

# **Objectives, Subsistence and Farm Development The Case of Tonga**

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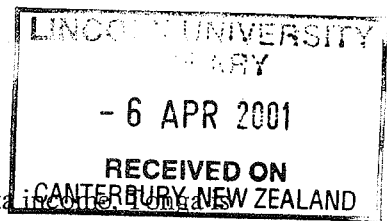
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## 1. Introduction

Characterised by its smallness in terms of population, land area and per capita income, Tonga is geographically fragmented. The smallness and lack of natural resources have led to its economy being overwhelmingly rural and agricultural. Most households derive a major part of their basic requirements from the cultivation and utilisation of land resources.

Agriculture contributes substantially to the general economy of Tonga, as clearly indicated by the sector's contribution of about 40 to 50 percent of gross domestic product (GDP). As a source of foreign exchange through exports, agriculture is by far the most important sector and accounts for the majority of the value of the Kingdom's total exports. Agricultural products have comprised about 70 percent of average total exports over the last ten years (Ministry of Finance, 1998).

Smallholder production is the main mode of agricultural production in Tonga. The 1993 Land Use and Crop Survey conducted by the Ministry of Agriculture and Forestry reported that of the 6665 tax allotments<sup>1</sup> surveyed, 88 percent were farmed by a single farmer and only 12 percent by multiple operators. The survey also showed that 75 percent of the farmers in Tonga farmed less than one hectare of crops and 19 percent farmed between one to 2.5 hectares (MAF, 1994b). The majority of agricultural smallholder producers in Tonga are semi-subsistence farm households. Thus, part of the total product is retained within the household for home consumption and for social and religious obligations. The remainder is sold.

## 2. The Problem

The present state of the economy requires smallholder farmers to commercialise further, and it is believed there is an increased role for the private sector ('Akolo, 1997). The Government accords high priority to export crop diversification in order to move toward more marketable crops, to increase foreign exchange earnings, to further develop a significant agricultural base, and to increase the degree of food security and self-reliance by exploiting the resources more rationally and sustainably. The realisation of these opportunities is, however, constrained by a number of production, marketing and institutional factors, coupled with an unfavourable macroeconomic environment. 'Akolo (1997) recommends that the development of agricultural policy should focus on encouraging entrepreneurial activity among farmers and agricultural service industries, and on building a private sector capacity in areas such as marketing and delivery of services to farmers.

Over the years, the Government and foreign donor agencies have put a lot of effort into the development of agriculture in Tonga. Development programs in the past were mainly commodity oriented and targeted export potential crops. Examples include the banana rehabilitation scheme, the coconut replanting scheme, vanilla development, the squash development project, coffee, yam bean, and other programmes. Ranges of policy instruments have supported these projects in attempts to promote the growth of the agriculture sector and the economy. Instruments include direct expenditure on MAF services, institutional strengthening and

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<sup>1</sup> A tax allotment is a parcel of land (normally 3.3ha) for farming registered under a male citizen over the age of 18

the provision of infrastructure facilities, market information, education, and economic incentives in the form of credit and subsidies.

Experience with agricultural development programs in Tonga, however, has been chequered. Tonga's agricultural economy has failed to expand production to its potential and to keep pace with the growth in imports. The balance of payments situation is structurally weak with too much reliance being placed on foreign remittances and aid to meet the persistent and growing trade deficit. It is evident that development efforts in the agricultural sector have produced little substantive development, and smallholder production has not fully responded. A significant proportion of agricultural development projects intended to assist smallholder agriculture development in Tonga have been uniformly unsuccessful in achieving their objectives of sustained increases in production and productivity (MAF, 1994a). Lavulo (1988) noted that the economic growth targets set by the National Development Plans have not been achieved. For example, the annual growth rate targets set by the Development Plan III (1980/85) and the Plan IV (1985/90), were 5.5 percent and 5.7 percent in their respective planning periods but the achievements were 4.5 percent and 3.4 percent respectively. The agricultural sector, however, was the biggest single contributor to this growth.

In 1992, the Ministry of Agriculture and Forestry (MAF) formulated a Plan of Operation aimed at economic recovery and attainment of the Government's development objectives. Specifically the plan called for doubling the volume of agricultural exports and foreign exchange earnings (from T\$19 million in 1991 to about T\$38 million in 1995). The projected returns from exports and the actual returns are presented in Table 1 and show that targets set proved to be far too ambitious.

**Table 1: Projected and actual export returns (in T\$m) from agriculture products 1991 - 1995.**

YEAR	1991	1992	1993	1994	1995
<i>Projected Returns</i>	19.02	14.97	21.35	30.80	38.06
<i>Actual Returns</i>	16.75	11.39	17.46	12.58	12.43

Source: Statistics Department, 1996

The low productivity of smallholder agriculture has been hotly debated, and explanations are usually given from two different perspectives. Policy makers and MAF argue that low levels of agricultural productivity can be attributed to smallholder farmers' inadequate responses, lack of commitment and poor adoption of improved technologies recommended by MAF (Sisifa *et al.*, 1993). Although many of the agricultural development programs could be faulted, policy makers and government agencies often believe that the most significant factors inhibiting smallholder agricultural production include farmers' attitudes, their traditional social institutions and cultural values. Hau'ofa and Ward (1980) claimed that the traditional culture is sometimes perceived by privileged elites to make the poverty of the masses more bearable. Explanations which emphasise social and cultural causes often cite waste of capital and labour in social and religious events and the resulting inability to save and invest, the low status of agriculture, or a preference for leisure as specific factors which have a negative effect on smallholder agriculture. Sevele (1983) argued that motivation is one of the major social constraints to development of agriculture in Tonga. He raised a conventional view that traditional institutions and behaviour are responsible for agricultural stagnation and that Tongan farmers do respond to market incentives in a predictable way. However, they rarely respond as fully as they could, given their social and resource situations.

The major proposition of this study is that relatively little attention has been paid to decision-makers at the micro-level, and not enough is known of their decision-making processes and strategies. The target group, the *smallholder farmers* are by far the most important element of agriculture development in Tonga, but there is little prior analysis of their needs and capabilities by planning bureaucracies in designing development projects. Agricultural development planners and policy makers from government departments, overseas expatriates and donor agencies have a limited understanding of smallholder farmers' goals, priorities, values and resource limitations, all of which are key aspects of their land use decision making. Many decisions made are based on insufficient and inaccurate assumptions of how farmers make decisions in response to various circumstances. Taylor (1980) pointed out that behaviour and social relationships in a small society are complex and outsiders from metropolitan countries can easily mis-interpret many social situations.

Schoeffel (1991) suggested that the technical design of agriculture development policies and technologies should incorporate a well-informed social and cultural analysis to achieve more realistic projections of outcomes and more effective and sustainable results. According to Gaul (1993), macro and micro-economic, socio-economic, cultural, familial, communal and societal factors affect all development projects. He proposed that an understanding of these factors and their linkages is a necessary ingredient in successful development. Development that ignores them is less likely to be successful and sustainable, both from the viewpoint of the planners and the recipients.

Production function analysis cannot cope with such complexity. Linear Goal Programming can, in principle, reflect the real environment, although its development for the study of smallholder farming has not, so far, been very effectively explored particularly for Tonga and the South Pacific.

### 3. Geographical Background

The Kingdom of Tonga is an archipelago of 172 coral and volcanic islands, of which 36 are inhabited, spread over 360,000 km<sup>2</sup> of territorial seas in the South Pacific. The majority of the islands are very small in size, ranging from those of only a few hectares to Tongatapu, the largest island, with an area of 265 km<sup>2</sup>. The total land area is 747 km<sup>2</sup> aggregated into the four major groups of Tongatapu and 'Eua (370 km<sup>2</sup>), Ha'apai (119 km<sup>2</sup>), Vava'u (143 km<sup>2</sup>) and the two small Niuas (71 km<sup>2</sup>). The largest of these is Tongatapu on which is located Nuku'alofa, the capital, where about 68 percent of the total population live.

The 1996 population census reported a total population of 97,446 broken down into 49,395 males and 48,051 females. There was an annual average population growth of only 0.3 percent in the ten years since the previous census, when the population was 94,649 (Statistics Department, 1996). It was recorded that 68 percent of the total population were residing in the main island, Tongatapu, 16.2 percent in Vava'u, 8.4 percent in Ha'apai, 5 percent in 'Eua and 2.1 percent from the Niuas. The average population density for the Kingdom was 150 persons per square kilometre, which is high compared to other islands in the Pacific, although it varies considerably over the Kingdom.

An estimated population of 45,000 now reside in Australia, New Zealand and the United States (Statistics Department, 1997). Family ties with Tonga remain strong and substantial remittances provide support for levels of consumption that exceed domestic production.

**Table 2: Geographical distribution of the population in 1986 and 1996.**

Division	1986	Percent	1996	Percent	Land Area (km <sup>2</sup> )	Density/ km <sup>2</sup>
Tongatapu	63,794	67.4	66,577	68.3	262	259
Ha'apai	8,919	9.4	8,148	8.4	132	74
Vava'u	15,175	16.0	15,779	16.2	144	132
'Eua	4,393	4.6	4,924	5.0	90	56
Niuas	2,368	2.6	2,018	2.1	70	28
<b>TOTAL</b>	<b>94,649</b>	<b>100</b>	<b>97,446</b>	<b>100</b>	<b>747</b>	<b>150</b>

Source: Statistics Department, 1997

Tonga's level of development is relatively high compared to other Pacific island countries. This is reflected in its per capita income, which was estimated in 1995/96 to be US\$1,909 placing it in the lower middle-income group by world standards (Ministry of Finance, 1998). However, it was reported that the social conditions in Tonga are far superior to those of other lower middle-income countries. Tonga has a lower population growth rate of 0.3 percent; infant mortality rate of about 23 per thousand live births (compared with 2.1 and 59 for other lower middle-income countries); 99 percent access to safe water, and a life expectancy at birth of 70 years (compared to 63.8 for lower middle income countries). Given these social indicators and a traditional social system based upon extended family ties, the incidence of severe poverty is very low in Tonga (ADB, 1996).

## 4. Land tenure system

A country's land tenure system is a critical factor in its economic, cultural and environmental make-up, and to its agriculture and forestry. The livelihood of most Tongans is intimately tied to the land. It is the basis of not merely their immediate subsistence but their cash transactions (Hardaker *et al.*, 1988). Consequently land distribution is fundamental to the organisation of social relations in Tonga. Access to land is crucial to the economic situation, power, prestige and security of any individual or family (ADB, 1995). Tonga has a unique land tenure system, based on the traditional hierarchical structure of society but securing the rights of individual landholders to a degree unparalleled in neighbouring Pacific Islands states. The Land Act elaborates that all land became the property of the Crown and was divided into royal, government and noble estates (James, 1995). From these estates all adult males were entitled to a tax allotment for his garden ('*api tukuhau*) of 3.34 hectares, and a smaller dwelling known as a town allotment ('*api kolo*) of 0.16 hectares. Allotments are made upon application from either the hereditary estates, or from Government land, depending on where the applicant is lawfully resident, and once registered the title is inheritable, according to strict rules of successions set out in the Constitution. There are four land tenure categories - the King's estates, the Royal Family's estates, the estates of the nobles and chiefs, and Government land. Only the last two categories of land are available for allotment as '*api* land.

The 1992 Annual Report of the Minister of Lands, Survey and Natural Resources showed the total registered holdings at the end of 1992 comprised 15,196 tax allotments ('*api 'uta*'), 12,557 town allotments ('*api kolo*) and 3,441 leaseholds ('*api lisi*). The land distribution was as follows:

<i>Allotment</i>	62.8%
<i>Unallocated Government land</i>	11.4%
<i>Unallocated noble's land</i>	6.9%
<i>Leases</i>	8.4%
<i>Small islands, lakes, lagoons</i>	10.5%
	100.00

Source: Statistics Department, 1986

Progressive allocation of allotments has meant that many hereditary estates are now fully allocated, although apparently land is still available for leasing - either formally or informally (and probably illegally). Land scarcity is now a major constraint to agricultural development in Tonga. While it is officially estimated that, today, about 60 percent of eligible people do not have a tax allotment, most people do have access to garden land, either the land of kin, in-laws or friends, or land leased from the Government, nobles or other allottees. These measures enable the necessary adaptation of what would otherwise be a rigidly equal distribution of land. Fukofuka (1994) argued that the present system constrains development and the whole land tenure system should be reviewed to counter the following problems;

- the increasing number of absentee landowners; about 10 per cent of those with tax allotments are now residing in a foreign country.*
- the difficulty of obtaining long-term leases of tax allotments from the tax allotment holders.*
- the high cultural value attached to land has meant that allotment holders, even those overseas, hold on to their land which they do not use, but which they regard is important to their security, status and identity (Fukofuka, 1994, p 147).*

## 5. Economic background

The economy of Tonga has three dominant features: a large semi-subsistence agricultural sector, a high degree of dependence on imported capital and consumption goods, and comparatively high inflows of finance in the form of remittances from Tongans living abroad. Foreign exchange is centered on the exports of two main commodities: *people* and *agricultural produce*. Whilst agriculture is vitally important to Tonga, both in an economic and social context, the economy is also under-pinned by remittances from the large expatriate population and by foreign aid assistance. Emigration has played an important role in the economy. About 45,000 ethnic Tongans are estimated to be residing abroad mainly in New Zealand, Australia and the USA. The World Bank (1996) estimated cash remittances from overseas residents to be about T\$40 million per annum or equivalent to 20 percent of nominal GDP. Despite a reduction in the cash remittances over the

years, there has been significant upsurge in the provision of remittances in kind, mostly consumer durables and light consumer goods.

