes. Newcomers to an area are less likely to join the the schemes, and in areas of rapid afforestation are less likely to procure unused land for their own households. Conversely, households that have been allocated marginal lands may benefit from timber schemes since they are unable to grow other crops on these lands.

Advance payments enable even those households with meager incomes to participate. Women also appear able to benefit from the schemes.

Block planting may result in elitism as politically powerful farmers may be able to procure more land than other members of the community.

5.7 Profitability

It is probable that the greatest increase in profitability could be made by increasing yields. This would involve improved site preparation (ploughing) and weeding, use of clones and higher applications of fertilizer. Mondi has adopted this approach. Unfortunately, expensive inputs increase farmers' (and firms') risk, particularly in the light of present levels of damage to trees (more than 60% of woodlots suffered some damage through fire, livestock and drought).

These measures would also increase the level of external management required in the schemes. Interference could be minimized by manipulating advance payments to allow more hired labour for firebreaks and site preparation while the payment of advances immediately after the work is completed would greatly facilitate the farmers' attempts to find hired labour.

A comprehensive system of receipts and balances owed, with realistic estimates of final profits is also needed for farmers to make informed decisions about increasing the area under trees, replacing other crops or hiring labour.

In keeping with their social responsibility outlook, SAPPI does not charge interest on loans and seedlings are provided free of charge. Risks are therefore lower, however, a possible danger of this approach is that SAPPI may not be able to subsidize their scheme in the future. Farmers may then become "locked in" by debt if the terms of contract deteriorate.

In the steeper inland areas, poor access roads greatly increase the costs of clearing and loading. It is unlikely that the situation will improve unless companies exert pressure on the government to fulfill past promises to fund the building of these roads. Lima with its experience in labour based road construction funded by government is most likely to succeed in this regard.

The provision of collection depots and weighbridges for road and rail transport may help to reduce expenses, although the costs of double handling may offset some advantages. However, these actions would stifle local contractors which is a serious disadvantage when considering the overall impact of the schemes. On the other hand some contractors are presently charging excessive transport fees. Companies should negotiate directly with contractors on behalf of the farmers and growers should be informed of reasonable prices in their respective areas.

Companies should take care to calculate profits under conservative estimates of yields before promoting the schemes in areas far from the pulp mills.

5.8 Terms of contract

At present farmers are not sufficiently organized to negotiate their own terms of contract. As an interim measure, there is a need for an independent party to review the terms. Recommendations should be enforced by legislation.

For instance, under the present terms, companies have first rights to the coppice. This clause is disturbing since produce from woodlots may legally remain under the control of the mills for more than 20 years, preventing the recirculation of raw materials within the community and the development of local employment opportunities (saw mills, building contractors, carpentry).

Mondi has commissioned the Community Law Centre of the University of Natal to review the Khulanathi contract. However, there is no guarantee that recommendations will be adopted, nor is it an ideal situation to have outsiders determining these conditions.

5.9 Tree growers associations

While commendable efforts have been made (particularly by Mondi) to encourage the formation of growers association, these organizations are still weak, fall under the control of the company and serve mainly to enhance communication among dispersed farmers and to resolve conflict between growers and cattle owners.

In the future, it may be possible for these organizations to take over the tasks which are presently being performed by the companies thus freeing farmers from the mill contract.

5.9.1 Tasks of associations

Studies elsewhere in Africa and India suggest that tree growers associations would have to service a minimum of 250 ha of commercial forest, would retain about 40% of the revenue from sales, and would need access to credit. They could then bear the costs of replanting felled areas, granting loans for pitting, planting, and firebreaks, and providing transport to collection depots.

Of particular importance would be the task of transporting the trees. From Figure 8 it can be seen that about 50% of the gross profit from trees is lost in harvest, extraction and transport costs. At present this service is provided by outside or local contractors. If these functions were taken over by farmers associations, a greater proportion of profit could be retained by the growers.

The associations could eventually establish small nurseries to provide farmers with *Eucalyptus grandis* and other tree species such as *Casuarina equisetifolia* for charcoal, *Acacia mearnsii* (black wattle) for fencing and firewood, and various early maturing fruit trees.

The associations may also develop a management plan tailored to suit their members needs. This would include land use plans, staggered planting dates to allow harvesting at different times, introduction of other species for fruit and household needs (roughly 30 trees, replanted at intervals will provide a household with sufficient wood for fuel), and hydrology guidelines to prevent local springs from drying up.

Ideally, tree growers associations would work toward freedom from mill contracts. This is probably in the interest of both the farmers and the mills. Independence from the existing commercial schemes could allow farmers greater flexibility to meet household needs, it could maximize profitability and create local employment. It could at the same time, reduce the cost of management and subsidies presently borne by the companies while being unlikely to greatly undermine an increasing supply to pulp mills.

Once completely free from the mill contract, alternative markets for trees may be sought. These may include local saw mills, charcoal factories or the highest bidder for pulp. Trees for fuel and building poles would also be considered since local prices are likely to exceed mill prices, although this market may quickly become saturated.

5.9.2 Factors mitigating against the success of farmers associations

The success of tree growers associations would depend on the level of cooperation which farmers could achieve. A number of factors mitigate against them. First, if one association services a minimum of 250 ha of forest then it will need a membership of approximately 200 to 250 growers. These farmers may be scattered over a large area with little infrastructure and poor means of communication, making it difficult to coordinate actions. Second, operations may suffer in the short term because of inexperienced or uncommitted management, difficulties of procuring credit and lack of technical expertise. Third, the most vital operations performed by the association would be felling and transport. These operations would provide the major income for other functions. Expensive equipment needed for these operations necessitate a large starting capital. Fourth, local or external contractors may undermine associations by offering lower prices for felling and transport. Conversely, individuals running a successful association may feel it is more profitable to abandon the association and start their own contracting business. Fifth, experiences of the Transkei Appropriate Technology Unit (TATU), have shown that the costs of training and capacity building for these types of associations to be extremely high.

For an association to weather these problems, farmers would have to be convinced of the long term benefits of forming the group, namely to transfer ownership of the scheme into their hands. Financial and technical support and management training would have to be made available to interested groups.

6 SUMMARY

6.1 Benefits to farmers

Schemes provide farmers with timely inputs, a secure market, capital and technical expertise. The companies operate in isolated and neglected rural areas and, unlike state extension departments, have a vested interest in seeing that woodlots are successfully cultivated and profits are acceptable to farmers.

Advance payments allow even those farmers with meager cash incomes to participate. Women appear to be able to participate in the schemes on an equal footing with men.

Costs of inputs are low relative to most other cash crops, However, the relatively long time taken to reach maturity increases risks of loss by fire or drought.

Woodlots do not appear to compete seriously for household resources (arable land and labour) but rather rationalize the farming system by diversifying risks and spreading labour inputs more evenly through the year. They are also a rational enterprise for marginal (especially steep) lands.

6.2 Problems with the schemes

On the other hand the proposed expansion of woodlots within land allocations may reduce food production in the future. Trees have been planted on arable lands which are suited to the production of more profitable crops (this is particularly disturbing considering the prohibitive costs of destumping once saplings are established in the soil). While costs of cultivating trees are low compared with other crops, the relatively long time taken to reach maturity increases risks of loss by fire or drought.

Existing hydrology guidelines are inadequate (particularly with regard to stream runoff in mini catchments), and largely ignored by farmers and the timber companies.

Schemes have been promoted in areas too far from the pulp mills. Promises have been broken regarding the provision of access roads to woodlots. Expectations of profits are unreasonably high in places. Poor site preparation, fire, drought and livestock damage have reduced yields among many woodlots. Private contractors have on occasion charged excessive fees. As a result, profitability of woodlots in some areas is questionable.

The terms of contract have never been negotiated with farmers and some clauses may be harmful to future development of the small grower industry.

Farmers associations are weak and presently under the control of the companies. While commendable efforts have been made (particularly by Mondi) to encourage the formation of growers association, these organizations are still weak, fall under the control of the company and serve mainly to enhance communication among dispersed farmers and to resolve conflict between growers and cattle owners. In the future, it may be possible for these organizations to take over the tasks which are presently being performed by the companies thus freeing farmers from the mill contract. However, factors mitigating against associations suggests that measures to retain profits in the local community or attempts to transfer greater ownership of the schemes to growers may never proceed beyond the creation of local contractors. While timber companies remain the sole provider of credit and technical support, the major task of associations will be to negotiate new terms of contract.

The schemes have also caused tensions particularly amongst communities with a past history of land dispute, where rapid expansion has taken place (often under pressure of annual targets), and where companies have embarked on an aggressive promotion policy. Most block plantings have proved unpopular with local residents since land is reallocated to relatively few beneficiaries, non-growers lose access to communal grazing and youth become concerned about space for the establishment of new households. Block planting may also result in elitism as the politically powerful are more likely to procure land than other members of the community.

6.3 Recommendations

The following recommendations are made.

There is a need for a comprehensive map of recommended land use systems in Natal / KwaZulu, giving the relative profitability of each system. This should be undertaken by the Department of Agriculture. Recommended crops should be actively promoted with adequate support for supply inputs and marketing.

There is a need for guidelines to estimate the effect of afforestation on stream runoff in mini catchments in the Bioclimatic Regions of KwaZulu. Some of the cost of researching these guidelines should be borne by Timber companies under their environmental conservation

budgets. Academic institutions such as the Department of Agricultural Engineering at the University of Natal have the capacity to perform this research. Water demand and stream flow should be calculated for the critical winter months under various percentages of afforestation. Afforestation should not proceed beyond the proportion which causes stream flow to drop below expected offtake, unless the forestry companies supply residents with earth dams. As afforestation effects hydrology beyond the boundaries of individual farms, it is justifiable to enforce hydrological recommendations by law.

Companies should proceed slowly with expansion in new areas (relying on word of mouth from farmer to farmer to promote enrollment). Extension efforts should concentrate on skill transfer to existing growers rather than active promotion (SAPPI Grow has embarked on this method of promotion since their inception - with encouraging results).

Trees should only be grown on land already allocated to households, block plantings should be avoided unless the majority of those using the designated communal land will remain beneficiaries after the scheme has been introduced (Lima has not encouraged block planting).

Every attempt should be made to increase final yields without increasing the level of inputs. The use of clones and higher levels of fertilizer may be justifiable (Mondi provides clones in coastal areas). Advance payments should be manipulated to allow more hired labour for site preparation and making firebreaks. Payments should be made immediately after the work is completed to facilitate hiring labour.

A comprehensive system of receipts and balances owed with realistic estimates of final profits is needed for farmers to make informed decisions about increasing areas under trees, replacing existing crops or hiring labour.

Access roads should be built by the companies to all woodlots (Lima is the only company which has undertaken to do this). Alternatively, trees should not be supplied to farmers who intend to plant on highly inaccessible land. Costs of transport and expected profits under conservative yields should be calculated by companies before expanding into areas far from mills.

Government subsidy should be given for the transport of trees from the inland areas which have in the past suffered more than the coastal areas from lack of development initiatives and infrastructure. This may also help promote rational land use on steep slopes.

Companies should negotiate with large contracting firms for cheap transport. Where local contractors are operating, farmers should be informed of reasonable prices for felling and transport. Aspirant contractors should be provided with training in skills needed for this task (felling and business management). Collection depots and rail transport should be provided to growers where possible.

Terms of contract need ultimately to be negotiated by growers. As an interim measure aspects of the contract should be reviewed by independent parties (Mondi has commissioned this) and recommendations enforced by government legislature.

Growers associations should be encouraged (Mondi and SAPPI are active in this regard). Their functions should be expanded beyond merely facilitative actions (communication and solving disputes). Growers associations should aim at negotiating new terms of contract, and forming cooperatives to transfer ownership of the schemes into the hands of farmers. Organizations such as TATU have personnel with the capacity and experience to work with these associations. Funds to develop associations should ideally be collected from growers, Timber companies and Government.