The Tongan economy is also characterised by a heavy dependence on imports. The ratio of imports to GDP is more than 50 percent, and taxes on imports are one of the main sources of government revenue. The country is also a net agriculture/food importer (ADB, 1995). Agricultural imports account for more than 25 percent of total imports and food imports constitute more than 80 percent of total agricultural imports. Though the ratio of imports to GDP has slightly declined, to 50 percent in 1992-93 from 67 percent in 1980-81, the trade deficit increased to T\$66.8 million in 1992 from T\$23.2 million in 1980 (NRBT, 1995). Table 3 shows the major items in the Tongan balance of payments for the period 1991/92 to 1996/97.

Table 3: Balance of payments (T\$ million; fiscal years ending June 30<sup>th</sup>).

	1991/92	1992/93	1993/94	1994/95	1995/6	1996/7
Merchandise Exports fob	21.9	16.3	22.0	21.9	15.9	16.2
Merchandise Imports fob	63.1	67.7	74.6	94.7	83.5	73.4
<b>Trade Balance</b>	<b>-41.2</b>	<b>-51.4</b>	<b>-52.6</b>	<b>-72.8</b>	<b>-67.6</b>	<b>-57.2</b>
Net service receipts	-6.6	-3.2	-7.7	1.6	7.9	8.2
Net investment income	3.0	3.1	3.2	1.3	0.8	1.8
Net transfers received	47.3	57.4	46.3	41.5	45.4	45.4
Current account balance	2.6	5.9	-10.9	-28.4	-13.4	-1.8
Capital account balance	6.0	4.2	4.5	11.8	10.7	7.3
<b>Overall balance</b>	<b>8.6</b>	<b>10.1</b>	<b>-6.4</b>	<b>-16.6</b>	<b>-2.7</b>	<b>5.4</b>

Source: NRBT, 1996 and 1997

The trade balance runs at a considerable deficit but this is mostly offset by private and official in-flows and tourism receipts. While Tonga's exports increased during the 1990s, imports also increased rapidly resulting in persistent large trade current account deficits (ADB, 1995). The trade deficits are usually financed out of the surplus of services, remittance income and official transfers. The trade deficit, which was T\$23.2 million in 1980, reached T\$52.5 million in 1990 and T\$67.6 million in 1995.

## 6. The Agriculture Sector

The agricultural sector has maintained a significant role in the economy as the major contributor to GDP, as shown in Table 4.

Table 4: Contribution of agriculture to gross domestic product (GDP).

YEARS	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture as % of GDP	38.9	38.0	36.7	35.1	36.9	38.1	38.6	35.8	35.2	35.1

Source: ADB, 1996; NRBT, 1997

Almost 80 percent of the agriculture production is for the domestic market with the remaining 20 percent produced for export. Domestic production concentrates largely on traditional root crops, namely yam, taro, cassava and sweet potatoes. For the export market, squash and vanilla are the two leading crops, while kava and watermelon are gaining importance. The volume of food-crop production in Tonga has remained high over the years. Table 5 shows the total area and quantity of crops recorded in the Land Use and Crops Survey (MAF, 1994b).

Table 5: Production estimates of major crops grown in Tonga in 1993.

Individual Crop	Area (ha)	Production (tonnes)	Percentage of Total Area
Cassava	2647.0	45,786.3	39.1
Squash	2113.0	20,890.0	17.8
Taro	1532.1	16123.8	11
Bananas	743.8	9655.4	8.3
Giant taro	7082	8,751.0	7.5
Yam	617.4	7345.7	6.3
Sweet Potato	564	5,575.6	4.8
Pineapple	140.9	2,263.3	1.9
Potatoes	80.5	995.0	0.8
Kava	250.5	928.5	0.8
Vegetables	46.7	513.6	0.4
Watermelon	67.5	834.0	0.3
Vanilla	803.6	397.1	0.3

Source: MAF, 1994b

However, according to the World Bank (1990) the true value added and contributions of agriculture to the economy are grossly understated by at least 25 percent. The understatement is related to underestimation in agricultural production for home consumption as well as marketed production for local and export markets.

## 7. Performance of the agriculture sector

Agriculture has undergone major changes in the past decade, as has the Tongan economy. Table 6 shows the significant contributions of agriculture to Tonga's export earnings.

Table 6: Contribution of agriculture to Tongan export earnings.

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
<i>Commodity</i>	<i>(in FOB T\$million)</i>									
Fruits	2.02	1.26	0.40	0.43	0.19	0.14	0.12	0.08	0.19	0.13
Coconut	1.63	1.14	0.86	0.40	0.68	1.05	0.33	0.14	0.16	0.24
Squash	0.09	0.54	1.98	4.84	11.16	7.32	17.56	11.38	5.88	5.44
Vegetables	0.03	0.00	0.03	0.01	0.04	0.01	0.04	0.02	0.03	0.09
Root crops	0.66	0.62	1.57	1.46	1.73	0.93	1.47	1.11	2.38	2.01
Vanilla	1.22	1.39	2.07	2.77	5.48	1.51	3.17	1.56	2.44	0.87
Other	0.16	0.07	0.06	0.02	0.25	0.38	0.23	1.23	1.11	2.39
<i>Agriculture</i>	<i>5.91</i>	<i>5.23</i>	<i>7.18</i>	<i>10.11</i>	<i>19.53</i>	<i>11.34</i>	<i>22.92</i>	<i>15.52</i>	<i>12.19</i>	<i>11.17</i>
<i>% of Exports</i>	<i>67</i>	<i>55</i>	<i>62</i>	<i>70</i>	<i>81</i>	<i>77</i>	<i>82</i>	<i>84</i>	<i>67</i>	<i>74</i>

Source: ADB, 1996; NRBT, 1997



The Tongan trade figures showed significant decreases, or eventual disappearance, from trade statistics of just about all the exports such as banana, copra and root crops which had been dominant in the 1970's and early 1980's (World Bank, 1993). That Tonga's trade deficit decreased from T\$102 million in 1988 to T\$97 million in 1993 is an achievement in comparison to other islands in the Pacific. .

## **8. Data Collection for Developing the Analytical Model**

An independent village survey was used as the main source of primary data for this study. The survey was conducted during the main field research visit from December 1997 to March 1998. The main fieldwork gathered primary data in order to develop a conceptual framework of smallholder decision making and to assist in model design. The premise for this framework was that land is the most critical resource in Tongan agriculture and therefore attention is focussed on land use decisions. This meant, amongst other things, being able to identify farmer's goals and priorities, and to quantify accurately for each village and region such economic parameters as;

- the resource endowment in terms of land, labour and capital,
- the level and composition of subsistence production, consumption, and investment,
- the level and sources of cash income and use,
- the level and means of cash consumption expenditure, investment and savings,
- some of the important linkage factors such as cash returns to labour in the production of farm outputs.

## **9. Farming system household survey**

The household head is traditionally the father or the most senior male member, and normally is the inheritor of the land. He directs most of the affairs of the household both internally and externally. The household head was therefore selected as the person for interviewing on behalf of the household. The farm household survey was undertaken to generate primary data of the farming systems, both quantitative and qualitative information, to allow a quantitative representation of the farm-household system such as required in mathematical programming models

In addition to the farm households, interviews were conducted with key people and groups in the village including,

- *Village chief or noble*
- *Village officer*
- *Village Church leaders*
- *Village committees or District agricultural committees*
- *Grower's group*
- *Women's group*
- *Agricultural Extension Officer*
- *NGO's and other development groups*
- *Village elders*
- *Progressive farmers*
- *Agricultural exporters*
- *Tonga Development Bank Officers*

No attempt was made to draw a random sample of households over the whole of Tonga; instead a small number of villages was selected and a sample of households in each was studied. Due to the limited time and resources available for fieldwork, it was decided to concentrate on the island groups of Tongatapu, Ha'apai and Vava'u. Geographically, these islands also make up the three main regions of Tonga. These three regions account for approximately 80 percent of the total land area and contained, in 1996, over 90 percent of the total population. The study compares the three major regions, which were selected because of the markedly different levels of market incentives. Each provides an independent case study of economic behaviour concerning land use decisions in semi-subsistence village communities.

Table 7: Population of the six villages by sex, 1986 and 1996.

VILLAGE	1986				1996			
	Total No. of HH*	Total Males	Total Females	Total People	Total No. of HH	Total Males	Total Females	Total People
Navutoka	115	360	366	726	131	403	409	812
Masilamea	37	135	142	277	36	136	131	267
Tefisi	85	263	242	505	100	315	313	628
Feletoa	72	229	256	485	58	182	212	394
Ha'ano	46	108	106	214	34	86	76	162
Koulo	45	134	141	275	38	122	138	260

Source: Statistics Department, 1997

\*HH = households

A sample of 18 households randomly selected were interviewed in each of the six-selected village. The sample represents more than 50 percent of the village population in the smaller villages (like Ha'ano (53%), Koulo (47%), Masilamea (51%)) and at least 20 percent of larger villages of Navutoka (15%), Tefisi (21%) and Feletoa (25%). Detailed data on farmers' goal ranking, and information on the previous cropping year's farm operation was used as the basis for the collection of primary data. The information for designing the model was collected from a sub-sample of 16 farmers drawn from the main sample. This was judged to be enough for the intended analysis while being manageable with the limited time and resources available.

## 10. Goal Specification of Tongan Smallholder Farmers

One of the main concerns in the analysis of multiple goal decision making problems is the presence of incompatible or conflicting multiple goals. In goal programming, the ranking of the various goals is necessary. Data collected allowed the objectives and priorities to be described and ranked. Using pilot surveys with smallholder farm households, discussions with key informants, secondary information, and the author's experience, six potential production objectives were identified for use.

- Objective 1: Household sustenance - provide household with secured supply of staple food.
- Objective 2: Use food, other products and cash for fulfilment of religious obligations.
- Objective 3: Use or exchange food and other products for social obligations to family, relatives and community.
- Objective 4: Cash – to accumulate cash for priority household demands.
- Objective 5: Risk – minimise economic risk.
- Objective 6: Leisure – organise work to have more leisure.

The smallholder farm household objectives and priorities were first specified using a series of open-ended questions in the farm household interview questionnaire. Farms were ranked into three homogenous groups based on a number of factors. These included the cropped area or farm size; and the degree of commercialisation (*subsistence, emergent and progressive*).

The general approach was to first rank all the objectives in order of preference and assign weighting factors to the objectives. Explicit weights are used to indicate the importance of one goal relative to all others. No single standard procedure exists for describing weights explicitly. A number of techniques have been used for the empirical measurement of farmers' goals (Patrick and Kliebenstein, 1980). No single method is correct, thus precluding all others from use. However, decisions on the method to use depend on the situation or whichever method is most appropriate for the decision-maker. Costa and Rehman (1999) noted some of the techniques involved presenting respondents with a predetermined statements on objectives such as paired

comparisons, rating scales and magnitude estimations. Magnitude estimation is more difficult to implement with the respondents and is, therefore, not used much. Paired comparisons and rating scales have provided similar rank for objectives in both studies with the former being the easiest to administer, as respondents are only asked which of the two alternatives they prefer. The general approach was to first rank all the goals in order of preference and assign weighting factors to the goals. The weights enable goals to be included in the multi-objective programming objective function.

Objective weighting was accomplished using the magnitude estimation method which is a more direct approach for obtaining ratio scaled preferences (Stevens, 1966). The six goals were presented to the respondents with the request to rate the importance of each goal. The rating values ranged from 0 to 10. More than one goal can have the same rating. The lower limit of 0 indicates no importance of the objective while the higher limit refers to the value of maximum possible importance. Responses from the three main farm types are summarised in Table 8.

**Table 8: Importance weighting of objectives by each farm category.**

FARM TYPES	Subsistence	Emergent	Progressive	
<b>Goals</b>	<i>Weight</i>	<i>Weight</i>	<i>Weight</i>	<i>LSD (5%)</i>
1. Home sustenance	10.00	10.00	10.00	0
2. Risk minimisation	8.30	7.20	3.80	0.64
3. Religious obligation	6.60	7.80	6.70	0.57
4. Social obligations	4.40	4.90	5.10	0.51
5. Leisure time	4.00	2.60	1.50	0.67
6. Profit maximisation	1.20	3.40	8.30	0.54
<i>LSD (5%)</i>	<i>0.47</i>	<i>0.62</i>	<i>0.48</i>	

Importance Scale: 0 = Not important at all; 10 = Extremely important.

Sample data (n = 108) ; LSD values p < 0.005)

Source: Field survey, 1998

This number reflects the importance associated with the minimisation of a deviation variable assigned to a given objective. The statistical assumptions are relatively simple and the technique can be used to find target levels of specific goals. Unlike paired comparison, magnitude estimation yields scores which represent the individual farmer's goal hierarchy. Because of the assumed scale properties, goal scores are comparable across individuals and scalar transformation of these scores is permitted. The goal information derived from magnitude estimation is suitable for developing a multiple goal programming model.

## 11. Land Tenure of Sample Households

The total number of tax allotments, and farmer allotments for the different island groups is presented in Table 9.

**Table 9: Percentage of farmed tax allotments for the three main island groups in 1992.**

	Tongatapu	Vava'u	Ha'apai
No. of tax allotments	9723	2547	1593
No. of farmed tax allotments	2474	1421	1029
Percentage of tax allotments farmed	25	56	65

Source: MAF, 1993

A large proportion of the total number of tax allotments (65 percent) and farmed tax allotments (46 percent) are located in the main island of Tongatapu. The relatively low percentage of tax allotments that are farmed in Tongatapu (25 percent) points to the presence of employment opportunities in sectors other than agriculture. These figures show that Tongatapu plays a predominant demographic and economic role within Tonga compared to that of other islands, including Vava'u and Ha'apai. It is clear there is still much unused land, of good quality which provides potential for increasing output.

Table 10 shows the number of active farmers surveyed and the number and percentage of those farming land that belongs to others. With the percentage of households that do not own any tax allotment, ranging from a low of 11 percent in Navutoka and Ha'ano to a high of 56 percent in Feletoa, it is also clear there is a land shortage through distribution problems.