APPENDIX A

SUMMARY STATISTICS

Table A.1 Summary statistics of grower operations and household characteristics

Variable	Sample Size	Mean	Median	Std Dev	Std Error	Min	Max
Days pitting per hectare (d/ha)	62	42,8	26,4	47,2	6,0	0,0	210,5
Days weeding per hectare (d/ha)	62	113,7	83,4	137,0	17,4	0,0	743,0
Days making firebreaks per ha (d/ha)	29	173,6	133,3	159,0	29,5	6,9	623,7
Gross profit per household (R/hh)	29	12673,3	8360,0	11700,8	2172,8	380,0	49172,0
Transport costs per tonne (R/t)	29	25,1	19,8	11,2	2,1	16,3	49,0
Transport costs per tonne per km (R/t/km)							
Net profit per household (R/hh)	29	4913,5	2404,3	5501,2	1021,6	-455,5	18523,4
Net profit per hectare (R/ha)	29	2372,4	2124,8	2577,0	478,5	-634,0	10584,2
Age at felling (years)	29	6,1	6,1	1,0	0,2	4,3	7,4
Mean annual increase (t/ha/yr)	29	13,1	12,7	7,7	1,4	2,0	32,9
Household characteristics (growers)							
Household size	62	10,3	10,0	5,1	0,7	2,0	31,0
Preschool children	62	1,5	1,0	1,9	0,2	0,0	10,0
Scholars	62	4,4	4,0	3,0	0,4	1,0	19,0
Full time employed members	62	1,3	1,0	1,5	0,2	0,0	6,0
Self employed members	62	0,3	0,0	0,5	0,1	0,0	3,0
Pensioners	62	0,6	0,5	0,7	0,1	0,0	2,0
Unemployed adults	62	1,3	1,0	1,1	0,1	0,0	5,0
Contrib. from migrants (times/yr)	62	23,3	12,0	18,6	2,4	6,0	88,0
Female headed (1=yes; 2=no)	62	0,3	0,0	0,5	0,1	0,0	1,0
Household characteristics (non-growers)							
Household size	31	9,6	8,0	5,2	0,9	4,0	26,0
Preschool children	31	1,6	1,0	1,4	0,3	0,0	5,0
Scholars	31	4,4	3,0	3,3	0,6	1,0	15,0
Full time employed members	31	1,3	1,0	1,0	0,2	0,0	5,0
Self employed members	31	0,1	0,0	0,3	0,1	0,0	1,0
Pensioners	31	0,5	0,0	0,7	0,1	0,0	2,0
Unemployed adults	31	1,3	1,0	1,0	0,2	0,0	4,0
Contrib. from migrants (times/yr)	31	22,9	20,0	14,6	2,6	12,0	66,0
Female headed (1=yes; 2=no)	31	0,2	0,0	0,4	0,1	0,0	1,0

APPENDIX B

HYDROLOGY CASE STUDIES

EVALUATION OF RUNOFF REDUCTION DUE TO AFFORESTATION IN A SMALL CATCHMENT IN THE MATIKULU AREA OF KWAZULU

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OBJECTIVE

The objective of this study is to evaluate the reduction of runoff due to the planting of *Eucalyptus grandis* in a small catchment of 0.30 km^2 in the Matikulu area of Kwazulu, 20 km North West of Mandini (29° 02' S and 31° 16' E) at an altitude of approximately 560m. Also evaluated in this study is the likely reduction in useful water supply from the stream at the outlet to the catchment.

METHODOLOGY

The *ACRU* agro-hydrological model was used to simulate the stream flow at the outlet to the catchment, firstly under present natural grassland and secondly under *Eucalyptus grandis* plantation. The differences in the stream flow under the two land uses were then evaluated for frequency of occurrence and reliability of supply to local users.

Technical aspects of the *ACRU* model and procedures outlined in this report are detailed in the *ACRU* Theory and User Manuals (Schulze, 1989 and Schulze, George, Lynch and Angus, 1989). Pertinent input into the model is presented in the following sections.

(a) Rainfall

A thirty-three year record of daily rainfall was extracted from the data housed at the Computing Centre for Water Research (CCWR). The station selected was MAPUMULO SAWB No. 0271099, at 29° 10' S : 31° 04' E at an altitude of 533m and a Mean Annual Precipitation (MAP) of 1083mm. The record was excellent from the period 1957 to 1990 and minor patching was done for missing data using Zucchini and Adamson, 1984. The record used was compared to other, local but less complete records at Eshowe, Entumeni and Doornkop and no anomalies were found in the record chosen. The entire daily record was adjusted to reflect the expected MAP at the site (1109mm).

(b) Evaporation

The Linacre 1984 equation was used to estimate the reference evaporation. This equation requires monthly means of daily maximum and minimum temperatures.

These data were obtained from the station ESHOWE at 28° 53' S : 31° 28' E at an altitude of 530m.

(c) Soils Information

The soils in the catchment area studied were likely of the Mispah form and are predominantly a silt clay loam. The physical properties of the soils used in the model for the A and B horizon are given in Table 1.

Table 1: Soil Physical Properties. (m^3/m^3)

Horizon	Porosity	Field Capacity	Wilting Point
A Horizon	0.435	0.242	0.138
B Horizon	0.435	0.248	0.133

(d) Vegetation

The study area is presently covered by Ngongoni veld. The site is relatively steep and is considered to be in fair hydrologic condition. The land cover data for the grassland and *Eucalyptus grandis* forest are summarised in Table 2. The data used for the *Eucalyptus grandis* is that for mature conditions, when the trees will be extracting the maximum amount of soil water and so have the greatest reduction in stream flow. The entire record is simulated with the trees in the mature condition, thus simulating a "worst case" scenario.

Table 2: Monthly land cover parameters

Parameter	Land Cover	J	F	M	A	M	J	J	A	S	O	N	D
Crop Coefficient	Present	0.63	0.63	0.63	0.55	0.42	0.38	0.32	0.36	0.42	0.50	0.59	0.63
	Afforested	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Interception	Present	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
(mm per rainday)	Afforested	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Root distribution	Present	0.90	0.90	0.90	0.90	0.94	0.94	0.94	0.92	0.90	0.90	0.90	0.90
in topsoil horizon	Afforested	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85

RESULTS AND DISCUSSION

The two simulations revealed significant differences. The mean annual streamflow under the natural veld conditions is 93 600 m^3 while under *Eucalyptus grandis* it is reduced to 43 700 m^3 as shown in Table 3. More significant, however, than the reduction of the long term average annual stream flow in half by the planting of the *Eucalyptus grandis*, is the reduction

of the minimum flow that could be used to supply water to local residents on a reliable basis. For this reason it is important to observe the flow frequency analysis presented in Table 3 and shown graphically in Figure 1.

Table 3 Average flows and flow frequency analysis.

		Stream flow (1000 m³)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average Flow	Present	12.3	14.8	11.2	6.5	5.4	3.0	2.3	3.1	6.9	9.4	9.5	9.2	93.6
	Afforested	4.3	7.4	5.4	3.9	3.2	2.0	1.5	1.4	3.7	4.5	3.7	3.7	44.7
Flow Exceeded 10% of the time	Present	24.9	35.7	24.8	11.6	10.0	6.0	4.2	7.5	12.1	29.5	18.0	19.7	162.0
	Afforested	11.6	17.6	16.1	10.7	7.7	4.8	3.9	3.1	4.1	14.9	8.8	7.2	101.0
Flow Exceeded 50% of the time	Present	9.4	10.3	8.3	4.8	3.8	2.8	1.8	2.1	2.3	4.6	6.7	6.9	86.8
	Afforested	3.1	3.0	3.7	2.4	2.0	1.4	1.0	0.9	0.9	0.9	1.0	1.0	32.3
Flow Exceeded 90% of the time	Present	3.7	2.3	1.4	0.9	0.6	0.7	0.4	0.5	0.5	1.0	1.5	1.6	35.7
	Afforested	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	6.6

It can be seen from Figure 1 that the lowest flows occur in either July or August for the two land uses. A constant supply of water to support domestic requirements, drawn directly from the stream, can be taken as the minimum occurring during the year. The amount of time that this minimum will be satisfied is inferred from the frequency analysis. For instance, under veld conditions, drawing a constant 4 200 m^3/month from the stream would result in a winter shortfall 90% of the time since this flow is only exceeded 10% of the time. However, a constant withdrawal of only 400 m^3/month would result in a satisfactory supply for 90% of the time. Under afforested conditions, though, the minimum withdrawal for 90% reliability would be 100 m^3/month. Hence it is clear, that even though the average flow is reduced by half for afforested conditions, the reliable long-term withdrawal from the stream is reduced by a quarter. This is due to the extremely variable nature of the stream flow as well as the high evapotranspiration demands of *Eucalyptus grandis*.

The problem could be alleviated somewhat if a storage facility was provided. In order to demonstrate the relative withdrawals or drafts that could be obtained under the two land type conditions, a storage-draft analysis was done. Since it is a comparison exercise, it was assumed that sufficient storage could be provided so that no shortfalls would occur over the full 33 year period of the simulation, which is very conservative.

Figure 2 shows the cumulative inflows and drafts from a dam. The constant draft that could be realised under present conditions is 8 100m^3/month and under afforested conditions is 3 600m^3/month. The problem of water supply is reduced dramatically by the provision of a storage dam, indicating, again, the variable nature of the runoff.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations drawn from this study are :

Changing the land use on the study catchment from the present veld to afforestation by *Eucalyptus grandis* causes a significant reduction in the streamflow available for other uses.

Consideration must be given both to the amount of water needed as well as to the consistency of the supply required at the catchment outlet.

Significant advantage can be realised by providing storage for the water.