**Table 10: Land tenure status and access.**

ISLAND GROUP	Tongatapu		Vava'u		Ha'apai	
	Navutoka	Masilamea	Tefisi	Feletoa	Koulo	Ha'ano
<i>Number of Households</i>	131	36	100	58	38	34
<i>Number of HH Surveyed</i>	19	19	18	18	18	18
% Households without land	11	44	28	56	33	11
% Households that farm borrowed land	47	68	72	72	78	78
% Households with leased land	5	5	0	6	0	0

Source: Field survey, 1998

Someone who does not hold land can, however, obtain land for food production and cash cropping through farming on other people's land, using short-term informal arrangements with relatives, friends, villagers and estate-holders.

## 12. Household Cash Income

Table 11 contains information on household income sources, including farm (crops, livestock, trees, handicrafts sales) and off-farm income. Off-farm income is the sum of earnings from full time or casual employment, remittances from overseas, gifts (cash and in kind received within Tonga) and other income. Information on household income is important not only in assessing the significance of agriculture as a source of income but it also provides an indication of the return to agriculture relative to other sources of income. An important feature of the households studied was that almost all obtained income from more than one source during the period under consideration. Table 11 shows the five major sources of income, that is agriculture, wage employment, fishing and other business, gifts and remittances (from relatives and friends), and exchange of mats and tapa. Although this range of cash earnings featured in all the six selected villages, there was significant variability amongst them.

Table 11: Average household cash income by source by village.

VILLAGE		Agriculture	Wages	Remittances	Business	Exchange	Total Income
Tefisi	A	100%	39%	61%	17%	44%	
	B	3350	1251	481	36.1	500	5618
	C	60%	22%	9%	1%	9%	
Feletoa	A	100%	50%	89%	6%	28%	
	B	2746	1227	861	28	378	5240
	C	52%	23%	16%	1%	7%	
Ha'ano	A	83%	28%	94%	39%	28%	
	B	1215	516	852	522	264	3369
	C	36%	15%	25%	15%	8%	
Koulo	A	83%	44%	94%	39%	61%	
	B	1456	820	870	620	577	4343
	C	34%	19%	20%	14%	13%	
Navutoka	A	68%	21%	89%	68%	5%	
	B	1754	468	878	1948	42	5090
	C	34%	9%	17%	38%	1%	
Masilamea	A	79%	42%	95%	11%	0%	
	B	3250	1229	950	316	0	5745
	C	57%	21%	17%	6%	0%	
LSD <sup>2</sup> (0.05)		894	996	561	562	331	1333

Row A is the percentage of households receiving income from the various sources; Row B is the total cash received (T\$) from each source; C is the percentage of Total Income from that source. LSD values  $p < 0.005$

Source: Field survey, 1998

### 13. Variation in income among villages

In Ha'ano village (Ha'apai), remittances are the major source of income, averaging 35 percent, followed by agriculture (29 percent) and wages (21 percent). In Koulo village (Ha'apai), income derived from wage employment was, surprisingly, the main source of income. The location of the airport in the village and the closeness to Pangai, the capital, provides more opportunities for paid employment which accounts for a majority of households earning. The farm labourer groups *kautaha* are also dominant, so agricultural labourer earnings also contribute. Some households are also involved in commercial fishing, and womens' groups exchange mats and handicrafts.

In Navutoka (Tongatapu), on the other hand, gifts and remittances, and fishing, business were the major sources of household cash income, comprising about 37 percent and 30 percent respectively. Agriculture accounted for 20 percent and wage employment for 12 percent. Data in Table 12 shows the breakdown of household income level per village. In Ha'ano, 44 percent of households received a total annual income of less than \$2000, and 66 percent received between T\$2000 to \$5000. In contrast, in Masilamea village none of the household had a total annual income of less than T\$2000, while more than 50 percent received income of more than T\$5000. This has resulted from a majority of households engaging in commercial agriculture, as indicated by the highest average income from agriculture.

<sup>2</sup> Fisher's Least Significant Difference

Table 12: Percentage households by income category.

Village	0 - T\$2000	T\$2001-5000	T\$5001 plus
Tefisi	28	39	33
Feletoa	6	61	33
Ha'ano	44	66	0
Koulo	17	72	11
Navutoka	16	58	26
Masilamea	0	47	53

Source: Field survey, 1998

## 14. Household Cash Expenditure

The Tongan smallholder household's expenditure pattern shows a similar pattern to that found in most developing countries. Despite a much lower cost of living, the average household income level is far from adequate. The pattern of expenditure revealed in this study also reflects the goals and priorities that households have. The present study showed the major categories of household expenditure include food, cash contributions to the church, social obligations, education, household utilities (including, maintenance, electricity, telephone, water), tobacco and kava. Details of the average patterns of village household expenditure are summarised in Table 13.

Household expenditure varies among villages, with average expenditure ranging from T\$1923 in Ha'ano to T\$4260 in Masilamea. Expenditure on Ha'ano that proved to be significantly lower than the other villages and reflects the more subsistence mode of living, and the village's isolation from public facilities such as electricity and telephone.

Table 13: Distribution of major household expenditure per village.

VILLAGE	Food	Church	Social	Educat*	Utility	Tob/Kava#	Other	Total
Tefisi A (T\$)	1352	834	186	156	450	287	178	3438
Tefisi B (%)	39	24	5	5	13	8	5	
Feletoa A (T\$)	1334	880	194	241	399.8	398.9	206	3655
Feletoa B (%)	37	24	5	7	11	11	6	
Ha'ano A (T\$)	709.7	641	159	209	28.7	158.9	16.7	1923
Ha'ano B (%)	37	33	8	11	2	8	1	
Koulo A (T\$)	1020	922	233	217	215.1	346.5	27.8	2981
Koulo B (%)	34	31	8	7	7	12	1	
Navutoka A (T\$)	1142	676	219	327	466.3	264	36.8	3121
Navutoka B (%)	37	22	7	11	14	8	1	
Masilamea A (T\$)	1930	974	211	258	526	297	63.2	4260
Masilamea B (%)	45	23	5	6	12	7	2	
LSD (0.05) (T\$)	39	25	6	7	11	9	3	1090

Row A is the amount spent (T\$/year), Row B is the percentage of Total Expenditure (%)

Educat\* = education

Tob/kava# = tobacco & kava

Source: Field survey, 1998

## 15. Goal Levels

The first goal relates to self-sufficiency in home food as farmers must produce adequate staple food for home consumption and avoid purchasing staple food (yam, taro, kumara and cassava) and pigs. The important staple crops consumed on Tongan farm households are yam, taro, cassava and sweet potatoes. Of these cassava and sweet potatoes are consumed throughout the year, as they do not have any seasonality in agronomic terms. Most of these crops are harvested in small quantities once or twice a week depending on the food needs of the household.

Table 14: Annual minimum requirement for the objective components for emergent farmers in Tongatapu.

Components	Yam	Taro	Kumara	Cassava	Porker (head)	Cash (T\$)
Home consumption	1200 kg	3000 kg	2200 kg	3000 kg	3	3000
Church requirement	500 kg	200 kg	200 kg	200 kg	6	905
Social consumption	500 kg	600 kg	200 kg	1000 kg	3	420
Planting material	800 kg					

Source: Field survey, 1998

In order to reflect the possibility of producing less, or greater levels, the Goal Programming constraints were formulated as, for example, the following equation for staple food requirement.

$$b_i = f_h^{c_j} - f_{h_n}^{c_j} + f_{h_p}^{c_j}$$

$$i, j = 1, 2, \dots, 5 \quad i = j$$

where:  $f_h$  = level of home food consumption

$b_i$  = target level ( $b_1 = 1000\text{kg}$ ,  $b_2 = 3000\text{kg}$ ,  $b_3 = 3000\text{kg}$ ,  $b_4 = 2200\text{kg}$ ,  $b_5 = 3$  head)

$c_j$  = commodity type ( $c_1 = \text{yam}$ ,  $c_2 = \text{taro}$ ,  $c_3 = \text{cassava}$ ,  $c_4 = \text{kumara}$ ,  $c_5 = \text{porker}$ )

The variables with the subscripts  $h_n$  and  $h_p$  are the negative and positive deviations respectively. The objective in the goal constraint is to minimise the under supply.

## 16. Minimise risks

Another goal is reflected in the emergent smallholders adopting production systems that put an emphasis on food security and risk avoidance. The production and on-farm storage of minimum staple food requirements, intercropping, crop diversification, planting of drought resistant crops and the fragmentation of individual holdings are all symptomatic of a desire to ensure that subsistence requirements are satisfied.

The security requirements operate as a constraint on the satisficing objective so there is a cost providing against ruin. This cost is the difference between the maximum expected income in the absence of the risk requirement. The smallholder is assumed, therefore, to minimise the cost of providing against the ruin by maximising expected goal attainment subject to ensuring that his subsistence requirement is met under the most adverse conditions he considers likely to arise. Crop outputs are specified in terms of their physical yields so that they can relate directly to the staple food requirements. The security constraint set ensures that taro, yam, sweet potato and cassava production in a poor year is at least equal to each basic subsistence requirement.

Thus, the goal of minimising risk was incorporated in the Goal Programming model as the following system constraint:

$$C_p^{c_j} = P_p^{c_j} - M_p^{c_j}$$

$$j = 1, 2, \dots, 4$$

where:  $C_p$  = minimum annual food consumption in a poor year  
 $P_p$  = total production in a poor year  
 $c_j$  = commodity type ( $c_1$  = yam,  $c_2$  = taro,  $c_3$  = cassava,  $c_4$  = kumara,) and  $M_p$  = quantity of product sold in a poor year at the associated price.

## Leisure

The final goal is to allow adequate time for leisure and was included in the Goal Programming model through the equation:

$$L_m = L_t^m - l_n^m + l_p^m$$

where:  $L_t^m$  = Leisure hours in each month  
 $m$  = month (1, 2, 3, ..., 12)  
 $L_m$  = monthly leisure requirement level  
and  $l_n^m$  = negative deviation and  $l_p^m$  = positive deviation in  $m^{\text{th}}$  month.

The demand for leisure was treated in much the same as the demand for staple food and cash consumption, incorporating it in the goal constraints. The amount of leisure (for 2 labour units) taken is constrained by the amount of productive work to be done and the total time available for allocation between farm work and leisure. From survey results a minimum leisure requirement of 192 hrs per month for emergent farm household was included except in December and January which were given 280 and 230 hours respectively. The objective in the goal constraint is to minimise the under achievement of leisure monthly requirements  $l_p^m$  or to maximise overachievement if in fact the minimum can be more than satisfied.

## 17. The Combined Objective Function

The motivation contained in the objective function reflects the demand of a semi-subsistence farmer to ensure that there will be sufficient production to meet family consumption needs (home, religious, social); ensure that adequate cash is generated for cash consumption requirements (living cost, social and church donations); ensure safety requirements are met or risk minimised, and ensure leisure requirements are met. This is achieved by minimising:

$$\begin{aligned} \text{Min} Z = & w_1 \sum_{j=1}^5 f_{h_p}^{c_j} + w_2 \sum_{j=1}^5 f_{c_p}^{c_j} + w_3 \sum_{j=1}^5 f_{s_p}^{c_j} + w_4 \sum_{m=1}^{12} E_{h_p}^m + w_5 \sum_{m=1}^{12} E_{c_p}^m + w_6 \sum_{m=1}^{12} E_{s_p}^m \\ & + w_7 \sum_{m=1}^{12} l_p^m + w_8 SC_p \end{aligned}$$

where:  $w_i$  = goal weights for under achievement of goals respectively; ( $w_1$  = home food,  $w_2$  = church food,  $w_3$  = social food,  $w_4$  = home cash,  $w_5$  = church cash,  $w_6$  = social cash,  $w_7$  = leisure,  $w_8$  = profit),  $f$  = staple food requirement level;  $E$  = minimum cash requirement;  $c_j$  = crop type ( $c_1$  = yam,  $c_2$  = taro,  $c_3$  = cassava,  $c_4$  = kumara,  $c_5$  = porker),  $h$  = home requirement,  $s$  = social requirement,  $c$  = church requirement,  $m$  = month (1, 2, ..., 12),  $l$  = leisure requirement,  $SC$  = surplus cash at end of April, and the variables with the subscript  $p$  (positive deviation) is referred to as deviational variables which represent the kilograms of crop, number of pigs, or cash under production relative to the minimum target level required.



## 18. Validation

Validation helps ensure that the input-output coefficients in the model closely resembled the real coefficients. This is achieved by constraining the model to the land use pattern of a previous season to determine aggregate requirement for each input and the output predicted by the model. The predicted values are then compared with the actual outputs. The data used in the validation procedures was derived from the field survey.