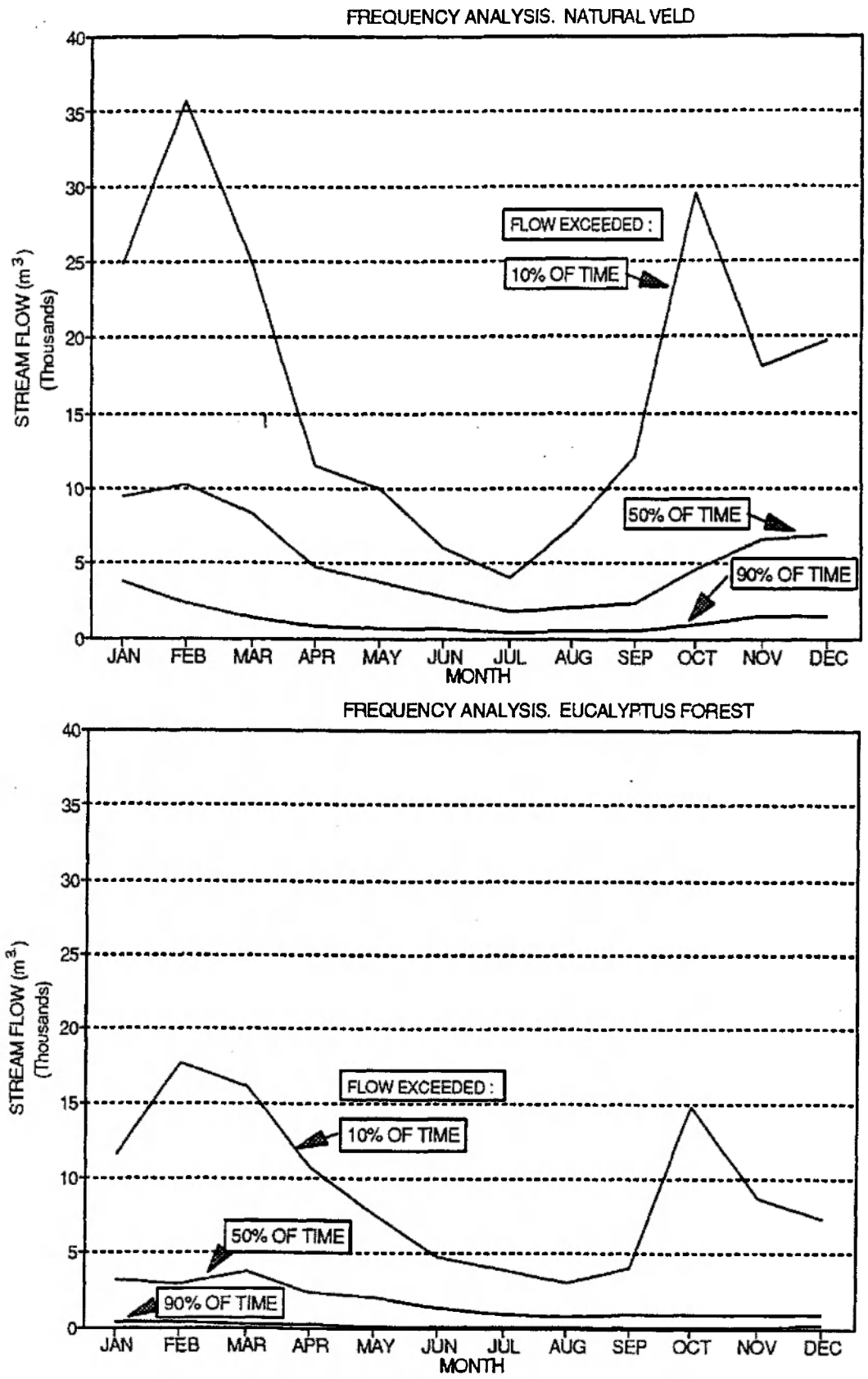

Figure 1 Stream flow frequency analysis for veld and afforested conditions.

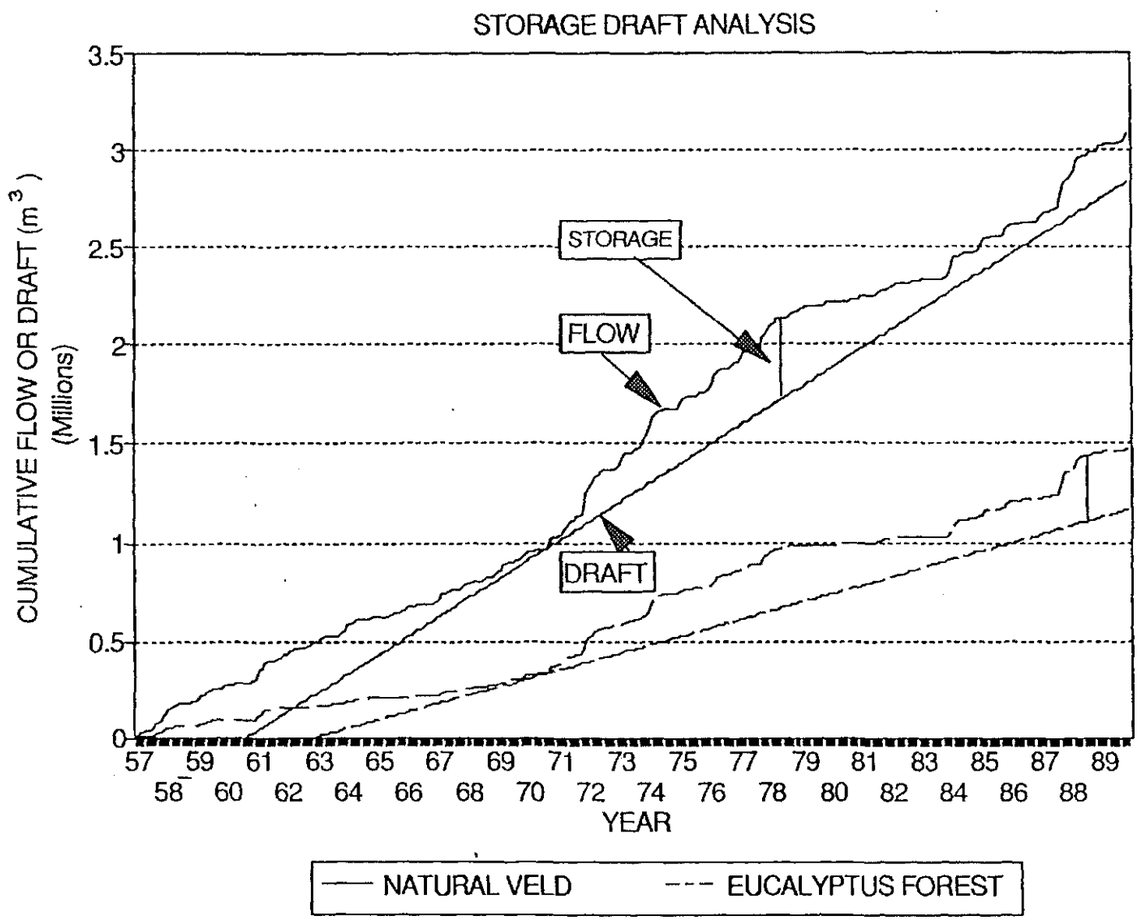

Figure 2 Cumulative flow and draft analysis for veld and afforested conditions.

SIMULATION OF THE EFFECT OF AFFORESTATION ON GROUND WATER RESOURCES AT NYALAZI

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OBJECTIVE

The objective of this study was to determine the effect of afforestation with *Eucalyptus grandis* on ground water resources in an area west of the N2 Highway, 23 km north of Mtubatuba in northern Natal (approximately 28° 13' S and 32° 16' E). The study is set out to establish whether proposed plantations of *Eucalyptus grandis*, carried out in a patchwork 1 ha in size, would have any local negative effect on accessability of water from wells and on the Nyalazi stream.

SIMULATION METHOD

The *ACRU* agro-hydrological model was used to simulate the ground water recharge, water utilisation and resulting water table fluctuation under both present land cover and under *Eucalyptus grandis* plantations. Technical details on the *ACRU* model and procedures outlined and mentioned in this report are all covered in the *ACRU* Theory and User Manuals (Schulze, 1989; Schulze, George, Lynch and Angus, 1989) and in a publication by Kienzle and Schulze (1992). The following information regarding the rainfall, reference evaporation, soils, geohydrology and vegetation characteristics was input into the model.

(a) Rainfall

Daily rainfall data for a thirty-year period from 1960 to 1989 were extracted through the Computing Centre for Water Research (CCWR) for the rainfall station NYALAZI(BOS), SAWB No. 0339523, situated at 28° 13' S, 32° 18' E at an altitude of 46 m and with a mean annual precipitation (MAP) of 990 mm. Missing data were infilled by the standard Zucchini/Adamson Model 5 method. Rainfall adjustment was not necessary, because the distance of the rain station to the modelling site is only four kilometres.

(b) Reference Evaporation, E_r

The Linacre 1984 equation was used to estimate the E_r. This equation requires monthly means of daily maximum and minimum temperatures to be input into the *ACRU* model. These temperature data were obtained from the meteorological station at Kangela near Mtubatuba, situated at 28° 24' S, 32° 12' E and altitude 50 m (Clemence, Miller and Siddons, 1987).

(c) Soils Information

Soils in the area are predominantly dry to wet grey regic sands of the Fernwood form. The soil physical parameters used in the simulations are listed in Table 1.

Table 1: Soil physical parameters used (all values in $m.m^{-1}$)

Horizon	Porosity	Field Capacity	Wilting Point
A Horizon	0.505	0.180	0.083
B Horizon	0.442	0.201	0.091
Intermediate Zone	0.400	0.100	0.035

(d) Geohydrology

Cretaceous sediments form the lower boundary of the aquifer system at Nyalazi. The Port Durnford beds (tertiary and recent sand deposits) overly this Cretaceous mudstone. Grey, wind blown sands of the Berea formation characterise the study area. No detailed information on important hydrogeological parameters is available. The saturated hydraulic conductivity is estimated from adjacent and similar areas. For this study, a saturated hydraulic conductivity of 3 $m.day^{-1}$ (i.e. 125 $mm.h^{-1}$) is assumed.

(e) Vegetation

The study area is covered at present by Ngongoni veld, interspersed by traditional settlements and with the grassland overgrazed, i.e it is hydrologically in poor condition. The proposed scenario of afforestation with *Eucalyptus grandis* will change important land cover parameters. Table 2 lists average monthly values of land cover parameters used as input into *ACRU*. The crop coefficient of 0.88 is based a long-term average, where the temporal changes within a complete rotation, i.e. development through stages of a young, intermediate and mature plantation with subsequent clear felling, are accommodated. The determination of maximum water table depletion, however, is based on the water demand of an eucalypt plantation in an intermediate age, when it has a crop coefficient of 1.05.

Table 2: Monthly land cover parameters used.

Parameter	Land Cover	J	F	M	A	M	J	J	A	S	O	N	D
Crop coefficient	Present	.60	.60	.60	.50	.38	.35	.35	.35	.38	.45	.52	.60
	Afforested	.88	.88	.88	.88	.88	.88	.88	.88	.88	.88	.88	.88
Interception (mm per rainday)	Present	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80
	Afforested	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Root distribution in topsoil horizon	Present	.90	.90	.90	.94	.94	.94	.94	.94	.92	.92	.90	.90
	Afforested	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60

Detailed information on the maximum depth of tap roots of *Eucalyptus grandis* does not exist. It is, however, accepted that eucalypt roots can extend very deep into the soil, and a maximum rooting depth of 12 m is assumed to be realistic value for soil and climatic conditions found in the study area (Kienzle and Schulze, 1991).

RESULTS

Simulation results on the impact of afforestation on ground water resources are summarised as follows:

(1) It will take approximately ten years after the first plantation until the water table has stabilised at a new, lowered, level. Fig. 1 shows the water table fluctuation under both present and afforested conditions. The simulations are based on input parameters as described above for the 30-year time period 1960 to 1989. This period represents a typical variation in rainfall pattern, with the occurrence of both wet periods (e.g. 1976/77 or 1984/85) and dry periods (e.g. 1962-1969 or 1980-1983). Under afforested conditions, the water table will continue to fluctuate between times of high recharge during wet years and times of little recharge during dry years. Disregarding the first nine to ten years when the initial drawdown of the water table occurs, the water table will fluctuate, under climatic conditions assumed, by approximately two metres.

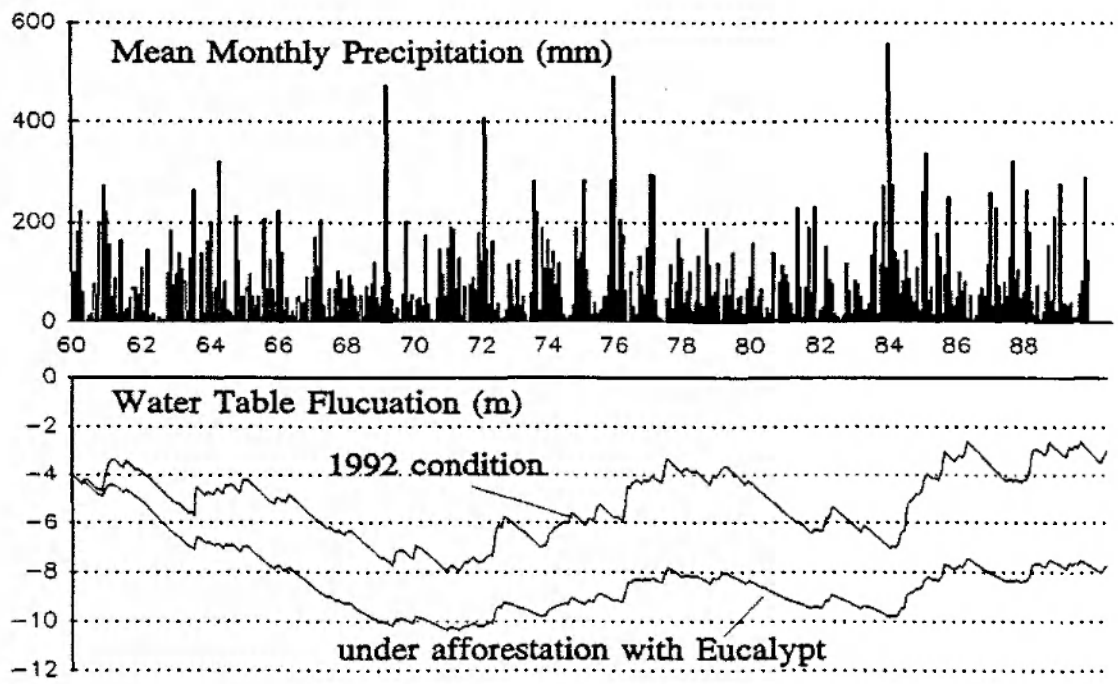

Fig. 1: Fluctuation of rainfall pattern and water table depth over a 30-year period.