These results led to a readjustment of the objective function. The solution from the first run, despite showing little difference to the existing operation with all the goals being achieved, gave higher priority to meeting subsistence requirements with lower surplus produce and cash output than might be expected. In other words, farmers prefer more surplus produce to sell for cash once the subsistence requirement levels are attained. This resulted in a modification of the objective function by including both the under-achievement and over-achievement deviation variables in the objective function. Weights were then attached also to the overachievement of goals, with more weight given to surplus cash and leisure compared to subsistence food and minimum cash requirements. Thus, the objective was modified to:

$$\begin{aligned}
 MaxZ = & -w_1 \sum_{j=1}^5 f_{h_p}^{c_j} + w_2 \sum_{j=1}^5 f_{h_n}^{c_j} - w_3 \sum_{j=1}^5 f_{c_p}^{c_j} + w_4 \sum_{j=1}^5 f_{c_n}^{c_j} - w_5 \sum_{j=1}^5 f_{s_p}^{c_j} + w_6 \sum_{j=1}^5 f_{s_n}^{c_j} \\
 & - w_7 \sum_{m=1}^{12} E_{h_p}^m + w_8 \sum_{m=1}^{12} E_{h_n}^m - w_9 \sum_{m=1}^{12} E_{c_p}^m + w_{10} \sum_{m=1}^{12} E_{c_n}^m - w_{11} \sum_{m=1}^{12} E_{s_p}^m + w_{12} \sum_{m=1}^{12} E_{s_n}^m \\
 & - w_{13} \sum_{m=1}^{12} l_{p}^m + w_{14} \sum_{m=1}^{12} l_{n}^m - w_{15} SC_p + w_{16} SC_n
 \end{aligned}$$

where:  $w_i$  = goal weights for under and over achievement of goals respectively; ( $w_{1,2}$  = home food,  $w_{3,4}$  = church food,  $w_{5,6}$  = social food,  $w_{7,8}$  = home cash,  $w_{9,10}$  = church cash,  $w_{11,12}$  = social cash,  $w_{13,14}$  = leisure,  $w_{15,16}$  = profit),  $f$  = staple food requirement level;  $E$  = minimum cash requirement;  $c_j$  = food type ( $c_1$  = yam,  $c_2$  = taro,  $c_3$  = cassava,  $c_4$  = kumara,  $c_5$  = porker),  $h$  = home requirement,  $s$  = social requirement,  $c$  = church requirement,  $m$  = month (1, 2...12),  $l$  = leisure requirement,  $SC$  = surplus cash in April, and the variables with the subscripts  $n$  (negative deviation) and  $p$  (positive deviation) are referred to as deviational variables which represent the kilograms of crop, number of pigs, or cash of over, or under, production relative to the minimum target level required.

The new objective function is to maximise the net value of weighted under and over achievements. The weight on the positive deviation reflects the importance attached for a goal to be achieved while weights on the negative deviation reflects the value of overachievement of the same goal.

## 19. Policies for Development

The smallholder agricultural performance is influenced by four main variables which are subject to policy intervention. Firstly, there is the limited availability and access to agricultural land, therefore it is a priority for the government to explore the scope for land reform. Evidence of increasing landlessness and under-utilisation of existing land indicates that there is scope for some land reforms measures to achieve agricultural growth objectives.

Secondly, there is a key role for agricultural research and technology development. The availability of appropriate improved technology, which is the prime responsibility of the Ministry of Agriculture and Forestry research and extension division, could be improved. Many currently used technologies have varied success due to different agro-ecological conditions; hence there is a need for more on-farm trial adaptive research to provide alternative technically feasible technologies. Thirdly, there is a need for a policy

environment which is conducive to the adoption of improved technologies. Since both market and institutional support service failures are important causes of poor performance, the impact of market and credit policies need further exploration. Finally, analysis should focus on farmer's goals and priorities. Understandably, the Government cannot directly change people's motivation and priorities but can set policies to encourage change in these personal characteristics through activities of education and supporting services. There is a need for farmers' motivation to be in line with national objectives. Key issues for this analysis include the non-economic objectives for church and social obligations that influence land use decisions.

Most farmers are reluctant to develop their land to any substantial extent unless they are certain that the improved land will remain theirs. So, this insecurity of tenure is one of the most serious factors retarding agricultural development in Tonga. This is consistent with the findings of others such as Hardaker, (1975), Crocombe (1975), Delforce, (1990) and Fukofuka (1994), who found the indigenous land tenure system is a static constraint, providing insufficient security to induce farmers to make land improvements or intensify production. Crocombe (1975) claimed that the system worked in 1985 when it was first formalised when the population was less than 20,000 people and enough land to allow the 3.34 hectares for every man. However, with the current five-fold increase in population, the land tenure system is no longer sensible thus needing a review of land tenure system. Relatively few agricultural holdings remain to be distributed so that unless the government changes the policy, future population growth will produce a marked increase in the number of landless families. Consequently, an important topic is the examination of policy impacts to reduce landlessness and improve access to land.

A possible land reform option involves redistributing land among holdings by means of reducing the ceiling on the size of holdings and by consolidation of tiny parcels of lands and the imposition of an upper limit on the size of holding that could be owned by any one family. Hardaker (1975) recommended redistribution of land currently held as Government, Noble's and Crown estates as tax allotments, or a compulsory subdivision of present tax allotments, as a viable strategy for solving the landlessness problem in Tonga. The objectives of pre-emptive structural reforms would seem to require at least the greater security of tenure to encourage on-farm investments.

In this model experiment it is assumed that the government is considering the option of subdividing the existing tax allotment (3.34 ha) quota that each man is entitled to. Important issues that policy makers need to address include what constitutes a "sufficient" size of holding and how to ensure efficiency and equity in the redistribution of land. The first consideration in determining the appropriate size for subdivisions of existing allotments is that the new holding should be large enough to provide the family with an adequate livelihood and an ability to achieve their goals. The goal-programming model was used to explore the effects of variation in the amount of land available to Tongan households. Government would prefer an average smallholder to be the standard as emergent farm households represent a significant proportion of the population. Therefore the results obtained were for a representative emergent farm household in Tongatapu (Farm 2), with a given set of goal structures, a farm labour force of 5700 hours per year and a set of standard resources. The capital and other factors were held constant at each indicated level. The land area was varied from the standard tax allotment quota to find the feasible minimum for the family to achieve their prescribed goals. Four land scenarios were explored:

Land Reform 1 :	50 percent reduction of existing quota (1.67 hectares)
Land Reform 2 :	one third of existing quota (1.11 hectares)
Land Reform 3 :	75 percent reduction of existing quota (0.835 hectares)

The results of the parametric variations of land supply and their likely impact on emergent farmers in terms of achievement of their goals and the cropping pattern are summarised in Tables 15 and 16 respectively. Land Reform 1 scenario, in which the standard tax allotment quota was reduced from 3.34 to 1.67 hectares, did not affect the solutions. However, the results of Land Reform 2, or reducing the tax allotment quota to 1.11 hectares, showed a minor effect in the status of various goal achievements (Table 15). The social requirement for porkers was partially achieved. In addition, significant changes in the farm operating plan occurred (Table 16) in which the total cropped area was reduced by 24 percent, squash was no longer featured in the plan, all available lands was being utilised, and no fallow land occurred with fertiliser being used instead.

The effects of a further reduction in allotment quota size to one-third of current holdings (0.835 ha) intensifies the problems. It was associated with more goals not being achieved, such as home food requirements for yam, taro and porkers, all the social cash and food requirements except taro, and taro, cassava and porker requirements for church obligations. The farm plan also showed 27 percent reduction of total cropped area, with a significant reduction in all crops except yam 1 and cassava 2. Income effect showed no surplus cash (100 % reduction) at the end of the year. Further reduction in land holding to 0.6 hectares gave an infeasible solution.

**Table 15: Goals achievement status for parametric variation in land sizes for an emergent farmer in Tongatapu.**

Goal	Annual requirements	Farm 2*	1.67 ha	1.1 1ha	0.835 ha
1. Home sustenance	Monthly living costs	3000	3000	3000	3000
	Yam consumption	720	720	720	0 (-720)
	Taro consumption	900	900	900	900
	Cassava consumption	1200	1200	1200	1200
	Kumara consumption	1000	1000	1000	1000
	Porker consumption	2	2	2	2
2. Church obligations	Monthly church costs	905	905	905	905
	Yam consumption	300	300	300	0 (-300)
	Taro consumption	100	100	100	0 (100)
	Cassava consumption	100	100	100	0 (100)
	Kumara consumption	90	90	90	90
	Porker consumption	6	6	6	3 (-3)
3. Risk minimisation	Poor year consumption	A	A	A	A
4. Social obligations	Monthly social costs	300	300	300	279 (-21)
	Yam consumption	250	250	250	0 (-250)
	Taro consumption	200	200	200	200
	Cassava consumption	300	300	300	0 (-300)
	Kumara consumption	170	170	170	170
	Porker consumption	3	3	1 (-2)	3
5. Profit maximisation	Surplus cash in April	717	713	500	0
6. Leisure time	Monthly leisure (hrs)	A	A	A	A

Minus (-) figures indicate under achievement for specified goals. A = Achieved

Farm 2\* = Emergent farm in Tongatapu

**Table 16: Summary of Tongatapu emergent farmers' farm plan under different allotment sizes.**

Production activity	3.34 ha	1.67ha	Change	1.11ha	Change	0.835	Change
Yam 1 (ha)	0.17	0.17	2%	0.19	12%	0.19	12%
Yam 2 (ha)	0.15	0.15	0%	0.15	0%	0.15	0%
Taro 1 (ha)	0.14	0.14	0%	0.14	0%	0.14	0%
Taro 2 (ha)	0.14	0.14	0%	0.05	-63%	0.05	-66%
Cassava 1 (ha)	0.27	0.27	0%	0.23	-17%	0.23	-17%
Cassava 2 (ha)	0.22	0.22	0%	0.23	3%	0.23	3%
Kumara 1 (ha)	0.09	0.09	0%	0.05	-47%	0.05	-48%
Kumara 2 (ha)	0.09	0.09	0%	0.08	-14%	0.05	-48%
Squash (ha)	0.19	0.17	-12%	0.00	-100%	0.00	-100%
Total crop (ha)	1.47	1.45	-1%	1.11	-24%	1.07	-27%
Fallow (ha)	0.32	0.23	-40%	0.00	-100%	-	-
Fertilise area (ha)	0.00	0.09	-	0.28	-	0.18	-
Sows	2	2	0%	2	0%	2	0%
Porkers	10	11	9%	11	10%	11	10%
Weaners	11	12	8%	13	18%	13	18%
Surplus T\$-Apr	717	713	-1%	500	-30%	0	-100%

"Change" indicates the percentage deviations in values compare to the initial model (3.34 ha).

"-" indicates the activity is not chosen by the model

Cropped area values are rounded off to 2 decimal places.

The second part of the land reform analysis was to explore the effects of possible land reform in subdividing existing allotments on the different representative farm types. The results of the analysis showed no effects on marginal, and some effects on emergent farm households in all island groups. As expected, the most significant impact was on Progressive farm households. All the goals were satisfied despite a 27 percent reduction in surplus cash. The significant changes also occurred in the farm plan and squash area was mostly affected with 89 percent reduction at 1.67 ha and was totally eliminated at the 1.11 hectares allotment size.

The results also reflect the effects of subdividing land on the fertility requirement as indicated by the level of fallowing and the application of fertilisers. As shown in Table 16, the reduction in available arable land was associated with a reduction in the fallow land and increasing use of fertiliser for soil fertility enhancement. For progressive farmers who use more land, reduction in land supply makes it impossible to fallow land so fertiliser is required to maintain the fertility level. For emergent farmers both fallow and fertilisers are required, while for marginal farmers, fertility is maintained by fallowing land. This implies that when land is adequate, farmers prefer to fallow due to the lower cost. The issue of maintaining soil fertility is of critical concern to the Ministry. However, owing to the prohibitive cost and lack of knowledge, it is expected that most of the Tongan farmers will continue to rely upon the fallow system for replenishing soil nutrients provided they have sufficient land.

Recommendations following this research might take several forms. The most important and immediate need involves the complete redistribution of land now being held by the nobility and royal family and/or subdividing existing allotments into smaller holdings. This would not only reduce land-lessness but allow more productive use of land of which a large proportion is idle. However, it is recognised that with the existing political and social structure of the Kingdom the implementation of the former recommendation will be difficult leaving the latter to be the only option. The goal programming analysis above showed subdividing of existing tax allotments into two (1.67 ha) allotment sizes appears to adequately provide the food and cash needs for the average family. This reform would enable more people to have access to land and improve tenure security. With that, people would not only improve the productivity of land but also be able to invest in longer term crops like kava and vanilla. They will be more able to respond to new market opportunities using land as collateral for credit. This is consistent with the national development objectives of reducing poverty, unemployment and inequality in Tonga.

The analysis also indicated a way of encouraging better land use would be to legalise the sub-leasing of tax allotments under appropriate circumstances. It is suggested that creating a legal market for tax allotments would allow tax allotment holders, such as marginal farm households who are unwilling or unable to use all their land, to lease some of them on a short term basis to those people who need it.

## 21. Output prices

Market innovations such as the establishment of a new local market place for Ha'apai island, or improvement of a farm to market road in Vava'u, should all be considered. Such developments may save some of the time that farm-household members devote to selling farm and household requisites. Because improvements in input and output marketing affect prices it is appropriate to evaluate them in the model. Output prices prevailing from 1990/1991 to 1991/97 for the two main cash crops, yam and squash were introduced into the models. Four market scenarios were explored:

Market 1	:	Increase in price of squash from 50 to 90c/kg
Market 2	:	50 percent reduction in price of squash to 25c/kg
Market 3	:	Increase price of yam to T\$1.90/kg
Market 4	:	Reduction in the price of yam to T\$1.30/kg

The performance of each model under these conditions is summarised in Tables 17 to 19. The effect of changes in the price of outputs for squash and yam on the farm-operating plan showed significant variations in responses. Market 1 and 2 was explored using the progressive and emergent farm household in Tongatapu which are actively involved in squash cultivation. As illustrated in columns 3 and 4 in Table 17, increased price of squash from 50c/kg to 90c/kg showed minor effects, with a one percent reduction of yam 2 in favour of a slight increase (0.1%) to the squash area. The increase in price also corresponds to a 0.1 percent reduction in total cropped area and 0.1 percent increase in surplus cash at the end of the year. However, a 40 percent drop in the price of export squash (Market 2) will only cause a 3 percent reduction in the area of squash but an increase in yam 2 by about 12 percent, and an increase in overall cropped area by 0.4 percent. The total cash surplus at end of April is slightly reduced by 1 percent.

Table 17: Effects of squash price variations on progressive and emergent farms in Tongatapu.