(2) Assuming a 1 ha patchwork of plantations in a chessboard pattern, a lowering of the water table of between two and five metres, dependent on prevailing climatic conditions, is predicted for the areas in and between the plantations.

(3) At times of highest water demand by the plantation (when the second and subsequent rotations are between three and four years old), the water table can be lowered by as much as eight metres below normal water table levels within the plantation.

(4) The larger the areal extent of individual plantations, the deeper will the water table be drawn down. This means that the water table depletion under a 1 ha plantation will be less than under a 10 ha plantation. In addition to that, the critical distance to which the lowering of the water table is still effective will be greater with a large plantation than a small plantation.

(5) The lowering of the water table will be most severe in the plantation and will lessen with the distance away from the plantation. Assuming a 1 ha plantation, the lowering of the water table will be effective at a distance up to 150 m away from the planation. This means that under a chessboard patchwork with 1 ha plantations the non-planted areas between the plantations will be affected by a lowering of the water table.

Because the total extent of the proposed plantation is not known, an accurate estimation of effects on the streamflow of the Nyalazi River cannot be given. It is, however, estimated that due to the relatively small total area of the plantations in the study area relative to the entire catchment area of the Nyalazi stream, only insignificant changes in streamflow would occur. The total water lost in an eucalypt plantation due to increased interception and transpiration would be 400 to 500 mm per year. This represents 4000 to 5000 m^3 ha^{-1}. If one assumes, for example, a total afforested area of 100 ha, up to half a million m^3 would be lost. Compared to the total input into the Nyalazi system, up to the study area, by precipitation in the order of 600 million m^3, this represents a small fraction (one in a thousand). The effects of afforestation, therefore, would have negligible regional effects and would be restricted to the area in direct vicinity of the plantations.

RECOMMENDATIONS

Plantations should be as far away as possible from boreholes and streams. In order to protect existing boreholes from drying up or streams and other water bodies from being affected, any plantation should have a "safety distance" of 200 m away from any boreholes, streams or wetlands/swamps. Plantations should be kept to a minimum size, i.e. rather plant a number of small plantations than one large one.

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APPENDIX C

DISCRIMINATING CHARACTERISTICS OF GROWER HOUSEHOLDS

Possible discriminating characteristics of grower households were determined using a linear probability function. Results are shown in Table C.1. Conditional probabilities are shown in Figure C.1.

Table C.1 Results from a stepwise linear regression of grower households on various household characteristics (df = 102; adj. R^2 = 0.78)

Variable	Beta	*t* ratio	Significance
Explanatory variable			
Household head formally employed	- 0.2234	-2.538	0.012
Size of land allocation (ha)	0.0180	2.995	0.003
Length of residence in area (years)	0.0352	8.334	0.000
Length of residence in area^2 (years)^2	- 0.0004	-5.977	0.000
Number of pensioners in household	0.1210	2.063	0.042
Area of cash crop^2 (ha)^2	- 0.0075	- 3.276	0.001
Area of maize fields (ha)	- 0.1497	2.563	0.012
Dependent variable			
Grower household (0 - not a grower; 1 - grower)			

The results show that the likelihood of a household joining the scheme are positively correlated with the size of land allocation and the number of pensioners in the household and negatively correlated with the area of cash crops and the area of maize fields. Families who had resided in an area for about 40 to 50 years were more likely to join than other households.

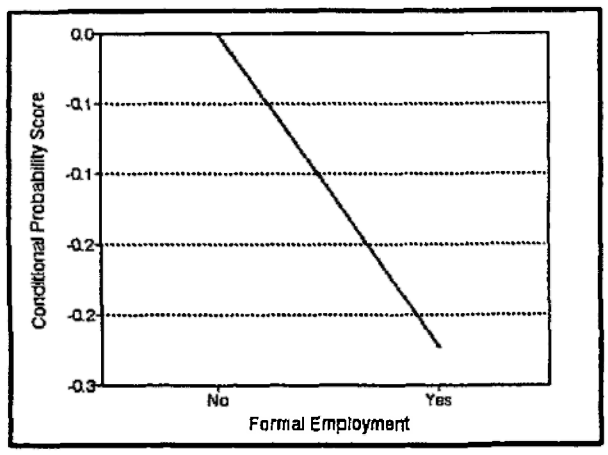

Figure C.1.1 The effect of formal employment of the household head on the probability score

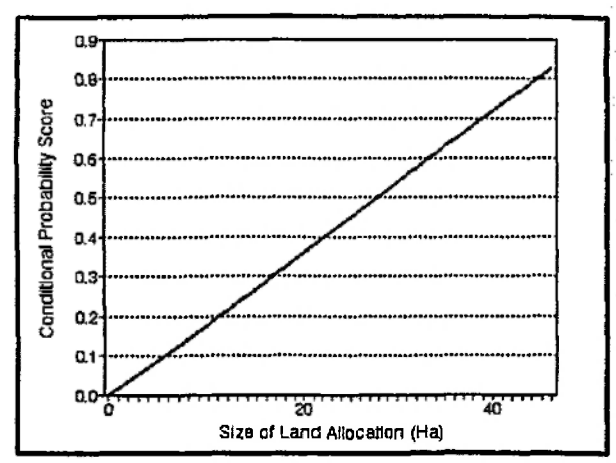

Figure C.1.2 The effect of size of land allocation on the probability score

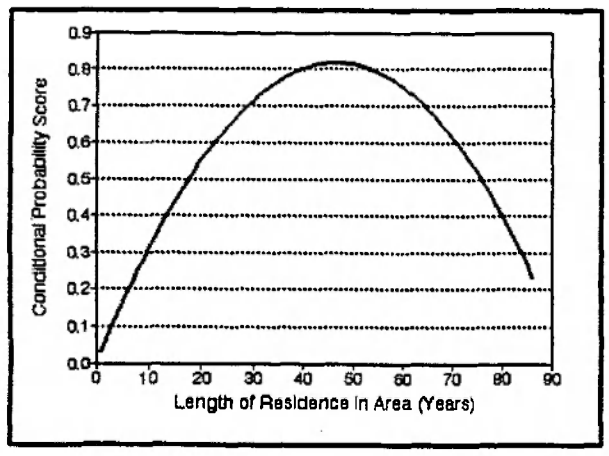

Figure C.1.3 The effect of length of residence of the households on the probability score