Production activity	Basic	Emergent				Progressive				
		Market 1	Change	Market 2	Change	Basic	Market 1	Change	Market 2	Change
Yam 1 (ha)	0.17	0.15	-11%	0.18	8%	0.27	0.27	0%	0.27	0%
Yam 2 (ha)	0.15	0.15	0%	0.15	0%	0.14	0.11	-24%	0.25	78%
Taro 1 (ha)	0.14	0.14	0%	0.14	0%	0.35	0.35	0%	0.35	0%
Taro 2 (ha)	0.14	0.14	0%	0.14	0%	0.08	0.08	0%	0.08	0%
Cassava 1 (ha)	0.27	0.27	-1%	0.29	5%	0.29	0.29	0%	0.29	0%
Cassava 2 (ha)	0.21	0.21	-2%	0.22	6%	0.11	0.11	0%	0.11	0%
Kumara 1 (ha)	0.09	0.05	-48%	0.09	0%	0.10	0.10	0%	0.10	0%
Kumara 2 (ha)	0.09	0.09	0%	0.09	0%	0.10	0.10	0%	0.10	0%
Squash (ha)	0.19	0.20	4%	0.00	-100%	1.05	0.75	-28%	0.84	-20%
Total crop (ha)	1.46	1.40	-4%	1.30	-11%	2.48	2.15	-13%	2.38	-4%
Sows	2	2	0%	2	0%	1	1	0%	1	0%
Porkers	10	10	0%	10	0%	4	4	0%	4	0%
Weaners	11	11	0%	11	0%	4	4	0%	4	0%
Surplus T\$-Apr	717	740	3%	680	-5%	3611	3629	0.5%	3550	-2%

"Change" indicates the percentage deviation in values compare to the initial model (3.34 ha).

"-" indicates the activity is not chosen by the model

"NA" indicates the model cannot choose the activity

Cropped area values are rounded off to 2 decimal places.

In comparison, Market 3 and 4 showed that changes in the price of yam have a more significant impact on the three main farm types. As expected, the impact of price changes are more intense on emergent and farm households, who rely more on yam as the main cash crop. As shown in Tables 18 and 19, an increase in the price of yam to T\$1.90/kg would generate an increased cash surplus of about 17 percent (progressive), 39 percent (emergent) and at least 50 percent for marginal farm households. While a lower price of T\$1.30 per kg (Market 4) would cause a reduction in cash surpluses of 58 percent (marginal), 30 percent (emergent), and about 20 percent for progressive households.

The models were used to explore the impact of relaxing market constraints for root crops to represent situations where opportunities for yam export to Fiji and Samoa arise, and where more opportunities for export of root crops and frozen cassava are attained. This was incorporated into the matrix by adding extra selling activities at a lower price eg. cassava (T\$0.08/kg), and yam (T\$1.30/kg), and increasing the market quota in the system constraints. Market 6 explores the opportunity for incorporating a new cash crop into the system to reflect the likely response of farmers to new potential crops such as watermelon, papaya, chilli, etc. In this case, watermelon for export and domestic food requirements is incorporated.

- Market 5: : increased market opportunities for yam and cassava
- Market 6: : export market opportunities for watermelon

Table 20 summarises the likely responses of emergent farmers in the three main sub-regions to improvement in market avenues for existing and new crops. The result shows that improved market export opportunities for yam and cassava (Market 5) would increase the cash surplus at the end of April dramatically by more than 140 percent for emergent farmers in the three main groups, with the highest increase of more than 200 percent in the in the Ha'apai group.

The variation among the island groups is attributed to the variation in the initial market constraints in each basic model. However, the general implication is that relaxing market constraints would allow some emergent farmers to operate in a similar environment to that of progressive farmers and so allow dramatic increases in cash surplus. The land utilisation also increased by 3 to 8 percent. Market 6 showed that incorporating watermelon into the system, which has both subsistence and cash

**Table 18: Effects of yam price variations on the three main farm types in Tongatapu.**

Production activity	FARM 1 – Progressive					FARM 2 – Emergent					FARM 3 – Marginal				
	Basic	Market 3	% Change	Market4	% Change	Basic	Market 3	% Change	Market4	% Change	Basic	Market 3	% Change	Market4	% Change
	T\$1.65	T\$1.90/kg		T\$1.30		T\$1.65	T\$1.90/kg		T\$1.30		T\$1.65	T\$1.90/kg		T\$1.30	
Yam 1 (ha)	0.27	0.27	0%	0.27	0%	0.17	0.15	-11%	0.15	-11%	0.05	0.05	-1%	0.05	4%
Yam 2 (ha)	0.14	0.11	-24%	0.21	47%	0.15	0.15	0%	0.10	-30%	0.05	0.05	0%	0.05	0%
Taro 1 (ha)	0.35	0.35	0%	0.35	0%	0.14	0.14	0%	0.14	0%	0.09	0.09	0%	0.09	0%
Taro 2 (ha)	0.08	0.08	0%	0.08	0%	0.14	0.06	-58%	0.05	-63%	0.09	0.09	0%	0.09	0%
Cassava 1 (ha)	0.29	0.29	0%	0.29	0%	0.27	0.27	-2%	0.27	-2%	0.26	0.22	-16%	0.27	2%
Cassava 2 (ha)	0.11	0.11	0%	0.11	0%	0.21	0.21	-2%	0.21	-2%	0.26	0.22	-16%	0.27	2%
Kumara 1 (ha)	0.10	0.10	0%	0.10	0%	0.09	0.09	0%	0.09	0%	0.05	0.05	0%	0.05	0%
Kumara 2 (ha)	0.10	0.10	0%	0.10	0%	0.09	0.09	0%	0.09	0%	0.05	0.05	0%	0.05	0%
Squash (ha)	1.05	1.06	1%	1.05	0%	0.19	0.30	54%	0.29	52%	0.05	0.05	0%	0.05	0%
Total crop (ha)	2.48	2.46	-1%	2.55	3%	1.46	1.45	-1%	1.39	-4%	0.90	0.81	-9%	0.91	1%
Surplus T\$-Apr	3611	4232	17%	2870	-21%	717	997	39%	500	-30%	119	311	161%	50	-58%

**Table 19: Effects of yam price variations on emergent farm types in Vava'u and Ha'apai groups.**

Production activity	FARM 5: Vava'u emergent					FARM 7: Ha'apai emergent				
	Basic	Market3	Change	Market4	Change	Basic	Market3	Change	Market4	Change
	T\$1.65	T\$1.90		T\$1.30		T\$1.65	T\$1.90		T\$1.30	
Yam 1 (ha)	0.13	0.13	0%	0.13	0%	0.11	0.11	0%	0.12	4%
Yam 2 (ha)	0.06	0.06	0%	0.06	0%	0.10	0.10	0%	0.10	0%
Taro 1 (ha)	0.13	0.13	0%	0.13	0%	0.11	0.11	0%	0.11	0%
Taro 2 (ha)	0.05	0.05	0%	0.05	0%	0.11	0.05	-50%	0.11	0%
Cassava 1 (ha)	0.28	0.28	0%	0.28	0%	0.29	0.29	0%	0.29	0%
Cassava 2 (ha)	0.23	0.23	0%	0.23	0%	0.28	0.26	-9%	0.29	4%
Kumara 1 (ha)	0.07	0.07	0%	0.07	0%	0.07	0.07	0%	0.07	0%
Kumara 2 (ha)	0.07	0.07	0%	0.07	0%	0.07	0.07	0%	0.07	0%
Squash (ha)	0.17	0.08	-49%	0.19	13%	-	-	-	-	-
Total crop (ha)	1.19	1.26	5%	1.22	2%	1.15	1.07	-7%	1.16	1%
Surplus T\$-Apr	724	1775	145%	439	-39%	476	646	36%	208	-56%

“Change” indicates the percentage deviation in values compare to the basic model (3.34 ha).

“-” indicates the activity is not chosen by the model

Cropped area values are rounded off to 2 decimal places.

**Table 20: Summary of emergent farmers' land use under different market avenues.**

Production activity	Farm 5 : Vava'u					Farm 2: Tongatapu					Farm 7 : Ha'apai				
	Emergent	Market5	% Change	Market6	% Change	Emergent	Market5	% Change	Market6	% Change	Emergent	Market5	% Change	Market6	% Change
Yam 1 (ha)	0.13	0.21	64%	0.13	0%	0.17	0.23	37%	0.15	-11%	0.11	0.18	63%	0.10	-9%
Yam 2 (ha)	0.06	0.06	1%	0.06	0%	0.15	0.13	-15%	0.10	-33%	0.10	0.10	0%	0.06	-46%
Taro 1 (ha)	0.13	0.13	0%	0.13	0%	0.14	0.14	0%	0.14	0%	0.11	0.11	0%	0.11	0%
Taro 2 (ha)	0.05	0.05	0%	0.05	0%	0.14	0.05	-63%	0.05	-63%	0.11	0.05	-50%	0.05	-50%
Cassava 1 (ha)	0.28	0.34	22%	0.28	0%	0.27	0.33	21%	0.27	-1%	0.29	0.35	18%	0.34	15%
Cassava 2 (ha)	0.23	0.23	0%	0.23	0%	0.21	0.21	-2%	0.21	-2%	0.28	0.25	-11%	0.20	-30%
Kumara 1 (ha)	0.07	0.07	0%	0.07	0%	0.09	0.09	0%	0.09	0%	0.07	0.07	0%	0.07	0%
Kumara 2 (ha)	0.07	0.07	0%	0.07	0%	0.09	0.09	0%	0.09	0%	0.07	0.07	0%	0.07	0%
Squash (ha)	-	-	-	-	-	0.19	0.30	56%	0.29	52%	-	-	-	-	-
Kava (ha)	0.17	0.08	-49%	0.05	-70%	-	-	-	-	-	-	-	-	-	-
Vanilla (ha)	0.00	0.00	0%	0.00	0%	-	-	-	-	-	-	-	-	-	-
Watermelon (ha)	0.00	0.00	0%	0.03	100%	-	-	-	0.03	100%	-	-	-	0.34	100%
Total crop (ha)	1.19	1.26	5%	1.08	-10%	1.46	1.57	8%	1.39	-5%	1.15	1.18	3%	1.06	-7%
Fallow (ha)	0.25	0.27	9%	0.22	-10%	0.32	0.32	1%	0.28	-12%	0.24	0.26	12%	0.20	-17%
Fertilised (ha)	0.00	0.00	0%	0.000	0%	0.00	0.00	0%	0.00	0%	0.00	0.00	0%	0.00	0%
Surplus T\$-Apr	724	1775	145%	726	0.3%	717	1811	153%	773	8%	476	1548	225%	501	5%

"Change" indicates the percentage deviation in values compare to the basic model (3.34 ha).

"-" indicates the activity is not chosen by the model

Cropped area values are rounded off to 2 decimal places.

Farm 5 = Vava'u emergent farm, Farm 2 = Tongatapu emergent farm, Farm 7 = Ha'apai emergent farm



potential caused little or no significant effect on Vava'u farmers, while it increased the cash surplus by 5 and 8 percent for farmers in Ha'apai and Tongatapu respectively.

The modelling experiment results were consistent with the fieldwork results that indicated that limited market avenue for root crops is the major constraining factor to increased production in Tonga. The general attitude amongst Tongan farmers revealed in the fieldwork was that many had made the attempt to expand commercial production but had become disillusioned when they found their efforts were poorly rewarded. As shown in Table 20, relaxing market constraints for existing root crops resulted in a significant increase in surplus cash with given resources and the cropped area. The incorporation of watermelon into the production system showed a moderate increase in cash surplus for Tongatapu and Ha'apai and can be recommended as a potential enterprise for export crop diversification. It implies that new crops with assured markets could be well incorporated into the system. The result also shows that the different market access associated with each farmer group is a major contributing factor to the variation among progressive, emergent and marginal farmers. The variation in responses to price changes by farm groups also reflects the status of Tongan farmers as price takers.

The result implies the need for the Government and private sector to strengthen market research and development. As the findings of the fieldwork confirmed, it is this aspect of the institutional framework of Tongan agriculture where action and change is required. Priority should be given to exploring the scope for opening up new markets for Tongan produce overseas as a means towards longer-term development of agricultural production.

It has been noted earlier in this chapter that one of the crucial components of smallholder agriculture development strategy is through technological advance. There are innumerable ways in which the methods of farm production in Tonga could be improved. No attempt can be made here to provide detailed technological improvement packages. Instead, on the basis of information gathered during the fieldwork, analyses offer the possibility of estimating the effects of change in technology either through improved varieties, or management practices, the use of machine cultivation in place of the traditional manual cultivation method or the use of inorganic fertilisers. The improved yields data were derived from MAF research results. MAF agronomists confirmed that improved farm practices could potentially increase crop yields for root crops by 40 percent, and in some cases even more (MAF, 1994c). The basic models assume that technologies are constant in the three regions and farm types. The three representative models for Tongatapu were used to explore farmers' responses to the introduction of new improved technologies. Productivity improvement measures are assumed to increase root crop yields by 20 percent of current base yields.

Table 21 summarises the effects of improved management technologies. The total cropped area is reduced by at least 18 percent and cash surplus is increased by about 60 percent (marginal), 15 percent (emergent) and less than 5 percent for progressive farms.

Table 21: Summary of farmers' lands use under improved technologies.

Production activity	Progressive			Emergent			Marginal		
	Basic	Tech1	Change	Basic	Tech1	Change	Basic	Tech1	Change
Yam 1 (ha)	0.27	0.22	-17%	0.17	0.12	-27%	0.05	0.04	-17%
Yam 2 (ha)	0.14	0.09	-37%	0.15	0.12	-17%	0.05	0.04	-16%
Taro 1 (ha)	0.35	0.29	-17%	0.14	0.12	-14%	0.09	0.08	-17%
Taro 2 (ha)	0.08	0.07	-17%	0.14	0.05	-68%	0.09	0.08	-17%
Cassava 1 (ha)	0.29	0.24	-17%	0.27	0.22	-17%	0.26	0.21	-19%
Cassava 2 (ha)	0.11	0.09	-17%	0.21	0.17	-18%	0.26	0.21	-19%
Kumara 1 (ha)	0.10	0.08	-17%	0.09	0.07	-19%	0.05	0.04	-16%
Kumara 2 (ha)	0.10	0.08	-17%	0.09	0.07	-19%	0.05	0.04	-16%
Squash (ha)	1.05	0.91	-13%	0.19	0.24	27%	0.00	0.00	0%
Total crop (ha)	2.48	2.08	-16%	1.46	1.20	-18%	0.90	0.74	-18%
Surplus T\$-Apr	3611	3720	3%	717	823	15%	119	191	61%

"Change" indicates the percentage deviation in values compare to the basic model (3.34 ha).

"-" indicates the activity is not chosen by the model

Cropped area values are rounded off to 2 decimal places.

## 24. Effects of Labour Policies

A fourth analysis was conducted to explore the effects of a variation in the family labour supply in emergent farm households. The parametric variation in the labour supply may provide an indication of the scope for expansion of productive employment in the agricultural sector. This is particularly important given the increasing number of people without land, and unemployment level. The downward variation in the labour supply will also reflect some of the outmigration effect that is significant in outer remote islands. It may also be used to reflect the farmer's pursuit of the leisure goal. Two main family labour scenarios were explored:

- Labour 1: 50% reduction in monthly family labour supply to 240 hours (1 adult).
- Labour 2: Family monthly labour supply of 180 hours (1 part-time).

The achievement status of goals and the corresponding farm plans generated for the basic model are summarised in Tables 22 and 23 respectively. The labour was varied from 120 hrs/month (one part-time) to 480 hours/month (2 full time people). In terms of goal achievement, the minimum cash and food requirement for home consumption is satisfied in all labour levels with the exception that porker requirements for home and social consumption at 180 hours. This is not fully met.

A 50 percent reduction in family labour units reduced total cropped area by 12 percent and surplus cash in April by 30 percent. As would be expected, reducing the family labour supply not only affects the achievement of the leisure goal but forces the hiring of more casual labour. The solution also showed that labour requirements in some months are supplemented by hired labour (a total of 50 hours of hired labour is used). With a further reduction in family labour supply to 180 hours per month (in Labour 2 column) there were reductions of the total cropped area by 27 percent and no surplus cash was generated at the end of April. The increased reliance on hired labour, along with a significant reduction in leisure hours, is one of the main features of the plan. In Labour 2, a total hired labour of 255 hours is required and none of the monthly leisure requirements are fully met. Most notably, the high labour intensive crops are most affected, with squash area reduced by about 90 percent.

**Table 22: Achievement status for goals for variation in family labour supply.**

Goal	Annual requirements	Farm 2	Labour1	Labour 2
		<i>480 hrs</i>	<i>240 hrs</i>	<i>180 hrs</i>
1. Home sustenance	Monthly living costs	3000	3000	3000
	Yam consumption	720	720	720
	Taro consumption	900	900	900
	Cassava consumption	1200	1200	1200
	Kumara consumption	1000	1000	1000
	Porker consumption	2	2	0 (2)
2. Church Obligations	Monthly church costs	905	905	905
	Yam consumption	300	300	300
	Taro consumption	100	100	100
	Cassava consumption	100	100	100
	Kumara consumption	90	90	90
	Porker consumption	6	6	6
3. Risk minimisation	Poor year consumption	A	A	A
4. Social obligations	Monthly social costs	300	300	300
	Yam consumption	250	250	250
	Taro consumption	200	200	200
	Cassava consumption	300	300	300
	Kumara consumption	170	170	170
	Porker consumption	3	3	1 (-2)
5. Profit maximisation	Surplus cash in April	717	500	0
6. Leisure time	Minimum leisure	A	PA	PA

A = Achieved, PA = Partially achieved  
 Minus (-) figures indicate under achievement for specified goals.  
 Farm 2 = Tongatapu emergent farm

**Table 23: Summary of emergent farm plan under different family labour supply levels.**

Production activity	Basic	Labour 1	Change	Labour 2	Change
	<i>480 hrs</i>	<i>240hrs</i>		<i>180 hrs</i>	
Yam 1 (ha)	0.17	0.19	12%	0.19	10%
Yam 2 (ha)	0.15	0.15	-1%	0.15	0%
Taro 1 (ha)	0.14	0.14	3%	0.14	-5%
Taro 2 (ha)	0.14	0.14	3%	0.05	-61%
Cassava 1 (ha)	0.27	0.22	-20%	0.21	-23%
Cassava 2 (ha)	0.21	0.22	3%	0.21	-1%
Kumara 1 (ha)	0.09	0.05	-49%	0.06	-39%
Kumara 2 (ha)	0.09	0.05	-49%	0.06	-29%
Squash (ha)	0.19	0.12	-37%	0.04	-80%
Total crop (ha)	1.45	1.27	-12%	1.10	-24%
Surplus T\$-Apr	717	500	-30%	247	-66%

"Change" indicates the percentage deviation in values compare to the basic model (480 hrs).  
 Cropped area values are rounded off to 2 decimal places.

This analysis is important in explaining the young people migration from the more remote islands, like Ha'ano to Tongatapu, for further education and employment opportunities, which reduces family labour available. This implies that when labour is a limiting resource, farmers will give greater priority to home food requirement. The results also indicate the effects when farmers give greater value to leisure or off-farm employment relative to time given to agricultural activities.

## 25. Effects of Off-farm Earnings

In Tonga, most farm households have one or more adults who work off the farm for at least part of the year. Such off-farm income can be an important determinant of the well being of the family. Off-farm earnings, which include paid employment, remittances and business income, constitute a significant proportion of household cash income. An alternative to agricultural development, which has seemingly not been recognised by policy makers, would be to give a higher priority to employment creation in rural areas. Off-farm earnings are significant in not only reducing the sole reliance on agriculture for a living, but also for providing capital for financing farm improvement activities. It is therefore important to explore the impacts of off-farm income levels on goal achievement and reinvestment in agriculture for different farm types. Various scenarios could be examined, for example:

Cash 1:	No off-farm earning.
Cash 2:	Restricted off-farm earnings to T\$50 per month.
Cash 3:	Increased off farm monthly earnings to T\$200 per month.
Cash 4:	Increased off-farm income to T\$300 per month.

The impacts on farm plans for the three main farm types in Tongatapu for different levels of off-farm income were examined and are summarised in Table 24. Goal achievement was significantly different between the three main farm types. Progressive (Farm 1) showed every goal was achieved, irrespective of the off-farm income level reflecting the large proportion (78%) of household income derived from agriculture. Farms 2 and 3 showed that the goals were not achieved at both zero and T\$50 off-farm income levels. As Table 24 shows the effects on emergent farms were minor compared to marginal farms with the cash and porker requirements for social obligations and church obligation not being fully met. In contrast to the marginal farm (Farm3), some of the cash requirements for living needs, church and social obligations were not met. The porker requirements and leisure were also affected both at zero and T\$50 income levels.

**Table 24: Summary of production and economic effects under different off-farm earnings for the three representative farms in Tongatapu.**

	Off-farm (T\$) level	0/mth	50/mth	120/mth	200/mth	300/mth
Farm1	SP-cash Apri (T\$)l	3079	3297	3611	3951	4354
	Cropped Area (ha)	2.73	2.67	2.48	3.08	3.27
Farm2	SP-cash Apri (T\$)l	326	492	717	1088	1516
	Cropped Area (ha)	1.46	1.46	1.43	1.51	1.56
Farm3	SP-cash Apri (T\$)l	0	0	119	475	899
	Cropped Area (ha)	1.11	1.11	0.9	0.72	0.69

Farm 1 - progressive, Farm 2 - emergent, Farm 3 - marginal  
SP = Surplus

The responses of these marginal farmers to off-farm income implies what other writers (Hau'ofa and Ward, 1980; Sisifa *et al.*, 1993) have noted in that they have "*target household incomes*". This refers to the threshold amount of cash that they must strive to obtain to meet their basic and immediate needs (basic living costs). It is argued that once these modest needs have been met, further efforts at production cease. The modelled reactions of progressive and emergent farm households are consistent with the findings in this survey in that civil servants are highly involved in cash cropping. Such farmers have a secured income source that allows them to finance farm improvements, but those who rely directly on agriculture are not in such a strong position. This implies that because the family labour supply is in excess of current farm requirements, there is opportunity for off-farm employment. Off-farm earnings ensure farmers have a more secured income and thus allows them to invest more on profitable agricultural ventures.

## 26. Effects of Credit policies

Another production incentive often used in agricultural policy is the provision of credit. An analysis of credit policy was conducted for two potential situations where the government provides more incentives through TDB credit lines with lower agricultural credit interest rates, and also where such assistance is not provided and therefore using a higher interest rates. Concessional credit for farm development purposes could be represented by adjusting interest rates and the proportion of borrowed funds used for on-farm investment. The three farm types from the outer islands were used to examine the impact of changes in interest rate charges on the level of borrowing and on farm plans. The main scenarios examined were parametric variations of monthly interest rate, from 3 percent to 15 percent.

The results from the model are summarised in Table 25. It shows there was no significant effect on progressive and emergent farm types, with both surplus cash and the total cropped area remaining constant. The total amount borrowed was T\$300 and T\$475 per year for progressive and emergent farms respectively. For marginal farms, raising the interest rates of 12 and 15 percent caused a 61 percent reduction in surplus cash, but no effect on the total cropped area. The results indicate a limited use of credit among farm households. This can be attributed to the combination of the low investment cost for traditional farm production, limited market opportunity, and good access to other sources of income, such as remittances.

Table 25: Effects of variation in interest rates on total cropped area and surplus cash for the three main farm types.

Monthly IR* (%)	Progressive		Emergent		Marginal	
	Farm 4		Farm 6		Farm 7	
	Cropped area	Cash (T\$)	Cropped area	Cash (T\$)	Cropped area	Cash (T\$)
3	1.61	300	0.89	474	0.83	129
5	1.61	300	0.89	474	0.83	128
8	1.61	300	0.89	475	0.83	128
12	1.61	300	0.89	475	0.83	50
15	1.61	300	0.89	475	0.83	50

\* IR = Interest Rate

Farm 4= Vava'u Progressive, Farm 6= Ha'apai Emergent, Farm 7= Ha'apai Marginal

## 27. Modelling the significance of church and social obligations

The models were used to explore the significance of church and social obligations on farm household production by varying the weights attached to the over achievement of objectives. The weights were derived from the basic models indicating the preferences of the farmer to maximise surplus cash (0.1) once the minimum requirements for food and cash requirements (0.0001) are met. Models of the 3 main farm types in Tongatapu were examined using the following scenarios:

- Church 1: More weight on church obligation (0.1) and less on April surplus cash (0.0001)
- Church 2: Less weight on church obligation (0.0001) in favour of April surplus cash (0.1)
- Social 1: More weight on social obligation (0.1) and less on April surplus cash (0.0001)
- Social 2: Less weight on social obligation (0.0001) in favour of April surplus cash (0.1)
- Leisure 1: More weight on leisure (0.1) and less on April surplus cash (0.0001)
- Leisure 2: Less weight on leisure (0.0001) in favour of April surplus cash (0.1)
- Profit Maximisation: Assume that farmer's prime objective is to maximise cash surplus.

The results of the modelling experiments are presented in Tables 26 and 27. Under scenarios Church 1 and 2, varying the weights on church goals has a significant impact on the farm plan and total cash surplus. For instance, in Church 1, if farmers prefer to overachieve on church goals (increase weight from 0.0001 to 0.1), and give lower importance to cash surplus generation (reduce weight from 0.1 to 0.0001), the system would fail to meet some of the current monthly cash and porker requirement fully. For progressive farms, the total

cropped area increased by 35 percent, while surplus cash at end of April decreased by 18 percent. In contrast, in Church 2 where more emphasis is put on surplus cash (0.1) and less emphasis on church obligations (0.0001), there was a minor effect on the total cropped area, but an increased surplus cash of 8 percent. There was also a significant variation among farm types in that Church 1, the emergent farmer, had a 48 percent reduction in surplus cash, and a 31 percent increase in cropped area.