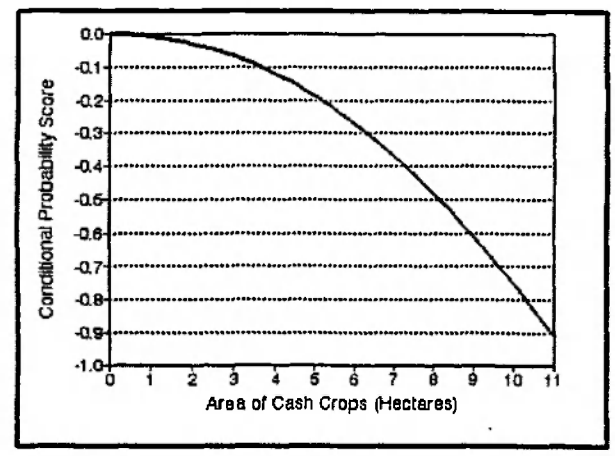

Figure C.1.4 The effect of area of cash crops on the probability score

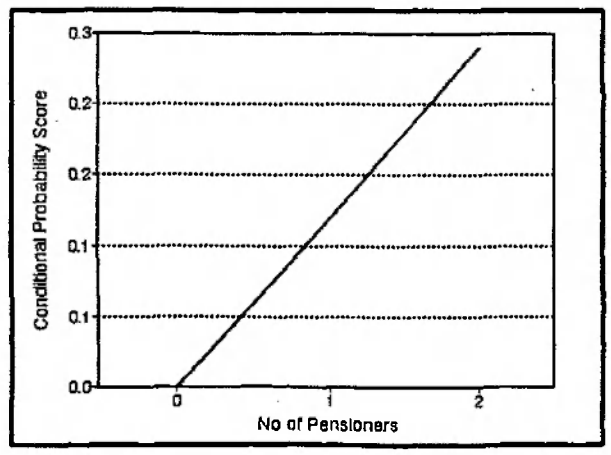

Figure C.1.5 The effect of number of pensioners in the household head on the probability score

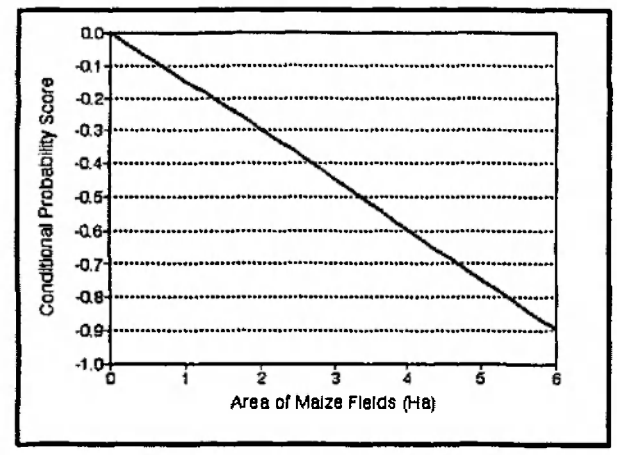

Figure C.1.6 The effect of area of maize fields on the probability score

Figure C.1 Factors effecting the probability of participation in the schemes

However, the function may be misleading due to correlations between explanatory and other household variables (area of cash crops is particularly highly correlated with size of land allocation). For this reason grower characteristics were further studied using factor analysis. Results are shown in Table B.2.

Table C.2 Results from a factor analysis of various household characteristics

	Component number		
Variable	1	2	3
Grower household (0-No; 1-Yes)	0.34*	0.35*	-0.54*
Household head formally employed (0-No; 1-Yes)	-0.42*	-0.40*	0.38*
Size of land allocation (ha)	0.78*	-0.27	0.13
Length of residence in area (years)	0.41*	0.55*	0.20
Number of pensioners in household	-0.11	0.68*	-0.01
Area of cash crop (ha)	0.56*	-0.38	0.06
Area of maize fields (ha)	0.07	-0.10	0.49*
Household owns substantial local business (0-No; 1-Yes)	0.38*	-0.41*	-0.47
Ratio of formally employed household members to other adults	-0.18	0.09	0.29
Number of cattle owned by household	0.71*	0.07	0.40*
Family member a member of the Tribal Authority (0-No; 1-Yes)	0.22	0.60*	0.16
% Variance accounted for by the component	19,3	16,4	11,1
Eigenvalue	2,12	1,81	1,22

* Shows a 9% or greater overlap in variance between the variable and the component

The first factor accounts for 19,3% of the variance amongst the chosen variables and describes characteristics of households with large land allocations. These households are likely to be well established and own relatively large herds of cattle. In coastal areas they have larger sugar and cotton fields. The household head is unlikely to be formally employed, and is not a pensioner, but may be involved in some local business. There is a large ratio of unemployed adults in these households. These households are more likely to join the schemes than households with opposite characteristics.

The second factor accounts for 16,4% of the variance and describes households where either the head or spouse is a pensioner. These households are also long established but have smaller land allocations. The head is not likely to be formally employed or to own a local business but may be a member of the local Tribal Authority. These households are also likely to join the

schemes.

The third component accounts for 11,1% of the total variance. It describes households whose head is formally employed. There is a high ratio of employed adults to other adults. The households may have cattle and maize but are unlikely to join the schemes.

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