**Table 26: Effects of altering the weight on church obligations on farmer's production plans.**

Production Activity	Progressive					Emergent					Marginal				
	Basic	Church1	% Change	Church2	% Change	Basic	Church1	% Change	Church2	% Change	Emergent	Market5	% Change	Market6	% Change
Yam 1 (ha)	0.27	0.27	0%	0.27	0%	0.17	0.08	13%	0.15	-11%	0.05	0.06	24%	0.05	0%
Yam 2 (ha)	0.14	0.15	7%	0.12	-12%	0.15	0.14	-44%	0.08	-44%	0.05	0.05	0%	0.05	0%
Taro 1 (ha)	0.35	0.35	0%	0.35	0%	0.14	0.14	0%	0.14	0%	0.09	0.09	0%	0.09	0%
Taro 2 (ha)	0.08	0.11	36%	0.08	0%	0.14	0.27	0%	0.05	-63%	0.09	0.09	0%	0.09	0%
Cassava 1 (ha)	0.29	0.29	0%	0.29	0%	0.27	0.27	65%	0.27	-2%	0.26	0.26	0%	0.21	-18%
Cassava 2 (ha)	0.11	0.11	0%	0.11	0%	0.22	0.09	104%	0.21	-6%	0.26	0.26	0%	0.21	-18%
Kumara 1 (ha)	0.10	0.10	0%	0.10	0%	0.09	0.09	0%	0.09	0%	0.05	0.05	0%	0.05	0%
Kumara 2 (ha)	0.10	0.10	0%	0.10	0%	0.09	0.21	0%	0.09	0%	0.05	0.05	0%	0.05	0%
Squash (ha)	1.05	0.85	-19%	1.05	0%	0.19	1.49	52%	0.29	52%	0.00	0.00	0%	0.00	0%
Total crop (ha)	2.48	2.32	-6%	2.46	-1%	1.47	1.92	31%	1.37	-6%	0.90	0.91	1%	0.80	-11%
Surplus T\$-Apr	3611	2963	-18%	3902	8%	717	371	-48%	1029	44%	119	50	-58%	326	174%

**Table 27: Effects of altering the weight on social obligations on different farm type production plans.**

Production Activity	Progressive					Emergent					Marginal				
	Basic	Social1	% Change	Social2	% Change	Basic	Social1	% Change	Social2	% Change	Basic	Social1	% Change	Social2	% Change
Yam 1 (ha)	0.27	0.27	0%	0.25	-8%	0.17	0.15	-11%	0.14	-19%	0.05	0.05	0%	0.05	0%
Yam 2 (ha)	0.14	0.11	-24%	0.09	-39%	0.15	0.08	-44%	0.07	-52%	0.05	0.05	0%	0.05	0%
Taro 1 (ha)	0.35	0.35	0%	0.33	-5%	0.14	0.14	0%	0.14	-3%	0.09	0.09	0%	0.09	0%
Taro 2 (ha)	0.08	0.08	0%	0.06	-22%	0.14	0.05	-63%	0.05	-66%	0.09	0.09	0%	0.09	0%
Cassava 1 (ha)	0.29	0.29	0%	0.28	-4%	0.27	0.27	-2%	0.26	-3%	0.26	0.26	0%	0.25	-5%
Cassava 2 (ha)	0.11	0.11	0%	0.10	-11%	0.22	0.21	-6%	0.20	-7%	0.26	0.26	0%	0.25	-5%
Kumara 1 (ha)	0.10	0.10	0%	0.09	-12%	0.09	0.09	0%	0.04	-52%	0.05	0.05	0%	0.05	0%
Kumara 2 (ha)	0.10	0.10	0%	0.09	-12%	0.09	0.09	0%	0.04	-52%	0.05	0.05	0%	0.05	0%
Squash (ha)	1.05	0.84	-20%	1.06	1%	0.19	0.29	52%	0.26	33%	0.00	0.00	0%	0.00	0%
Total crop (ha)	2.48	2.24	-10%	2.33	-6%	1.47	1.37	-6%	1.21	-18%	0.90	0.90	0%	0.87	-3%
Surplus T\$-Apr	3611	3345	-7%	3752	4%	717	423	-41%	1052	47%	67	-44%	95%	290	144%

“Change” indicates the percentage deviation in values compare to the basic model (3.34 ha).

Cropped area values are rounded off to 2 decimal places.

Minus (-) figures indicate under achievement for specified goals.

**Table 28: Effects of altering the leisure weights on production plans of the different farm types in Tongatapu.**

Production Activity	Progressive					Emergent					Marginal				
	Basic	Leisure1	% Change	Leisure2	% Change	Basic	Leisure1	% Change	Leisure2	% Change	Basic	Leisure1	% Change	Leisure2	% Change
Yam 1 (ha)	0.27	0.31	14%	0.27	0%	0.17	0.19	11%	0.15	-13%	0.05	0.04	-22%	0.05	0%
Yam 2 (ha)	0.14	0.20	44%	0.13	-11%	0.15	0.15	-1%	0.15	-1%	0.05	0.05	-8%	0.05	0%
Taro 1 (ha)	0.35	0.35	0%	0.35	0%	0.14	0.14	3%	0.14	3%	0.09	0.09	-4%	0.09	0%
Taro 2 (ha)	0.08	0.08	-1%	0.08	0%	0.14	0.05	-61%	0.05	-61%	0.09	0.09	-4%	0.09	0%
Cassava 1 (ha)	0.29	0.11	-63%	0.29	0%	0.27	0.21	-23%	0.27	-1%	0.26	0.26	-1%	0.26	-1%
Cassava 2 (ha)	0.11	0.11	0%	0.11	0%	0.21	0.21	-1%	0.21	-1%	0.26	0.11	-60%	0.26	-1%
Kumara 1 (ha)	0.10	0.06	-43%	0.10	-1%	0.09	0.05	-50%	0.09	-2%	0.05	0.04	-13%	0.16	247%
Kumara 2 (ha)	0.10	0.09	-5%	0.10	-1%	0.09	0.09	-2%	0.09	-2%	0.05	0.04	-9%	0.05	0%
Squash (ha)	1.05	0.00	-100%	0.93	-11%	0.19	0.00	-100%	0.30	55%	0.00	0.00	0%	0.00	0%
Total crop (ha)	2.48	1.30	-47%	2.34	-6%	1.45	1.08	-25%	1.44	-1%	0.90	0.71	-21%	1.00	12%
Surplus T\$-Apr	3611	2500	-31%	3619	0.2%	717	500	-30%	757	6%	119	89	-25%	154	29%

“Change” indicates the percentage deviation in values compare to the basic model (3.34 ha).

Cropped area values are rounded off to 2 decimal places.

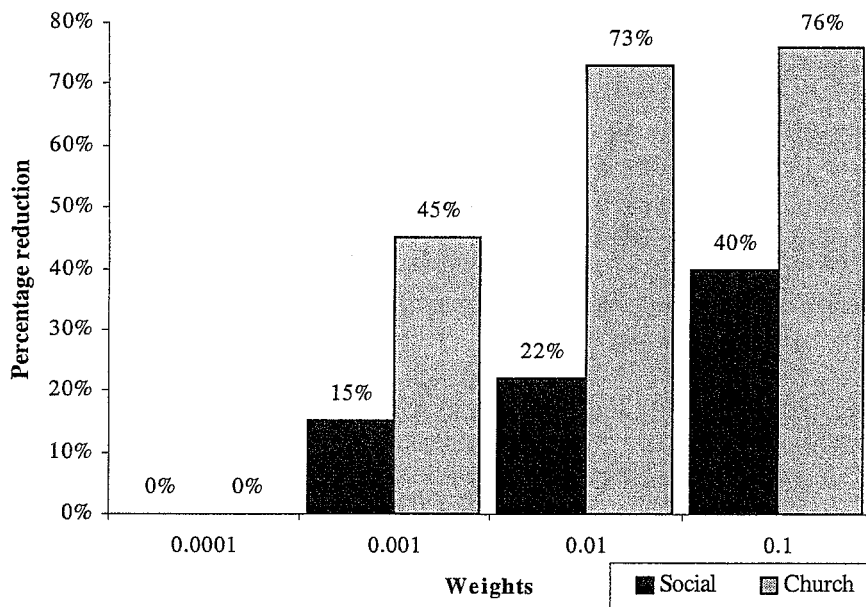
Minus (-) figures indicate under achievement for specified goals.



Reversing the weight in favour of surplus cash (0.1) would increase surplus cash by 44 percent. For a marginal farm household the cash surplus is reduced by 58 percent in Church 1, but increased by 178 percent when the weightings are reversed (Church 2). These differences are attributed to the variation in income levels among the three groups and the variation in the weights for each farm type in the initial models. A similar trend was observed with the social obligation goal. More weight on the achievement of social goals showed differences among production plans of the three farm types, with decreases in surplus cash by 44 percent (marginal), 41 percent (emergent) and only 7 percent in progressive. Reversing the weights in favour of achieving cash surplus showed a 4 percent increase for progressive farmers, 41 percent for emergent, and, most significantly, 144 percent for the marginal farm households.

The effect of varying the weights for social and church goals relative to cash surplus were further explored using an emergent farm type in Tongatapu (Farm 4). Figure 1 shows the percentage reduction in surplus cash at the end of the year when the respective goal weights for church and social obligation change. These figures are compared with the initial model in which the weights on each were set at 0.0001 indicating the preferences of the farmer for meeting the minimum requirements.

**Figure 1:** Percentage reduction in surplus cash when varying goal weights for social and church obligations in an emergent farm household in Tongatapu.



From the data it can be seen that increasing the weights for social and church obligations from 0.0001 to 0.001 would reduce surplus cash by 15 percent and 45 percent respectively. Further increases of social and church weights to 0.1 would subsequently reduce the cash surplus by 40 percent and 76 percent. Figure 2 depicts the changes in the level of surplus cash for an emergent farm household in Tongatapu when the weights on profit maximisation are varied while other goals remain constant. The initial weight at the basic model was 0.01. Further increases in weight up to 1 would result in a minor increase in cash surplus (ie. less than 10 percent). Reductions of the weighting on surplus cash also revealed a reduced cash surplus. The results not only reflect the value of the social and church obligation goals featured in the objective function, but that changing the importance of each would have a significant impact on household income and production levels. This implies that any variation in outputs, both between the different farm types and within each farmers' group, may be attributed to the variation in importance (weights) each household attached to each goal.

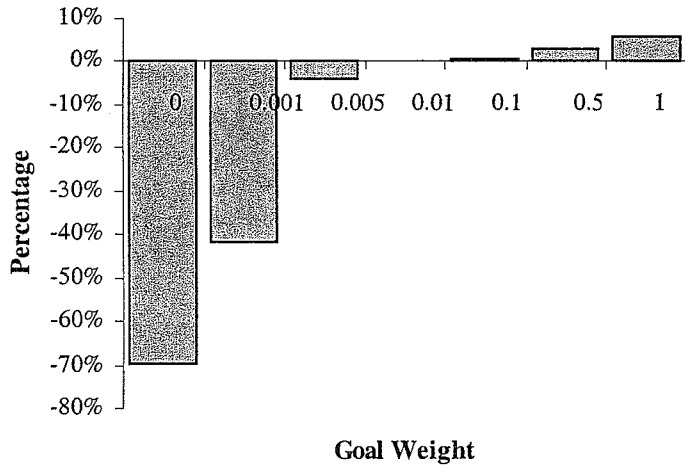


Figure 2: Effects of varying goal weights for maximising cash surplus in emergent farm household in Tongatapu.

The models were also run to assess the significance of the leisure goal. The results are summarised in Table 28. As noted in the model development phase, the three farm types have different leisure requirements. The effects of varying the leisure goal weights relative to surplus cash shows that more weight on the overachievement of leisure hours would cause significant reduction of total cropped area (47 percent) and a 31 percent reduction of surplus cash for a progressive farm. Farm plan changes were characterised by the omission of squash, a labour intensive crop for both progressive and emergent farms. In the solution, as expected, the overachievement of leisure increases the use of hired labour for all farm types. The opposite effects occur when the weighting is reversed, as indicated in the Leisure 2 column on the table. Putting less weight on the importance of leisure in favour of cash surplus would have a minor effect on progressive farms, but more effect on emergent and marginal farms.

The last scenario represents the situation of a profit maximising scenario. It assumes that the prime objective of the smallholder is to maximise total cash surplus at the end of April. The objective function was modified to maximise cash surplus after home food requirements and living costs are met. Table 29 shows a significant variation among the different farm types in both changes in total crop area, and in surplus cash at end of April. Under this scenario, progressive farms would reduce root crop production in favour of growing more squash, and accounts for the 5 percent increase in the crop area and the 15 percent increase in surplus cash. In the emergent farm household, despite increasing the surplus by about 80 percent, the total cropped area would be reduced by about 30 percent. Production effects include a reduction in root crop production and increased squash cultivation. The reduction in total cropped area is attributed to market constraints. Marginal farmers with a profit maximisation objective would not only increase the cropped area by 15 percent, but also would have a three-fold increase in surplus cash.

The result of this analysis not only indicates the significance of non-economic goals in the smallholder farmer's decision making, but it also reflects the limitations of using the profit maximisation model approach to the Tongan situation (the key argument in this research). The findings of this research suggest that the actual behaviour of smallholder farmers in Tonga cannot be described in terms of a single goal maximising behaviour. Moreover, the multiple objective goal programming approach provides a more realistic reflection of actual smallholder behaviour. Variability in the responses expressed by changes in production plans and surplus cash output is observed between the three main farm types where the behavioural assumptions vary. Progressive farmers who give more priority to maximising surplus cash in favour of church, social, and leisure were the least affected compared to the other two farm types.

**Table 29 :** Affect of concentrating on a simple profit maximising objective for the three main farm types in Tongatapu.

Production activity	Progressive			Emergent			Marginal		
	Basic	Objective	% Change	Basic	Objective	% Change	Basic	Objective	% Change
Yam 1 (ha)	0.27	0.23	-13%	0.17	0.13	-25%	0.05	0.04	-22%
Yam 2 (ha)	0.14	0.07	-50%	0.15	0.06	-59%	0.05	0.17	241%
Taro 1 (ha)	0.35	0.32	-8%	0.14	0.13	-9%	0.09	0.09	-4%
Taro 2 (ha)	0.08	0.05	-33%	0.14	0.04	-72%	0.09	0.08	-15%
Cassava 1 (ha)	0.29	0.27	-6%	0.27	0.19	-31%	0.26	0.13	-52%
Cassava 2 (ha)	0.11	0.09	-17%	0.21	0.13	-40%	0.26	0.10	-62%
Kumara 1 (ha)	0.10	0.08	-20%	0.09	0.04	-52%	0.05	0.39	764%
Kumara 2 (ha)	0.10	0.08	-20%	0.09	0.08	-12%	0.05	0.04	-7%
Squash (ha)	1.05	1.40	34%	0.19	0.24	24%	0.00	0.00	0%
Total crop (ha)	2.48	2.60	5%	1.46	1.03	-29%	0.90	1.03	15%
Sows	1	1	0%	2	2	0%	2	1	-50%
Porkers	4	4	0%	10	10	0%	12	2	-83%
Weaners	4	4	0%	11	11	0%	18	2	-89%
Surplus T\$-Apr	3611	4152	15%	717	1299	81%	119	513	331%

“Change” indicates the percentage deviation in values compare to the basic model (3.34 ha).

Cropped area values are rounded off to 2 decimal places.

Minus (-) figures indicate under achievement for specified goals.

## 28. Aggregation for macro-policy consideration

It would be interesting to consider the results of these analyses to infer the response of all farms of the same category as an input to a macro-level model.

If government were to provide improved technology packages, current food and cash crops might improve yields by 20 percent. It might also be possible to improve market access for yam and cassava through export opportunities resulting from market research. The proposed market and technology development program might require a total annual investment of about T\$270,000. The cost for development activities might be something like those in Table 30.

**Table 30: Summary of proposed intervention cost estimates (T\$).**

Project Activities		Total Costs
1.	Market Research and Development:	
	- Market extension and training	T\$45,000
	- Market research studies and missions	T\$60,000
	- Market extension and training	T\$50,000
2	Research and Extension Technology Development:	
	- On-station adaptive Research	T\$35,000
	- On-farm demonstration	T\$50,000
	- Extension support	T\$30,000
<b>Total Investment Required</b>		<b>T\$270,000</b>

\* Estimates based on planning department experience

Working under the assumption that the representative farm “adequately” represents other holdings, the eight representative models developed in this study was used to evaluate the results of a proposed development program. This was done by multiplying each representative farm plan and its associated financial results by the number of holdings it represents to obtain a regional aggregate of production, activity levels and financial data (eg. surplus cash at the end of the year). The project benefits have been estimated for each island group on the basis of information from the 1993 Land Use Crop Survey and the categorisation into the 3 main farm types. According to the Land Use and Crop survey (MAF, 1994b), the total number of farmers in each region was estimated to be: Tongatapu (3193), Vava’u (1601) and Ha’apai (968). The relative distribution of farm types was estimated from the survey results. Table 32 details the project induced changes in land use pattern and likely increases in surplus cash for the eight representative models. These results were then used to determine overall project benefits. This is summarised in Table 31 below.

If the project was properly implemented it has the potential to generate incremental surplus cash of more than 3 million. More realistically there are additional factors such as risk, imports and a time lag involved in strengthening adaptive research and extension capacities. With a modest target and a more conservative estimate of 40 percent adoption for year 1, an incremental cash surplus or revenue of T\$1.3 million could be attained.

**Table 31: Summary of proposed project benefits (T\$).**

Farm Type	Region	% Farm type	No. of growers	Incremental T\$	Incremental at 100 %	Incremental at 40 %
					T\$M	T\$M
1	Tongatapu	6	192	537	0.10	0.04
2	Tongatapu	50	1597	594	0.95	0.38
3	Tongatapu	44	1405	470	0.66	0.26
4	Vava’u	6	96	566	0.05	0.02
5	Vava’u	50	801	535	0.43	0.17
6	Vava’u	44	704	627	0.44	0.18
7	Ha’apai	33	319	885	0.28	0.11
8	Ha’apai	67	649	583	0.38	0.15
<i>Total Incremental Benefit</i>					<i>3.30</i>	<i>1.32</i>

**Table 32: Summary of the projected changes in representative farm land use patterns given market and technology development.**

Production activity	TONGATAPU									VAVA'U									HA'APAI					
	Progressive			Emergent			Marginal			Progressive			Emergent			Marginal			Emergent			Marginal		
	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9	Farm 10	Farm 11	Farm 12	Farm 13	Farm 14	Farm 15	Farm 16	Farm 17	Farm 18	Farm 19	Farm 20	Farm 21	Farm 22		
Yam 1 (ha)	0.27	0.26	-4%	0.17	0.12	-3%	0.05	0.07	57%	0.27	0.22	-17%	0.13	0.11	-16%	0.05	0.03	-26%	0.11	0.12	6%	0.04	0.07	66%
Yam 2 (ha)	0.14	0.09	-37%	0.15	0.09	41%	0.05	0.04	-14%	0.11	0.09	-17%	0.06	0.05	-16%	0.04	0.01	-66%	0.10	0.04	-62%	0.04	0.03	-17%
Taro 1 (ha)	0.35	0.29	-17%	0.14	0.12	-5%	0.09	0.08	-17%	0.26	0.22	-16%	0.13	0.11	-17%	0.08	0.07	-17%	0.11	0.09	-17%	0.08	0.07	-17%
Taro 2 (ha)	0.08	0.07	-16%	0.14	0.05	-17%	0.09	0.08	-17%	0.08	0.07	-17%	0.05	0.05	-17%	0.08	0.05	-40%	0.11	0.05	-53%	0.08	0.05	-38%
Cassava 1 (ha)	0.29	0.27	-8%	0.27	0.22	-21%	0.26	0.20	-25%	0.23	0.19	-17%	0.28	0.24	-17%	0.25	0.16	-36%	0.29	0.26	-10%	0.26	0.19	-26%
Cassava 2 (ha)	0.11	0.09	-17%	0.21	0.17	-26%	0.26	0.15	-43%	0.11	0.19	76%	0.23	0.20	-17%	0.25	0.15	-40%	0.28	0.21	-26%	0.26	0.15	-41%
Kumara 1 (ha)	0.10	0.08	-18%	0.09	0.07	2%	0.05	0.04	-16%	0.08	0.07	-9%	0.07	0.06	-16%	0.04	0.04	16%	0.07	0.06	-13%	0.04	0.04	16%
Kumara 2 (ha)	0.10	0.08	-18%	0.09	0.07	2%	0.05	0.04	-16%	0.08	0.07	-18%	0.07	0.06	-16%	0.04	0.03	-16%	0.07	0.06	-16%	0.04	0.03	-16%
Squash (ha)	1.05	0.09	-91%	0.19	0.24		0.00	0.00	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kava (ha)	-	-	-	-	-	-	-	-	-	0.25	0.13	0%	0.17	0.06	-65%	-	-	-	-	-	-	-	-	-
Vanilla (ha)	-	-	-	-	-	-	-	-	-	0.15	0.15	0%	0.00	0.00	0%	-	-	-	-	-	-	-	-	-
Total crop (ha)	2.48	1.32	-47%	1.46	1.16	-3%	0.90	0.69	-40%	1.61	1.40	-13%	1.19	0.92	-23%	0.83	0.55	-33%	1.15	0.89	-22%	0.83	0.63	-24%
Fallow (ha)	0.48	0.40	-15%	0.32	0.23	-5%	0.16	0.24	3%	0.39	0.31	-20%	0.25	0.18	-28%	0.14	0.09	-33%	0.24	0.18	-24%	0.14	0.12	-12%
Fertilise area (ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sows	1	1	0%	2	2	0%	2	2	0%	1	1	0%	2	2	0%	2	1	-50%	2	2	0%	2	1	-50%
Porkers	4	4	0%	10	10	-17%	12	12	0%	4	4	0%	12	12	0%	5	10	100%	12	12	0%	20	10	-50%
Weaners	4	4	0%	11	11	-15%	18	18	38%	4	4	0%	13	13	0%	6	9	50%	13	13	0%	12	9	-25%
Surplus T\$-Apr	3611	4148	15%	717	1311	81%	119	589	395%	3000	3566	19%	724	1259	74%	178	805	352%	476	1013	113%	128	711	455%

“Change” indicates the percentage deviation in values compare to the basic model (3.34 ha).

“-” indicates the activity is not chosen by the model

Cropped area values are rounded off to 2 decimal places.

Minus (-) figures indicate under achievement for specified goals.

## 29. Summary and Conclusions

Using the GP approach, the representative farm models were used to identify microeconomic supply reactions to various policy measures. Production and consumption decisions were simultaneously analysed, permitting an appraisal of adjustments in land use in accordance with farm household goals. In the modelling experiments, three farm household types were distinguished, according to the resource endowment and objective functions, to account for different supply responses. Comparing the three different farm types, it was striking that progressive farmers with a higher resource capacity, better access to markets (both domestic and export), and with a higher priority on maximising surplus cash, would develop operating plans superior to marginal farmers. In contrast, marginal farmers were more concerned with their survival rather than maximising cash surplus. But, given their limited resource base, different personal goals and preferences, and the level of risk they found acceptable, they generally would behave in a rational way.

The solving of the GP models indicates that some goals cannot be achieved under the desired policy. Tradeoffs therefore occur due to limited resources. The different models also allow planners to review critically the priority structure of each farm type in view of the solutions derived by the respective models. Indeed, the most important feature of the GP model is its flexibility, which allows simulation under numerous variations of constraints and goal priorities.

Recent analysis of agricultural performance and critiques of Tongan government policies toward agriculture not only identified the constraints on agricultural production but also indicated farmers' likely responses to policy changes. The modelled effects of different policy measures confirms that market development instruments, improved technologies and increasing farmer motivation can have a substantial and positive impact on farm revenue and commercial development. A change in technology, either through improved cultivars or improved management, could have a strong impact on the production structure, as shown by farmers being able to meet their food and cash requirements with less land. This result emphasises that access to markets, and having a "commercial mentality", are the prime influencer's in farmers determining their production options. The result showed that social and church obligations, and leisure requirements, also have significant effects on land use decisions of emergent and marginal farm households even though these may have a negative impact on farm revenues. Varying the weighting on these goals in favour of a cash surplus, or profit maximisation, clearly increases the cash surplus. It was also evident in these findings that Tongan smallholder farmers are not producing as much as they are able with their existing resources. This suggests that policies should concentrate on improving market access and getting the prices right.

Increasing landlessness has resulted in more people being available for agricultural labour and employment by those households with land to develop. There is evidence of a lively labour market existing in the villages; some respondents asserted "hiring casual labour is not a constraint but having the cash to pay them is the main problem". Nevertheless, it is important to emphasise the substantial potential to generate employment in the smallholder agriculture sector. Given the proper incentives, including the development of improved production systems allowing for sustained intensified production, the agricultural sector appears to offer the best prospects of any sector in Tonga of providing employment to match the potential growth of the workforce. For example, the successful development of the squash industry has significantly increased demand for hired labour and increased wage rates during the squash season.

The increasing migration to urban areas in response to economic and social pressure for education, employment and the prestige of urban living, plus a lessening attachment to the traditional village lifestyle, are indicative of cultural and economic trends in Tonga. These are expected to continue. Increasing migration puts more localised pressure on the land available for cultivation, which results in more intensive use of land, reduced fallow and increased reliance on fertiliser to offset the nutrient depletion of soils. The problems also further impact on cropping patterns. As some respondents in Tongatapu pointed out, "*we have to change our cropping pattern, because we no longer fallow land for yam, therefore we just rely more on taro, cassava and sweet potatoes for our staple food*". This research recommends social policies for Government to address, including institutional development of the outer islands, improved support services, education and off-employment opportunities to retain locals and reduce migration. An internal immigration policy is also an option to reduce competition for land especially in Tongatapu, which already has a high population density ( 259 people per km<sup>2</sup>).

While the emphasis of this research has been on the creation and development of individual holdings, it may be advantageous to encourage farmers' groups and co-operatives. Promotion of small farmer organisations that vertically integrate production and marketing may strengthen income gains and reduce income disparities among smallholder farmers. Farmers' groups are currently operating, especially in Vava'u and Ha'apai, but on a basis of labour sharing ventures. However, promotion of export growth, and collective production should be encouraged to enable small-scale farmers to capture the benefits of large-scale marketing and persistent economies of large-scale production. Co-operative and farmer group arrangements may also enable better access to credit and other complementary inputs that are essential if farmers are to adopt new innovations that will raise their productivity, output and incomes. These self-managed farmer organisations might ultimately take the form of co-operatives, depending on the key limiting factors in the provision of these different inputs and services in the local village community. One reason why farm organisations are necessary is that the costs of dealing with a large number of small farmers is very high. By developing self-managed farmer organisations, farmers can buy inputs in much larger quantities at a cheaper price, and acquire larger group loans, with lower bank service costs per farmer. Farmer organisations are also necessary to increase the participation of rural people in efforts to influence agricultural policy and to articulate the needs and problems of the farm community to the agricultural service agencies.

Increasing export production from the agricultural sector is regarded as the key factor for the growth of the Tongan economy. The economy urgently needs enlarged foreign exchange earnings. The cash income of farm households needs to be increased to stimulate industrialisation. The increasing commercialisation of the semi-subsistence farms is an important requirement for increasing production with a limited land area. In Tonga where markets for land and capital are not well developed, pricing instruments appear to have limited influence on resource allocation. Market and institutional development are therefore the required instruments. The market for the farmer must be enlarged. At the same time, the efficiency of the marketing organisations needs to be improved. Since a large proportion of the consumers of agricultural produce is within the agricultural sector, it will be difficult to enlarge the domestic market rapidly. Increasing the export of agricultural products will therefore be an important strategy for enlarging the market for the subsistence farmer.

Based on the findings from this study, given appropriate types of improved technology, supportive agricultural policies (research and extension, market, land tenure, education, etc), and appropriate incentives, smallholder farmers can simultaneously pursue the goals of increasing national agricultural production and securing increased rural welfare. Fleming and Hardaker (1995 pp 47) noted that the Tongan experience with vanilla, squash and kava indicates that finding the right products to supply to the right markets is not easy. But, if it can be done, the rewards can be great. However, the sustainability performance of the agricultural sector depends on both how long the niche markets for these crops remain open and profitable for Tongan farmers and the success of efforts to diversify agricultural products and exports to other markets. If the momentum continues long enough, and if sufficient new export crop opportunities are available, the loss of a single market commodity will not be serious enough to stop the momentum for development that will have been built up. Increasing commercialisation requires modification of farmers' objectives towards greater priority on profit maximisation. It also requires improvement in the ability of semi-subsistence farmers to be able to manage the uncertainties and risks that come with increasing commercialisation. For new products and new inputs to be introduced, the dissemination of new knowledge through extension needs to be improved.

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